

## Order PASSERIFORMES

The largest and most diverse order of birds, commonly called passerines or perching birds, and comprising some 5712 species in 45 families (based on Sibley & Monroe 1990; Sibley & Ahlquist 1990), and well over half the world's known bird species. In the HANZAB region, Passeriformes represented by some 382 species in 39 families. Tiny to large: smallest passerine is Pygmy Tit *Psaltria exilis* of Java, with a total length c. 8 cm; largest is Greenland Raven *Corvus corax principalis*, with a total length c. 64 cm and weighing up to 1.7 kg. Superb Lyrebird *Menura novaehollandiae* of e. Aust. probably second largest in Order, with a total length (in adult male) of c. 103 cm, including tail of c. 70 cm, and weight up to c. 1.1 kg. Cosmopolitan except Antarctica and some oceanic islands; and occupying all terrestrial habitats.

Overall, Passeriformes are characterized by (based on Raikow 1982; Sibley & Ahlquist 1990; and DAB [=Schodde & Mason 1999]): Palate aegithongnathous (except Conopophagidae [gnateaters]). Intestinal caeca rudimentary. Single left carotid artery (except paired in *Pseudocalyptomena* and possibly other broadbills [Eurylaimidae]). Aftershaft reduced or absent. Neck short, with 14 cervical vertebrae in most, but 15 in Eurylaimidae (broadbills); atlas perforated; metasternum usually two-notched (rarely four-notched). Bicep slip absent. Expansor secundariorum often present (Berger 1956; Raikow 1982; *contra* Beddard 1898; Ridgeway 1901). Pelvic muscles AXI (AX in *Dicrurus* [drongos]). *Ambiens* absent. Iliofemoralis externus usually absent, but present in some groups as 'developmental anomaly' (Raikow 1982). Tensor proptagialis brevis tendon present. Hypocleideum present (except Menuridae [lyrebirds]). Wings eutaxic. Usually ten primaries, but p10 often reduced or absent; 11 primaries in Menuridae (lyrebirds), most Eurylaimidae (broadbills), most Furnariidae (ovenbirds), and some Passeri (oscines [see below]). Usually nine secondaries (ten in Menuridae [lyrebirds]). Usually 12 rectrices, but from six (*Stipiturus* [Maluridae]) to 16 (Menuridae). Lesser primary and secondary coverts usually reduced or absent (Zeidler 1966; Morlion 1985; Winkler & Jenni 1996), but a few well-developed lesser primary coverts are present in Superb Lyrebird (Morlion 1985). Uropygial preen glands naked. No basipterygoid process. Nasal glands minute. Foot anisodactyl. Hallux incumbent, large and directed backwards; toes 2, 3 and 4 directed forward; digital formula 2-3-4-5. Deep plantar tendons usually of type VII (lacking vinculum), but often type I in Eurylaimidae (broadbills). Spermatozoa bundled with coiled head and large acrosome.

The DNA-DNA hybridization studies of Sibley & Ahlquist (1985a, 1990) revealed much about the relationships within the Passeriformes and resulted in fundamental changes to the higher level taxonomy of passerines, not least to the taxonomy of the Australo-Papuan oscine passerines. Importantly, these studies showed that many elements of the Australo-Papuan avifauna (e.g. the A'asian wrens [Maluridae], robins [Petroicidae], babblers [Pomatostomidae], and so on), represent an endemic radiation of forms that bear an external resemblance to Eurasian families. Many of the findings of DNA-DNA hybridization studies regarding the Australo-Papuan oscines have since been broadly corroborated by studies using protein allozymes (e.g. Christidis 1991; Christidis & Schodde 1991) and microcomplement fixation (e.g. Baverstock *et al.* 1991, 1992), though there are also many points that remain uncertain and many familial relationships within the Passeriformes are unresolved (Christidis & Boles 1994). (For discussion of historical taxonomic arrangements preceding results of DNA-DNA hybridization studies, see BWP, and Sibley & Ahlquist [1985a,b, 1990]).

The Passeriformes divide into two main groups:

**SUBORDER TYRANNI (SUBOSCINES):** The distribution of the suboscines is centred in the American and Afro-Asian Tropics, with a massive radiation in South America (Sibley & Ahlquist 1990; DAB). Suboscines characterized by mesomyodian syrinx, with or without a single pair of intrinsic syringeal muscles (van Tyne & Berger 1976; Campbell & Lack 1985; DAB). Suborder sometimes named Oligomyodi (e.g. Sibley & Ahlquist 1985a,b), Deutero-Oscines (e.g. Morony *et al.* 1975; Voous 1977), or Clamatores (Campbell & Lack 1985). Poorly represented in the HANZAB region: only TYRANNIDAE (tyrant-flycatchers), with two species, both accidental to South Georgia; ACANTHISITTIDAE (NZ wrens), with four species (one extinct) in three genera, endemic to NZ; and PITTIDAE (pittas), with four species in one genus in HANZAB region (three breeding, one accidental). Tyranni formerly included the Menuridae and Atrichornithidae (e.g. Wetmore 1960; Storer 1971), though subsequently shown that these two families should be included in Passeri (e.g. Sibley 1974; Sibley & Ahlquist 1985, 1990).

**SUBORDER PASSERI (OSCINES OR SONGBIRDS):** Cosmopolitan in distribution. Within the HANZAB region there are 36 families of Passeri. The Australo-Papuan Passeri can be subdivided into several supra-familial groups, but those recognized differ between authors (for further information, see Sibley & Ahlquist 1985, 1990; DAB). Oscines are

characterized by acromyodian syrinx, with three or four pairs of intrinsic syringeal muscles (van Tyne & Berger 1976; Campbell & Lack 1985; Sibley & Ahlquist 1990; DAB).

Suborder Passeri comprises the major element of the Aust. and NZ passerine avifauna. The families recorded in the HANZAB region, and the representatives in the region, are (following Christidis & Boles [1994] for Aust., with additional species for wider region added as appropriate):

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- MENURIDAE (lyrebirds): two species in one genus; endemic to Aust.;
- ATRICHORNITHIDAE (scrub-birds): two species in one genus; endemic to Aust.;
- CLIMACTERIDAE (A'asian treecreepers): six species in two genera breeding in Aust.;
- MALURIDAE (Australopapuan fairy-wrens, emu-wrens and grasswrens): 22 breeding species in three genera in Aust.;
- MELIPHAGIDAE (honeyeaters and Aust. chats): 76 species in 26 genera in Aust. and NZ, all breeding;
- PARDALOTIDAE (pardalotes, scrubwrens, thornbills and allies): 51 species (one extinct) in 15 genera in HANZAB region, all breeding;
- PETROICIDAE (A'asian robins): 23 species in eight genera in HANZAB region, all breeding;
- ORTHONYCHIDAE (logrunners): two breeding species in one genus in Aust.;
- POMATOSTOMIDAE (A'asian babblers): four breeding species in single genus in Aust.;
- CINCLOSOMATIDAE (whipbirds, wedgebills, quail-thrushes and jewel-babblers): eight breeding species in two genera in Aust.;
- NEOSITTIDAE (sitellas): single species breeding in Aust.;
- PACHYCEPHALIDAE (whistlers, shrike-thrushes and allies): 17 species in seven genera in HANZAB region, all breeding;
- DICRURIDAE (monarchs, flycatchers, fantails and drongos): 19 species in seven genera in HANZAB region, all breeding;
- CAMPEPHAGIDAE (cuckoo-shrikes, trillers and minivets): eight species (one extinct) in two genera in HANZAB region, all breeding;
- ORIOLIDAE (Old World orioles and figbirds): three species in two genera in Aust., all breeding;
- ARTAMIDAE (woodswallows, butcherbirds and currawongs): 14 species in four genera in HANZAB region, all breeding;
- PARADISAEIDAE (birds of paradise): five breeding species in two genera in Aust.;
- CORVIDAE (crows and jays): six breeding species in single genus in Aust. and NZ, including one introduced to NZ;
- CORCORACIDAE (Aust. mudnesters): two species in two monospecific genera, endemic to Aust.;
- CALLAEIDAE (NZ wattlebirds): three species (one extinct) in three monospecific genera, endemic to NZ;
- LANIIDAE (shrikes): two species in HANZAB region, one accidental to Prince Edward Is, the other accidental to Christmas I.;
- PTILONORHYNCHIDAE (bowerbirds): ten species in seven genera in Aust. (nine species) and NZ (one species), all breeding; Piopio of NZ probably extinct (Heather & Robertson 1997);
- ALAUDIDAE (larks): two breeding species in HANZAB region (including one successfully introduced to Aust. and NZ);
- MOTACILLIDAE (wagtails and pipits): eight species in two genera in HANZAB region, only two breeding (one on South Georgia), the rest non-breeding visitors or accidentals;
- PRUNELLIDAE (accentors): one species successfully introduced to NZ;
- PASSERIDAE (Old World sparrows and A'asian finches): 22 species in nine genera (including four successful introductions) in HANZAB region, all breeding;
- FRINGILLIDAE (Old World finches): seven species in four genera in HANZAB region, all introduced except one naturally occurring vagrant to South Georgia;
- EMBERIZIDAE (buntings, cardinals, tanagers and allies): two successfully introduced species, occurring NZ and Lord Howe I.;
- NECTARINIIDAE (sunbirds and spiderhunters): single breeding species in Aust.;
- DICAEIDAE (flowerpeckers): single breeding species in Aust.;
- HIRUNDINIDAE (swallows and martins): eight species in four genera in HANZAB region, including four breeding species in Aust. and NZ, one non-breeding visitor and three accidentals;
- PYCNONOTIDAE (bulbuls): one successfully introduced species in Aust.;
- SYLVIIDAE (Old World warblers): 13 species in eight genera in HANZAB region, including ten breeding species (one extinct) in Aust. and NZ, and three accidental to region;
- ZOSTEROPIDAE (white-eyes): seven species (one extinct) in single genus in HANZAB region, all breeding;
- MUSCICAPIDAE (Old World flycatchers, thrushes and chats): eight species in six genera in HANZAB region, including five breeding species (two introduced), and four accidentals (including one on Prince Edward Is);
- STURNIDAE (starlings and mynas): five species in four genera, four breeding in HANZAB region (including two species successfully introduced, and one species now extinct), and one accidental.
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The Aust. oscines fall into two distinct clusters, each with at least three major supra-familial lineages (DAB): One cluster is the Passerida, comprising the Muscicapoidea (including true thrushes and allies), Sylvioidea (true warblers and babblers, and swallows, and others), and Passeroidea (including larks, pipits, sunbirds, flowerpeckers and all finches and their allies). The other cluster is the Corvida, which is centred on the Australo-Papuan region (though its origins are not certain) and which also comprises three main lineages: Menuroidea (lyrebirds, scrub-birds, treecreepers and bowerbirds), Meliphagoidea (A'sian wrens, pardalotes, acanthizid warblers, and honeyeaters), and Corvoidea (A'sian robins, logrunners, A'sian babblers, whipbirds and quail-thrushes, sitellas, whistlers, fantails and monarchs, birds of paradise, butcherbirds and woodswallows, cuckoo-shrikes, Old World orioles, crows and mudnesters).

Throughout this volume, arrangement of families follows that of Christidis & Boles (1994) except that the Meliphagidae precedes the Pardalotidae. This change was made to ensure the Meliphagidae were dealt with in a single volume, rather than split between volumes, and because the switch meant no change to the positioning of Meliphagidae relative to the Pardalotidae (including Acanthizidae), one another's closest relatives, and because there is little overriding evidence of the exact taxonomic positioning of all families within the Meliphagoidea; Sibley & Monroe (1990) also placed the Meliphagidae between the Maluridae and Pardalotidae. However, DAB points out that based on structure of humeral fossa, positioning of Meliphagidae between the Maluridae and Pardalotidae is not correct.

DAB, however, varies from the familial arrangement of Christidis & Boles (1994) in several ways. The main differences are: (1) recognition of Pardalotidae and Acanthizidae as separate families (combined in Pardalotidae in Christidis & Boles); (2) minor rearrangement of the sequence of the families Paradisaeidae–Artamidae–Campephagidae–Oriolidae between the Dicruridae and Corvidae (cf. Dicruridae–Campephagidae–Oriolidae–Artamidae–Paradisaeidae–Corvidae in Christidis & Boles); (3) and use of the more traditional muscicapoid (flycatcher) – sylvioid (warbler) – passeroid (finch) sequence of Sibley *et al.* (1988), Sibley & Ahlquist (1990) and Sibley & Monroe (1990) and much contemporary literature of n. hemisphere, with families in the sequence Muscicapidae–Sturnidae–Hirundinidae–Pycnonotidae–Zosteropidae–Sylviidae–Alaudidae–Dicaeidae–Nectariniidae–Passeridae–Motacillidae–Estrildidae–Fringillidae and noting recognition of the Estrildidae as a separate family (cf. the reversed sequence of Christidis & Boles, as given above, and which submerges the Estrildidae within the Passeridae). For discussion of the reasons for these changes, see DAB (and discussion under these families in future volumes of HANZAB).

Arrangement of genera and species within families also follows Christidis & Boles (1994), which was in turn largely based on Schodde (1975) unless there were specific reasons for change. Lastly, with few exceptions, which are discussed in individual species accounts, taxonomy of subspecies follows DAB.

Passerines are extremely diverse in body form and plumage, and vary greatly in rates of maturation. Some attain adult plumage within months or weeks of fledging; others can take up to 9 years to attain adult plumage (e.g. Superb Lyrebird). Degree of sexual dimorphism also varies greatly: some monomorphic, others vary in either size, plumage or both. Common pattern of annual moult is a single complete post-breeding (pre-basic) moult, but some groups (e.g. Maluridae) or species (e.g. Banded Honeyeater *Certhionyx pectoralis*) also undergo a partial pre-breeding (pre-alternate) moult annually. Moult of primaries usually outward. Secondaries moult from innermost and outermost toward s5. Moult of tail usually centrifugal (outward from centre). Young altricial, nidicolous and dependent on adults for food; usually hatch with sparse to very sparse covering of down, mainly on dorsum; Menuridae (lyrebirds) have heavy natal down. Juvenile plumage usually duller than adult, and in many sexually dimorphic species, often similar to that of adult female.

There are few common features of food, feeding behaviour, social organization and behaviour, voice or breeding in such a large and diverse group of birds.

Volant; extinct Stephens Island Wren *Traversia lyalli* probably the only flightless passerine (Millener 1988). Movements vary greatly: some species long-distance migrants (e.g. Barn Swallow *Hirundo rustica*, Nightingale *Luscinia megarhynchos* and many Old World warblers, such as *Acrocephalus* and *Locustella*, breed in temperate Palaearctic and migrate to Africa or Indian subcontinent [BWP]; Acadian Flycatcher *Empidonax vireescens* breeds North America and migrates to South America [Ridgely & Tudor 1994]), others sedentary in small territories (e.g. Cactus Wren *Campylorhynchus brunneicapillus* of sw. USA and Mexico [Ricklefs 1975; Ehrlich *et al.* 1988]). In HANZAB region, movements also vary widely: e.g. Yellow-faced Honeyeater *Lichenostomus chrysops* regular annual migrant in parts of e. Aust.; Rifleman *Acanthisitta chloris* of NZ sedentary in small territories. In Aust., movements often poorly known and unstudied; many species often said to be nomadic, with such claims often based on no or very poor knowledge of actual movements and based only on apparently irregular occurrence in an area (see General Introduction [Movements] for fuller discussion of this point).

Arboreal or terrestrial or both; some strictly arboreal (e.g. Hirundinidae), others strictly terrestrial (e.g. Menuridae, Pittidae); most combine both arboreal and terrestrial foraging to varying degrees, but usually with one predominating. Feed on almost all known food, from plant material to vertebrate animals, but most show some specialization for certain food, such as feeding on nectar (Nectariniidae), seeds (Passeridae), fruit (Zosteropidae), small vertebrates (Artamidae) and, commonly, insects (e.g. Maluridae, Pardalotidae, Petroicidae and others). Mostly feed by gleaning

and probing, including probing flowers for nectar; and other substrates for invertebrates; also feed by sallying, including various sallying techniques (sally-hovering, sally-striking and sally-pouncing), each suited for one group of prey, particularly moving animals.

In passerines, parental care in both sexes is well developed. However, a few species are parasitic, e.g. cowbirds *Molothrus* (Campbell & Lack 1985). Young are dependent on parents for food. Young beg by gaping, typically exposing brightly coloured inside of mouth, often with contrasting pale or dark spots; in non-passerines, bright gape present only in hoopoes (Upupidae), mousebirds (Coliiformes) and cuckoos (Cuculiformes) (BWP). See Boles & Longmore (1985) for descriptions of colours and markings inside the mouths of some Aust. passerines.

Anting is a highly specialized behaviour: ants are held in the bill and applied to the plumage, usually to the underside of the wing-tip (direct or active anting, or ant-application), or ants are allowed access to the plumage (indirect or passive anting, or ant-exposure), or both, e.g. anting recorded in Regent Honeyeaters *Xanthomyza phrygia* in HANZAB region, with bird then seen eating ant. Thought to be unique to Passeriformes (e.g. Simmons 1966; Campbell & Lack 1985; BWP). Suggested this may be comfort behaviour related to maintenance of feathers, by perhaps reducing ectoparasite load, removing stale or excess lipids, or adding supplementary essential oils (Campbell & Lack 1985); some secretions of ants are antibiotic, inhibiting growth of both fungi and bacteria, and the secondary acquisition of these antibiotic secretions would be an important advantage of anting (Ehrlick et al. 1986).

Other behavioural characters include head-scratching indirectly (or over the wing) in most families, with the foot brought up above the lowered wing. Head oiled indirectly, as seen in most taxa, but passerines also oil head by head-scratching, in which bird oils the bill directly, then transfers the oil first to one foot by scratching the bill, and then to the head by scratching the head with foot. To oil the undersurface of the wings, use bill or bill and head together, extending one wing at a time sideways and forward, carpus uppermost, and often alternating rapidly from one wing to the other. The stretching of one wing as a comfort movement seems common to all birds, but in passerines it is often accompanied by sideways fanning of tail. After both wings are stretched, passerines often give a two-leg stretch as they straighten the tarsal joints and lift the body. Heat is dissipated by gaping and panting (not by gular-fluttering, so far as known) (Campbell & Lack 1985; BWP). Bathing widespread, mainly by standing in shallow water, but some groups jump into and out of water repeatedly, or flight- or plunge-bathe, while others bathe only or mainly in rain or among wet foliage; for further details of bathing, see Campbell & Lack (1985). Passerines do not flap wings in the manner of non-passerines to dry, but perform various shaking movements, as well as preening (Campbell & Lack 1985). Dusting confined to only a few groups, but sunning, both for gaining heat (sun-basking) and other purposes (sun-exposure), is widespread, and of two distinct types: (1) lateral posture, in which sunning bird squats or sits down, usually on ground, and leans to one side exposing the flank or the 'sun-wing', which has been lowered and partly unfolded, and the fanned tail, which has been brought round to the same side; and (2) spread-eagle posture, in which bird squats or lies flat with both wings open and tail fanned (details in Campbell & Lack 1985; Simmons 1986).

There is a high incidence of co-operative breeding in Aust. and NZ, and it is especially common and well-studied in the Maluridae but is more widely recorded, including within the Acanthisittidae, Meliphagidae, Petroicidae, Pomatostomidae and Corcoracidae (see Dow 1978, 1980; Brown 1987; Ford 1989; Rowley & Russell 1997).

In vocal abilities, species of Passeriformes are more accomplished than those of any other order, but songs may be simple or highly complex, and repertoires small or large. Mimicry of calls of other species is practised by many species; c. 15% of Australian passerine species have been reported to mimic (Marshall 1950). The Superb Lyrebird and the Tui *Prosthemadera novaeseelandiae* have been classed among the best seven of the world's songsters (Hartshorne 1973). Oscines, or songbirds, have specialized forebrain song nuclei, and, through auditory feedback, learn their songs from those of adults, in much the same way as human young learn their spoken language from adults. In contrast, the songs of suboscines are relatively simple (like the non-learned call-notes of songbirds), repertoires are small, geographical variation is minimal, and development of song appears to take place without any imitative or feedback process. Some oscine species use vocal learning to generate large song repertoires and may vary them geographically, even locally. Other oscine species forgo these possibilities and have song repertoires more like those of suboscines; how the learning process maintains stereotypy of song over the range of such species is a mystery (Kroodma 1996).

Apart from the five families discussed hereunder, syringeal structure of passeriform species of our area is similar, there being four pairs of intrinsic muscles. Pittidae have no intrinsic muscles (Ames 1971); calls are mostly loud strong whistles (Pizzey 1980). Acanthisittidae also have no intrinsic muscles, but the presence of a well-developed drum (fusion of posterior tracheal elements) suggests they may have once been present; vocal repertoire is not great (Ames 1971). Menuridae and Atrichornithidae have similar syringeal structures, with three pairs of intrinsic muscles; songs are highly developed, and there can be much mimicry (Ames 1971). Climacteridae, with four pairs of intrinsic muscles, exhibit gross asymmetry of the extrinsic muscles, unusual directions of muscle fibre in the intrinsic muscles, and an exceptionally robust sternotracheal muscle (Ames 1987); calls are brisk, sharp and piping (Pizzey 1980).

Extended tracheae are found in the genus *Manucodia* (Paradisaeidae), the calls of which are deep, loud or far-carrying (Frith 1994). In the only species occurring in our area, the Trumpet Manucode *M. keraudrenii*, the trachea forms a flat coil between the skin and the pectoral muscles, sometimes extending over the abdominal muscles as well,

and may be up to 828 mm in length, compared with body-length, from bill to pygostyle, of c. 150 mm (Ames 1971; Clench 1978).

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## Family CALLAEIDAE<sup>1</sup> New Zealand wattlebirds

A small but morphologically rather diverse family of three species of small-medium to medium-large passerines, endemic to NZ. Two species, Saddleback *Philesturnus carunculatus* and Kokako *Callaeas cinerea*, extant but threatened; the third, Huia *Heteralocha acutirostris*, is extinct (Oliver; Peters; NZCL). Taxonomic affinities of the family have been subject to some debate. Garrod (1872) suggested that the Huia was related to the families Icteridae (New World orioles, grackles and allies) and Sturnidae (starlings), but this was later rejected by Mayr & Amadon (1951), who placed the New Zealand wattlebirds between the Grallinidae (*Grallina*, *Corcorax* and *Struthidea*) and the Cracticidae (butcherbirds and allies). Sharpe (1877) placed them in the Corvidae between *Picathartes* (rockfowls and rock-jumpers) and *Falcula* (vangas). Based largely on pterylography and osteology (summarized below), Stonor (1942) concluded that all three species of New Zealand wattlebirds are from the same stock that gave rise to the Sturnidae and their immediate allies. Again, Mayr & Amadon (1951) rejected the hypothesis that Callaeidae and Sturnidae are allied. Oliver combined Saddleback and Huia in the family Philesturnidae, and placed Kokako in a separate but closely allied family Callaeidae. Williams (1976) did not give an opinion concerning the affinities of the group. Sibley & Ahlquist (1985, 1990) lacked DNA samples of the three species and were thus unable to conduct DNA–DNA hybridization analysis with other passerines; consequently these authors combined them as the family Callaeidae and placed them between the Corvidae and Picathartidae.

Species range in size from medium-small (Saddleback: length c. 20 cm, weight c. 80 g) to large (Huia: length c. 53 cm, c. 400 g). Morphological and osteological characteristics shared by the three species are (Stonor 1942; Williams 1976; Oliver): Wings rather short and rounded at tips. Ten primaries; p10 rather long. Nine secondaries, including three tertials. Tail long and rounded at tip; 12 rectrices. Bill varies between species: rather short and robust with decurved upper mandible in Kokako; long and straight with compressed ridge along culmen in Saddleback; and, in Huia, very long and sickle-shaped in adult female, shorter and only slightly decurved in adult male. Tongue morphology varies: lanceolate and shallowly bifid at tip in Saddleback, oblong and truncated at tip in Kokako (McCann 1964). Tarsus rather long; scaling laminiplantar. Feet rather large and strong. Hindclaw fairly long. All species have distinct and brightly coloured fleshy wattle on each side of gape. All species have weak keel to sternum and large nasal depressions. Kokako has following cranial features: distinct 'bridge' on upper edge of nasal; large lachrymals with thickened basal portion abutting jugal bar; large post-orbital processes; deep temporal fossae; two small unfused sesamoid bones, larger of which separates articulation of lower mandible from quadrate; maxillo-palatines expanded below vomer into pointed head; and palatines thickened and trans-palatine processes extend posteriorly to acute tip. Huia has similar palate structure and post-orbital processes to Kokako, but also has: articulation of lower mandible extends greatly backward; smaller lachrymals; distinct occipital crest; lacks deep temporal fossae; and lacks sesamoid bones. See Buller (1888) for more details on osteology of the Huia. Little known about osteological characters of Saddleback, but said to be similar to Huia, particularly in having distinct extension of articulation of lower mandible.

Plumage varies: mostly bluish grey in Kokako; blackish with distinct rufous band across upperparts in Saddleback; black with white tip to tail in Huia. Juvenile Kokako and Saddlebacks superficially resemble adults, but have softer and more loosely textured feathers of head and body. Kokako hatch with well-developed natal down (Gill 1993). Undergo a partial post-juvenile (first pre-basic) moult to adult-like first immature (first basic) plumage. Acquire adult plumage in complete first immature post-breeding (second pre-basic) moult, probably when c. 1 year old. After acquiring adult plumage, a complete post-breeding (pre-basic) moult each cycle produces successive adult (basic) plumages with no change in appearance. Sexes alike in plumage. Primaries moult outward, starting at p1; in Kokako, up to three primaries grow at once. Moult of tail and body not well known; timing probably much as moult of primaries.

Inhabit native forests, from lowlands to higher altitudes of mountain ranges. In NI, Kokako found mainly in structurally complex lowland forests, preferring tall mature hardwood forest dominated by *Tawa Beilschmiedia tawa* with emergent podocarps; in SI, occur in higher-altitude forests dominated by beech *Nothofagus*. Only survive in habitat free of most exotic predatory mammals. Saddleback occupies evergreen coastal and mixed lowland broadleaf forests, especially seral forests and secondary growth with high turnover of dead wood and numerous fruiting shrubs; also in coastal and montane shrublands. Translocated populations of Saddleback also occur in range of other habitats, such as lowland beech forest, mixed evergreen podocarp–hardwood forest and in exotic pines and wattles. Huia mainly inhabited montane and lowland hardwood–podocarp forests with dense understorey, occasionally beech forest (I. Flux; J.G. Innes; T.G. Lovegrove; see species accounts).

<sup>1</sup> For discussion of correct spelling of family name, see Peters.

In Saddleback and Kokako, breeding adults sedentary and territorial throughout year and from year to year, though, in Saddleback, adults known to traverse neighbouring territories to forage and drink. In Kokako, young disperse, sometimes >20 km, before settling into territories close to natal territories (see species accounts).

Omnivorous, but main components of diet vary with species: Kokako eats mainly fruit and leaves and, less often, flowers, moss, buds, nectar and invertebrates; Saddleback eats mainly insects and berries, as well as other invertebrates and nectar and occasionally buds; Huia considered a specialist predator of Huhu beetle *Prionoplus reticularis* larvae, but also ate other invertebrates and fruit. Forage at all levels in forests: on soil, in leaf-litter and decaying timber on ground; and among branches and live and dead foliage of trees and shrubs from near ground to canopy. Forage mostly by probing, tearing and gleaning; probe bark of trees, dead and decaying wood of branches, trunks, stumps and logs, and often tear off chunks of bark or wood from trees, exposing insects beneath. Sometimes lift fronds, leaves, lichens or moss, and sometimes toss leaves like a Common Blackbird *Turdus merula*. Bills long and strong, and forage with them either open or closed; upper mandible sometimes used as skewer; also use bill to zirkeln. Male and female Huia had markedly different bills: males had strong, slightly decurved, moderately long bills and well-developed cranial musculature, allowing them to break up rotten wood by chiselling and gaping; while females had longer, slender and more decurved bills, suited to probing holes and crevices. Use feet to manipulate and hold food. Kokako and Saddleback forage throughout day; and usually forage singly or in pairs, very occasionally in larger groups. Saddlebacks often seen foraging with Grey Fantails *Rhipidura fuliginosa* (see species accounts).

Social organization of the family appears to be rather uniform. None appear to be particularly gregarious, with birds usually seen singly or in pairs, but sometimes form small family groups after breeding (see species accounts). All species monogamous and form long-term pair-bonds, possibly remaining paired for life. Where known, both parents feed nestlings and fledgelings, but only female incubates or broods. All species thought to nest solitarily and defend an all-purpose territory throughout the year. Territories maintained mostly by vocalizations, but threat displays, chasing and even physical fighting have been recorded during territorial disputes. Both extant species perform Archangel Displays (see species accounts) and courtship feeding as part of pair-formation and pair-bond maintenance. Vocalizations also play a major role in all sexual activities and all other aspects of social behaviour.

Vocalizations are varied, but all produce melodious piping or flute-like vocalizations. Other vocalizations include organ-like notes, and harsher chattering or churring vocalizations. Much variation between different locations in the vocalizations heard, and components of song can often be categorized to local dialects. All respond strongly to imitation or playback of their vocalizations. Both extant species often perform duets, and both also sometimes counter-sing with neighbours.

Solitary nesters. Typically, female alone constructs nest, incubates and broods, while being fed by the male. However, young usually fed by both parents. A variety of nesting sites used, but Kokakos nest mostly among branches of trees and shrubs, 2–32 m above ground, mostly ≤10 m, while Saddlebacks usually nest in hollows in trees or epiphytes at low levels, including on ground. Huia's nested on ground to high in canopy. Build large, cup-shaped nests, consisting of loosely constructed base mostly of sticks and twigs, with inner layer and lining of finer material. Eggs oval, though also elliptical-ovate in Kokako. Ground-colour pale, usually shades of pale to darker pinkish or purplish grey, but also white and very pale browns; marked with spots and blotches, sometimes streaks or lines, of shades of brown and purple, usually concentrated at large end. Clutch-size usually two or three, occasionally one or four; Huia's said to have often laid clutches of four, but clutch-size variously claimed to be from one to five. Normally raise one or two broods per season. Incubation period from 16 to 28 days; fledging period, from 25 to 37 days. Breeding failures largely result of predation, mostly by small introduced mammals, such as rats *Rattus* and Common Brushtail Possums *Trichosurus vulpecula*, which are able to attack the low and easily accessible nests, but also by predatory birds such as Swamp Harriers *Circus approximans*, Southern Boobooks *Ninox novaeseelandiae* and Wekas *Gallirallus australis* (see species accounts).

All members of family globally threatened: Kokako is endangered; Saddleback near threatened; and Huia extinct (Stattersfield & Capper 2000; Fuller 2002; NZCL; for details see species accounts). Ranges of Saddleback and Kokako much reduced, but both increasing with translocations to offshore islands and protected mainland sites (particularly Saddleback). Main threat is predation by introduced mammalian predators; Kokako also probably adversely affected by competition from introduced omnivores and herbivores, which eat foods also eaten by Kokako and have altered pattern of regeneration of forests. Historically, all three species adversely affected by loss or fragmentation of habitat, through logging (both clear-felling and selective logging, and subsequent degradation) and large-scale clearing and burning of native vegetation, and to some extent, hunting. Predation by introduced mammals may also have contributed to extinction of Huia.

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*Philesturnus carunculatus* Saddleback

*Sturnus carunculatus* Gmelin, 1789, *Syst. Nat.* 1(2): 805 — Queen Charlotte Sound, South Island, New Zealand.

This generic name is one of those coined hybrids beloved of French ornithologists in the 19th century. The French name 'Philésturine' mirrors the combination of a synonymized genus *Philedon* Cuvier, 1817, friarbird, and the genus *Sturnus* Linnaeus, 1758, starling. 'Ce nom indique les rapports que le Philésturine présente tout-à-la-fois avec les Philédons et avec les Étourneaux' (Geoffroy St-Hilaire 1832; *Nouv. Ann. Mus. Hist. Nat. Paris*, 1: 390). The Saddleback was named the 'Wattled Stare' [= starling] by Latham (1785; *Gen. Synop. Birds*, III, p. 9, pl. xxxvi), from Modern Latin *carunculatus*, wattled, carunculated (from Latin *caruncula*, a small piece of flesh).

MAORI NAME Tieke.

OTHER ENGLISH NAMES North Island or South Island Saddleback; Jackbird; Wattled Stare.

POLYTYPIC Nominate *carunculatus*, originally probably in forests of most of SI, and many offshore islands, including Stewart I.; now, following translocations, only on islands in Marlborough Sounds, Fiordland and Stewart I.; *rufusater* (Lesson, 1828), originally, forests of all NI and many offshore islands; now exists naturally only on Hen (Taranga) I., and translocated to islands in Hauraki Gulf, e. coast of Coromandel, Bay of Plenty, Mokoia I. (L. Rotorua) and Kapiti I., and, recently, to two protected mainland sites in Wellington and n. Hawkes Bay.

**FIELD IDENTIFICATION** Length 25 cm; wingspan unknown; weight: NI: males 80 g, females 70 g; SI: males 85 g, females 75 g. Rare but distinctive NZ endemic, with: strong, slightly downcurved, and sharply pointed starling-like bill that runs evenly into flattened forehead; distinct wattles hanging from gape; rather dumpy body; rather long tail with slightly rounded or slightly notched tip, and which often curves downward; short, rounded wings, extending just past uppertail-coverts at rest; very long legs, giving upright appearance; and long feet with strongly hooked claws. Much smaller than Kokako *Callaeas cinerea*, with longer and more slender bill and a shorter tail; slightly smaller than Tui *Prothemadera novae-seelandiae*, but with stouter more chisel-shaped bill (more slender and curved in Tui), and with much shorter wings and longer legs. Adults glossy black with chestnut upperbody, secondary coverts and undertail-coverts, and bright orange-red wattles. Sexes alike but males slightly larger and, within pair, usually have larger wattles; sexes also distinguishable by dimorphic vocalizations (see Voice). No seasonal variation. Two subspecies, *rufusater* of NI and *carunculatus* of SI, that differ only slightly in adult plumages but more markedly in juvenile and immature plumages. Adult *rufusater* from NI have fine yellowish band between black hindneck and chestnut mantle, which is not present in adult SI *carunculatus*. Juvenile *rufusater* very similar to adult but juvenile *carunculatus* very different from adult. Immature plumages like respective juvenile plumages: very like adult in *rufusater* (more so than juvenile), quite different from adult in *carunculatus* (but with more adult-like plumage than juvenile). See descriptions below for details. NI (subspecies *rufusater*): **Adult** Mostly glossy black, with faint bluish sheen in some lights and with: fine yellowish band across upper mantle separating black of hindneck from chestnut rest of upperbody; and with red-brown undertail-coverts. In some lights, lores appear velvety black giving effect of contrasting black mask. Yellowish band across mantle becomes brighter in older males. On folded wing, secondary coverts chestnut, continuous with chestnut of upperbody; rest of wing, brownish-black, covering much of lower upperbody and isolating saddle. Underwing appears wholly dark; coverts, black and remiges, dark brown. Bare parts glossy black apart from pendulous oval reddish-orange wattles that hang from gape, over malar area to sides of throat. **Juvenile** Similar to adult but largely brownish black (not black), and upperbody, secondary coverts and undertail-coverts duller, brown faintly tinged chestnut; belly also faintly barred buff. Demarcation

between hindneck and mantle less well defined, and lack yellowish band. Primary coverts, remiges and tail, duller black than in adult, without hint of gloss; primaries and rectrices also more pointed than in adult. Feathers of head and body also softer and more loosely textured than in adult or first immature. Bare parts glossy black, as adult, apart from wattles, which small and pale orange; and gape, yellow. **Immature** Vary, from similar to juvenile to quite like adult; all retain some juvenile plumage of wing and tail. Those like juvenile have patches of black on head, neck and underbody, and slightly redder-brown upperbody, secondary coverts and undertail-coverts. Those like adult have patches of dark-brown in otherwise blackish head, neck and underbody, and slightly duller chestnut upperbody, secondary coverts and undertail-coverts (with no yellowish band between hindneck and mantle). All birds retain juvenile tail (with more pointed tips to rectrices than in adult) and most juvenile remiges; some replace one or more tertials, which glossy black (as adult) and contrast strongly with much browner retained juvenile remiges. Most birds also retain greater secondary coverts, which are contrastingly duller than new coverts and scapulars; some replace outer coverts, which contrastingly brighter than retained juvenile coverts. Bare parts as adults but wattles usually smaller. SI (nominate *carunculatus*): **Adult** As NI adults but without yellowish band between hindneck and mantle. **Juvenile** Very different from adult (cf. NI juveniles). Nearly wholly dark brown with: varying chestnut tinge to head and neck; blackish-brown lores and anterior malar area; chestnut wash or faint scalloping from back to uppertail-coverts; and dull chestnut undertail-coverts. Tail, black-brown. Folded wing, dark brown with slightly paler warm-brown edging to feathers. Underwing: coverts, olive-brown; remiges, grey-brown. Gape, yellow; and wattles smaller than in adult, pale orange. Rest of bare parts as adult. **Immature** Somewhat similar to SI juvenile (*carunculatus*) but more olive-brown overall and, in most, with scattered patches of blackish on head, neck and underbody; and chestnut marginal and median secondary coverts, as adult, forming chestnut band on shoulder, which instantly distinguishes from juvenile and adult. Most birds also have richer chestnut upperbody, brighter than in juvenile but duller than in adult; others appear virtually identical to juvenile but have adult-like texture to feathers of head and body. Retain juvenile tail (with more pointed tips to rectrices than in adult); and most juvenile remiges, though some replace one or more tertials, which

glossy black (as adult) and contrast strongly with much browner retained juvenile remiges. Most birds retain greater secondary coverts, which contrast strongly with new chestnut secondary coverts, and with new plumage of upperbody; some replace outer coverts, which chestnut, as adult, and also contrast strongly with retained juvenile inner greater secondary coverts. Bare parts as adults but wattles usually smaller.

**Similar species** None.

Active, noisy and easy to locate and observe; inquisitive, and tolerate close approach and observation. Often seen in pairs, or in small family parties of adults and young; males also seen singly, particularly when females incubating or brooding; occasionally seen in larger groups, during interactions at territorial boundaries or when independent young forage together in temporary flocks. Often observed foraging with Grey Fantails *Rhipidura fuliginosa*; and sometimes associate with flocks of Whiteheads *Mohoua albigilla*, Yellowheads *Mohoua ochrocephala* and Brown Creepers *Mohoua novaeseelandiae*. Site-attached adults strongly territorial. Forage actively and noisily, from ground to top of canopy; among leaf-litter and other debris on ground, and on trunks, branches and in foliage. When foraging on ground can become almost covered by leaf-litter; also probe into crevices and dig into rotting logs, and hammer at bark or wood. Considered weak fliers; prefer to move about by hopping or bounding along branches, from branch to branch or across forest floor. Usually fly only short distances, typically <50 m, with rapid, sometimes noisy, wing-beats on short, rounded wings; sometimes undertake long downward glides of 100–200 m, interspersed with a few rapid wing-beats, when crossing deep valleys. Avoid crossing open gaps in forest, preferring to move through vegetated corridors. Roost in cavities in trees, under stream banks or beneath epiphytes. Noisy and clamorous; Songs vary: some described as loud, clear, melodious, beautiful, musical and flute-like, others as soft, melodious, and flute-like, audible only at close range; loud chattering Song, by both sexes, the most common vocalization, often described as *cheet, te-te-te-te*. (Above from Heather & Robertson [2000]; T.G. Lovegrove; and text below.)

**HABITAT** Based on contribution by T.G. Lovegrove. Evergreen coastal and mixed lowland broadleaf forests, especially seral forests and secondary growth where high turnover of dead wood and numerous fruiting shrubs; also in coastal and montane shrublands. Translocated populations also occur in range of other habitats, such as lowland *Nothofagus* forest, mixed evergreen podocarp–hardwood forest and in exotic pines and wattles (see below). On most NI islands occurs from near sea-level to near summits, e.g. to 300 m on Hen I. (Atkinson 1964), to over 600 m on Little Barrier and Kapiti Is (T.G. Lovegrove) and to over 200 m on Cuvier I (D.H. Brunton). Only survive in habitat free of most exotic predatory mammals (see below).

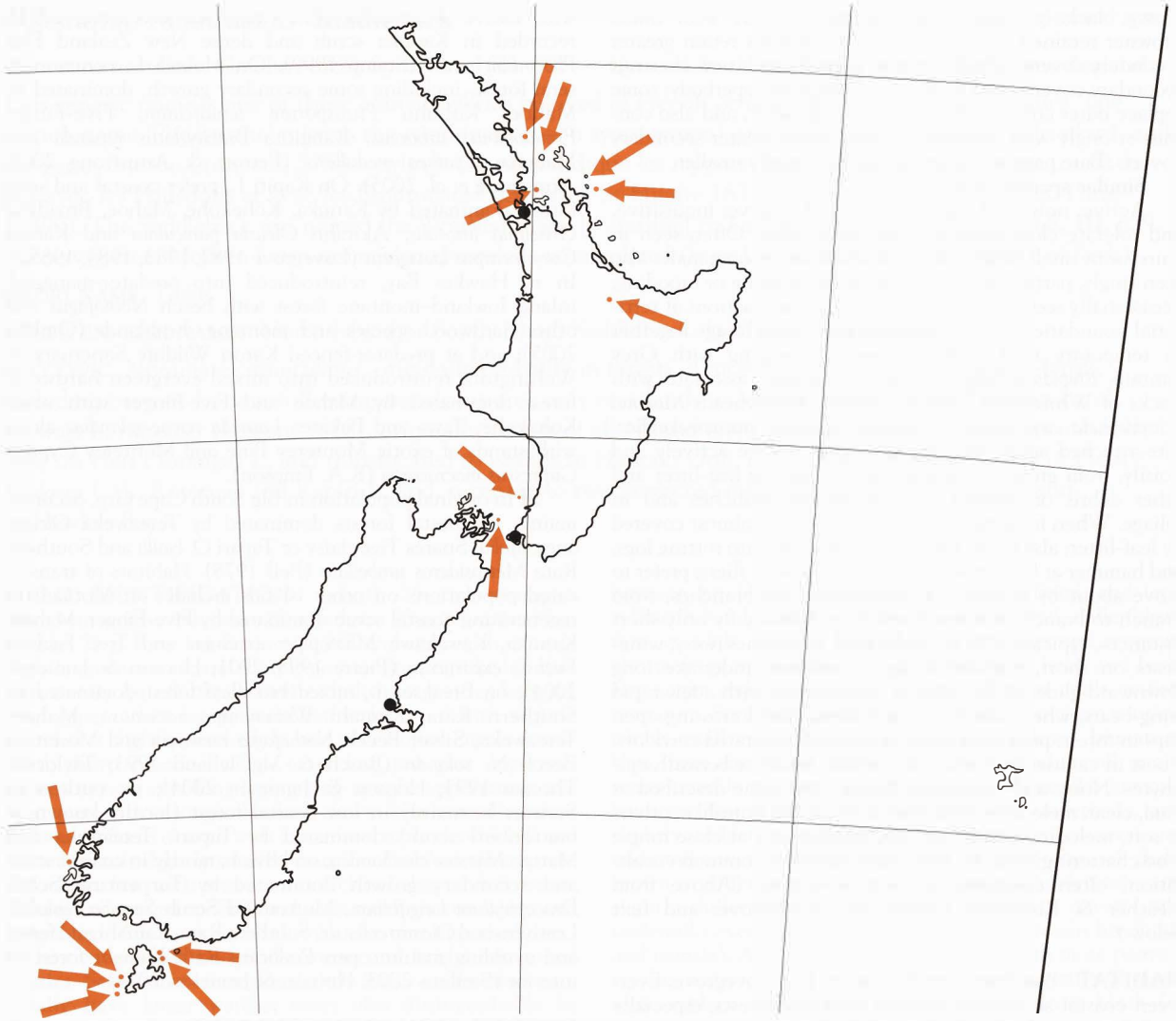
**NI** In surviving original population on Hen I., most numerous in coastal forests of Pohutukawa *Metrosideros excelsa*, Kanuka *Kunzea ericoides* and mixed steepland forests of evergreen broadleaf species; less common in the mature forests of Pohutukawa–Puriri *Vitex lucens* and Taraira *Beilschmiedia tarairi*–Tawa *B. tawa* (Atkinson & Campbell 1966). Reintroduced populations on other n. islands mostly found in evergreen coastal and seral forest dominated by Pohutukawa, Kanuka, Kohekohe *Dysoxylum spectabile*, Mahoe *Melicytus ramiflorus* and Puriri 5–20 m tall, with a continuous lower canopy of young trees and a dense understorey of shrubs, ferns and grasses (Atkinson & Campbell 1966; Jenkins 1976, 1978; Lovegrove 1980, 1992; O'Callaghan 1980). On Tiritiri Matangi I., thriving in mature coastal forest in gullies, young plantings of mixed coastal species (canopy 3–5 m tall) and in introduced Brush Wattle *Paraserianthes lophantha* shrubland

with native understorey (J.L. Craig; see also Craig 1994); recorded in Kanuka scrub and dense New Zealand Flax *Phormium tenax* (Stamp 1999). On Mokoia I., common in seral forest, including some secondary growth, dominated by Mahoe, Kohuhu *Pittosporum tenuifolium*, Five-Finger *Pseudopanax arboreus*, Rangiora *Brachyglottis repanda* and Mamaku *Cyathea medullaris* (Perrott & Armstrong 2000; Armstrong *et al.* 2005). On Kapiti I., prefer coastal and seral forests dominated by Kanuka, Kohekohe, Mahoe, Broadleaf *Griselinia littoralis*, Akiraho *Olearia paniculata* and Karaka *Corynocarpus laevigatus* (Lovegrove 1982, 1983, 1984, 1985a). In n. Hawkes Bay, reintroduced into predator-managed, inland lowland–montane forest with beech *Nothofagus* and other hardwood species and montane shrublands (Omler 2005); and at predator-fenced Karori Wildlife Sanctuary in Wellington, reintroduced into mixed evergreen hardwood forest dominated by Mahoe and Five-Finger with some Kohekohe, Tawa and Pukatea *Laurelia novae-zelandiae* along with stands of exotic Monterey Pine and Monterey Cypress *Cupressus macrocarpa* (R.A. Empson).

**SI** In original population in Big South Cape Grp, occurred mainly in coastal forests dominated by Teteaweke *Olearia angustifolia*, Snares Tree-daisy or Tupari *O. lyallii* and Southern Rata *Metrosideros umbellata* (Bell 1978). Habitats of translocated populations on other islands include: on Motuara I., regenerating coastal scrub dominated by Five-Finger, Mahoe, Kanuka, Kawakawa *Macropiper excelsum* and Tree Fuchsia *Fuchsia excorticata* (Pierre 1995, 2001; Hooson & Jamieson 2004); on Breaksea I., mixed broadleaf forest dominated by Southern Rata, Kamahi *Weinmannia racemosa*, Mahoe, Teteaweke, Silver Beech *Nothofagus menziesii* and Mountain Beech *N. solandri* (Rasch & McClelland 1993; Taylor & Thomas 1993; Hooson & Jamieson 2004); sw. outliers of Stewart I., mainly in low coastal forest (locally known as muttonbird scrub) dominated by Tupari, Teteaweke and Matipo *Myrsine chathamica*; on Ulva I., mostly in coastal scrub and secondary growth dominated by Turpentine Scrub *Dracophyllum longifolium*, Muttonbird Scrub *Senecio reinoldii*, Leatherwood *Olearia colensoi*, Southern Rata, Kamahi and ferns; and avoiding mature open Podocarp–Rata–Kamahi forest of interior (Steffens 2003; Hooson & Jamieson 2004).

**DISTRIBUTION AND POPULATION** Based on contribution by T.G. Lovegrove. Endemic to NZ, mainly on offshore islands (NZCL); formerly widespread in NI and SI and offshore islands. Many translocations to offshore islands and recently, to two protected mainland sites with pest-proof fences or intensive control of introduced mammalian predators.

**NI** Between c. 1890 and 1964, before translocations, confined solely to Hen (Taranga) I. (500 ha), in Hen and Chickens Grp, Hauraki Gulf (Oliver), where Kiore *Rattus exulans* only introduced mammal. Subsequently translocated to 12 offshore islands, one lake island and two mainland sites, from Motukawanui I. in N to Kapiti I. and Wellington in S, mainly in Hauraki Gulf and Bay of Plenty; several translocations unsuccessful (see Introductions below). Independently colonized Coppermine I., in Hen and Chickens Grp, by 1979, having been previously recorded there in 1967 (Newman 1980). Currently occur Hen, Lady Alice, Whatupuke and Coppermine Is in Hen and Chickens Grp, Little Barrier I., Tiritiri Matangi I., Cuvier I., Red Mercury I., Stanley I., Whale I., Mokoia I. in L. Rotorua, and Kapiti I.; and on mainland, at Karori Wildlife Sanctuary and, possibly, Boundary Stream (Merton 1973, 1975; Williams 1976; Mills & Williams 1979; Lovegrove 1996a; Brunton 2000; Heather & Robertson 2000; Hooson & Jamieson 2003a; also see Table 1). **SI** By c. 1905, and till translocations in 1964, confined to three islands off s. Stewart I.: Big South Cape I. (936 ha), Pukeweka I. (2 ha) and Solomon I. (25 ha), which were free of all introduced



mammals (Guthrie-Smith 1925; Merton 1969, 1973, 1975; Williams 1976; Mills & Williams 1979; Roberts 1994; Heather & Robertson 2000; Hooson & Jamieson 2003a; Oliver). Subsequently translocated to 20 islands, mostly round Stewart I., four in Marlborough Sounds, four in Fiordland and one in L. Te Anau (see Introductions below). Independently colonized Tamaitemioka I. from adjacent Pohowaitai I. by crossing 20 m gap in 2001–02 (Hooson & Jamieson 2003a). Currently occur on: Motuara I. and Inner Chetwode I. in Marlborough Sounds; many islets round Stewart I.: North, Womans, Motunui, Jacky Lee, Ulva, Kundy, Betsy, Big (Stage), Kaimohu, Putauhinu, Pohowaitai and Tamaitemioka Is; Breaksea, Anchor and South Passage Is. in Fiordland; and Erin I. in L. Te Anau (Lovegrove 1996a; Heather & Robertson 2000; Pierre 2000; Hooson & Jamieson 2003a; Willans 2003; Edge 2004; also see Table 2).

**Breeding** Throughout range.

**Introductions** Many translocations since 1925 in NI, and since 1964 in SI, to offshore islands and to protected mainland sites in NI with pest-proof fences or intensive control of introduced predatory mammals (see Tables 1, 2). Saddleback is species on which former New Zealand Wildlife Service (now NZ Dept of Conservation) perfected technique of island translocations of endangered wild forest birds (Merton 1965b, 1973, 1975; Nillson 1978; Lovegrove & Veitch 1994).

**Change in range, populations** Formerly widespread throughout much of mainland NZ and on many offshore islands (Williams 1962, 1976; Merton 1965a, 1973, 1975; Mills & Williams 1979; Oliver; NZCL). One of the commonest passerine fossils in deposits formerly under forest (Worthy & Holdaway 2002) and so probably occurred throughout, including E of, both main islands before Polynesian occupation, but forests were burnt soon after their arrival (McGlone 1989; Worthy & Holdaway 2002; also see Masthead). Occurred throughout much of NI, though at time of early European settlement apparently rare or already absent N of Lower Waikato, from parts of Bay of Plenty, East Coast and Hawkes Bay (Buller 1888; Turbott 1967; Oliver). Also widespread in n., w. and s. SI, though in European times generally absent from e., except on Banks Pen. (Potts 1882; Buller 1888; Oliver). From c. 1770 to early 1800s, when first Brown Rats *Rattus norvegicus* and Cats introduced (Atkinson 1973; King 1990; see Threats), populations probably declined gradually; by 1880s, coinciding with spread of Black Rats and later, mustelids *Mustela* (Atkinson 1973; King 1984, 1990), populations were in rapid decline with range contracting, and had become extinct on mainland by early 1900s (Turbott 1967; Williams 1976; Lovegrove 1996b; Pierre 2000; Worthy & Holdaway 2002; Oliver). In early 1870s, still abundant round Wellington, including Tararua and Ruahine Ras (Buller 1888;

**Table 1.** Translocations of NI subspecies *rufusater* to islands and mainland sites (largely summarized from Lovegrove [1996a] and Hooson & Jamieson [2003a]). Outcomes: S = successful, U = unsuccessful (with year of last record, or not recorded after, given in parentheses). Number introduced = number of birds unless stated.

Site of introduction	Year	Outcome	Source of birds	Number Introduced	Reference
Little Barrier I.	1925	U <sup>A</sup>	Hen I.	12 birds <sup>1</sup> or 4 pairs <sup>3</sup>	1,2,3,4
	1984	S	Cuvier I.	50	5,6
	1986	S	Chickens Is	42	5
	1987	S	Cuvier I.	47	5
	1988	S	Cuvier I.	49	5
Kapiti I.	1925	U <sup>A</sup>	Hen I.	9	2,3,4,7
	1981	U(1985) <sup>B</sup>	Hen I.	25	5,8
	1981	U(1985) <sup>B</sup>	Cuvier I.	50	5
	1981	U(1985) <sup>B</sup>	Chickens Is	25	5
	1982	U(1985) <sup>B</sup>	Hen I.	22	5
	1982	U(1985) <sup>B</sup>	Cuvier I.	50	5
	1982	U(1985) <sup>B</sup>	Chickens Is	22	5
	1983	U(1985) <sup>B</sup>	Cuvier I.	50	5
	1987	S	Stanley I.	43	5
	1988	S	Stanley I.	39	5
	1989	S	Stanley I.	40	5
Lady Alice (Big Chicken) I.	1950	U(?)	Hen I.	3 pairs	3,4,9
Whatupuke (Middle Chicken) I.	1971	S	Whatupuke I.	21	4
Red Mercury I.	1964	S	Hen I.	23	10,11
Cuvier I.	1966	S	Hen I.	29	4,12
Fanal I	1968	S	Hen I.	29	4,13
Stanley I.	1968	U(?)	Hen I.	25	4,5,13
	1985	U(?)	Cuvier I.	29	5,6,14
Motukawanui I.	1977	S	Cuvier I.	24	5,6
Tiritiri Matangi I.	1983	U(1986)	Hen I.	16	5
	1984	U(1986)	Hen I.	12	5,14
Mokoia I., L. Rotorua	1984	S	Cuvier I.	24	5,14,15
Moturoa I.	1992	S	Tiritiri Matangi I.	36	5
Whale (Motuhora) I.	1997	U(1999)	Tiritiri Matangi I.	26	16
Karori Wildlife Sanctuary	1999	S	Cuvier I.	40	16,17
Boundary Stream	2003	S	Tiritiri Matangi I.	39	16
	2004	∓ <sup>C</sup>	Cuvier I.	38	18

<sup>A</sup> Disappeared quickly on Little Barrier (Turbott 1947, 1961); not recorded Kapiti after 1931 (Wilkinson & Wilkinson 1952; Merton 1973) or 1932 (Stidolph 1948).

<sup>B</sup> Most gone by 1985 (Lovegrove 1996a).

<sup>C</sup> Outcome uncertain as at Feb. 2005 (W. Sullivan).

REFERENCES: <sup>1</sup> Turbott 1947; <sup>2</sup> Wilkinson & Wilkinson 1952; <sup>3</sup> Merton 1965a; <sup>4</sup> Merton 1973; <sup>5</sup> Lovegrove 1996a; <sup>6</sup> CSN 32; <sup>7</sup> Stidolph 1948; <sup>8</sup> Veitch 1985; <sup>9</sup> Chambers *et al.* 1955; <sup>10</sup> Merton 1965b; <sup>11</sup> Merton 1969; <sup>12</sup> Blackburn 1970b; <sup>13</sup> Blackburn 1968; <sup>14</sup> CSN 33; <sup>15</sup> Craig 1990; <sup>16</sup> Hooson & Jamieson 2003a; <sup>17</sup> Brunton 2000; <sup>18</sup> Sullivan 2004.

Turbott 1967). NI Probably extinct on mainland by c. 1890, surviving only on Hen I. (Williams 1976; Oliver). Later reports from mainland doubtful and unconfirmed: at Kopuapounamu R., in n. Raukumara Ra., Feb. 1935 (CSN 1939–40), and Urewera Country, possibly in c. 1950s (Williams 1962). Common on Great Barrier I. in 1868 (Hutton 1869a) and recorded in 1882 (Oliver) but later disappeared (Bell & Brathwaite 1964). On Little Barrier I., very common in 1867 (Hutton 1869b) but Cats introduced in c. 1870; rare in 1880 and rarer still in 1882 (Reischek 1887), and absent thereafter till failed reintroduction in 1925 (Turbott 1947, 1961; Merton 1965a), and successful reintroductions in 1980s, after Cats eradicated in 1980 (Veitch 1980, 1983, 1985; Miskelly 1988; see Introductions, above). On Cuvier I., recorded in 1878 (Oliver) but wiped out by Cats some time between 1889 and 1900 (Merton 1970; Veitch 1985; Lovegrove 1996a); after reintroduction in 1968 (see Introductions) abundant by mid-1970s (Jenkins 1976, 1978; Reed 1976). Formerly common on Kapiti I., but certainly gone from there some time in 19th century (Wilkinson & Wilkinson 1952; Merton 1965a; Lovegrove 1996b). Became

one of the most abundant and widespread birds on Middle Chicken I. within 6 years of introduction in 1964 (Merton 1969), a pattern repeated on many other islands following translocations after mid-1960s (Merton 1973, 1975; Lovegrove 1996a; Hooson & Jamieson 2003a). SI Probably extinct on mainland by c. 1905 (Williams 1976), surviving only on three islands off Stewart I. (Guthrie-Smith 1925; Oliver). Occurred on Stephens and D'Urville Is (Oliver) and particularly abundant on Stephens in early 1890s, but along with Piopio *Turnagra capensis*, extinct there within 5 years of lighthouse being built (Medway 2004). Common on Banks Pen. at least till 1859, but disappeared quickly as area deforested and introduced predators invaded (Potts 1873, 1882; Dawson & Cresswell 1949; Turbott 1967); recorded round Reefton and W. Paparoa Ra. till 1880s (Phillipps 1948; Onley 1980). Unconfirmed claims that persisted in Nelson till mid- to late 1910s (Williams 1960). Apparently rare on Stewart I. by early 1800s, though common on some offshore islets (Williams 1976). Common on Big South Cape, Pukeweka and Solomon Is, with population of several hundred, in 1961. However, after accidental introduction, and subsequent plague, of Black

**Table 2.** Translocations of SI nominate *carunculatus* to islands (largely summarized from Lovegrove [1996a] & Hooson & Jamieson [2003a]). Outcomes: S = successful, U = unsuccessful (with year of last record, or not recorded after, given in parentheses). Number introduced = number of birds unless stated.

Site of introduction	Year	Outcome	Source of birds	Number Introduced	Reference
Kaimohu I.	1964	S	Big South Cape I.	15	1,2,3
Big (Stage) I.	1964	S	Big South Cape I.	21	1,2,3
Inner Chetwode I.	1965	U(1973) <sup>A</sup>	Big South Cape I.	30	2
	1970	U(1973) <sup>A</sup>	Big I.	17	2,3
Betsy I.	1969	S	Big I.	16	2,3
Womans I.	1972	S	Big, Kaimohu & Betsy Is	20	2,3
North I.	1972	S	Big, Kaimohu & Betsy Is	19	2,3
Putauhinu I.	1974	S <sup>B</sup>	Big I.	23	3
	1976	S <sup>B</sup>	Big I.	23	3
	1984	S <sup>B</sup>	Kundy I.	41	4,5,11
	1978	S	Big & Kaimohu Is	26 <sup>3</sup> or 38 <sup>4</sup>	3,4,5
Kundy I.	1980	U(1983)	Big & Kaimohu Is	34	4,5,6,7
Maud I.	1982	U(1983)	Big & Kaimohu Is	38	4,5,6,7
Motunui I.	1981	S	Big & Kaimohu Is	20	4,5
Jacky Lee I.	1986	S	Big & Kundy Is	46	4,5
Breaksea I.	1992	S	Kundy & Big Is	59	4,5,7
Motuara I.	1994	S	Jacky Lee & North Is	26	4,5,8,9,10
Allports I.	1999	U(2001)	Motuara I.	8 <sup>D</sup>	11
Pohowaitai I.	1999	S	Kundy I.	30	11
Ulva I.	2000	S	Big I.	30	11
S. Passage I.	2001	S	Breaksea I.	35	11
Bauza I.	2003	U <sup>C</sup>	Breaksea I.	28	12
Anchor I.	2002	S	Breaksea I.	31	13,14
	2004	S	Breaksea I.	24	13,14,15
	2003	U(2004) <sup>D</sup>	Breaksea I.	18	13,14,15
Erin I., L. Te Anau	2004	? <sup>D</sup>	Breaksea I.	20	13,14,15

<sup>A</sup> Unsuccessful; gone by 1973 (Merton 1973, 1975; Nillson 1978; Rasch & McClelland 1993; Lovegrove 1996a).

<sup>B</sup> Population gradually declined between 1974 and 1997. Kiore eradicated 1997 and population recovered quickly (Hooson & Jamieson 2003a).

<sup>C</sup> Probably unsuccessful: Stoats cleared before release but detected again in 2004 (H. Edmonds).

<sup>D</sup> Stoats cleared before first release, outcome uncertain, June 2005 (S. Taylor).

**REFERENCES:** <sup>1</sup> Blackburn 1965; <sup>2</sup> Merton 1973; <sup>3</sup> Nillson 1978; <sup>4</sup> Roberts 1994; <sup>5</sup> Lovegrove 1996a; <sup>6</sup> Bell 1983; <sup>7</sup> Rasch & McClelland 1993; Pierre <sup>8</sup> 1999, <sup>9</sup> 2000, <sup>10</sup> 2001; <sup>11</sup> Hooson & Jamieson 2003a; <sup>12</sup> Willans 2003; <sup>13</sup> Edge 2004; <sup>14</sup> D.P. Armstrong; <sup>15</sup> S. Taylor.

Rats, population had declined to <70 birds by 1965; and probably wiped out by 1970, though a few birds said to have possibly survived till 1973 (Blackburn 1965; Merton 1965a, 1973, 1975; Bell 1978; Nillson 1978).

**Status** Near Threatened (Stattersfield & Capper 2000); rare (Pierre 2000). Hooson & Jamieson (2003a) recommended downgrading status of subspecies *rufusater* to Least Concern (IUCN 2001); and listing nominate *carunculatus* as Near Threatened (IUCN 2001); see following population estimates.

**Populations NI** In 2002, total population estimated at 6630 birds, with present capacity to increase to >19,000 (Hooson & Jamieson 2003a). In 1973, total population estimated at c. 1000 birds (Merton 1973); and by early 1990s, estimated at 4800 birds (Lovegrove 1996a). Most recent estimates of populations are: Cuvier I., c. 1000 in 1998 (Lovegrove 1996a; for earlier estimates see CSN 26, 28); Stanley I. c. 250 in 1990s (Lovegrove 1996a); Hen I., c. 490 in June 1983 to June 1986 (Lovegrove 1986; also see Skegg 1964; Blackburn 1968); estimate of Hooson & Jamieson (2003a) derived from Lovegrove (1986); Kapiti I., 97 in 2000 (Hooson & Jamieson 2003a); Little Barrier I., 2500 in 2000 (Hooson & Jamieson 2003a); Mokoia I., c. 220 in 1996 (Armstrong *et al.* 2005), and 200 in 1999 (Hooson & Jamieson 2003a; also see Lovegrove 1996a); Red Mercury I., c. 400 in 1996 (Lovegrove 1996a); Tiritiri Matangi I., 600 in 2002 (Hooson & Jamieson 2003a), and 800 in 2004 (Brunton 2005; also see Cassey 1997; Parker 2003); Whatupuke I., c. 500 in 1996 (Lovegrove 1996a); Karori Wildlife Sanctuary, 40–50 in early 2005 (R.A. Empson). **SI** In 2002, total population estimated 1265 birds, with present

capacity to increase to 2500 (Hooson & Jamieson 2003a). In 1973, total population estimated at c. 150 (Merton 1973); in 1975, c. 200 (Merton 1975); in 1978, 180 (Nillson 1978); in 1990, 300–500 (Rasch & McClelland 1993); by late 1990s, c. 650 (Pierre 1999, 2001). Most recent estimates of population for some islands are: Breaksea I., 400 in 2001 (Hooson & Jamieson 2003a; also see Rasch & McClelland 1993); Jacky Lee I., c. 65 in 1991 (Roberts 1994; Lovegrove 1996a); Kaimohu I., 30 in 1997 (Roberts 1994; Hooson & Jamieson 2003a); Kundy I., 200 in 1999 (Hooson & Jamieson 2003a; also see Roberts 1994); Motuara I., 130 in 2001 (Roberts 1994; Lovegrove 1996a; Hooson & Jamieson 2003a); Motunui I., c. 60 in 1991 (Roberts 1994; Lovegrove 1996a); North I., 60 in 1995; Putauhinu I., 300 in 2001; Womens I., 30 in 1994 (Hooson & Jamieson 2003a; also Roberts 1994; Lovegrove 1996a). **DENSITIES:** On Tiritiri Matangi I., mean 4.06 birds/ha, Jan. 2003 (Parker 2003) and 13.0 and 9.3 birds/ha in two areas (Cassey 1997).

**THREATS AND HUMAN INTERACTIONS** Based on contribution by T.G. Lovegrove. Extinction from mainland caused mainly by spread of alien mammals: Brown Rats after c. 1770 (Atkinson 1973, 1985; Lovegrove 1996b), Cats in early 1800s (King 1984, 1990), Black Rats after c. 1860 in NI and after c. 1890 in SI (Atkinson 1973), and Stoat *Mustela erminea*, Ferret *M. furo* and Weasel *M. nivalis* from 1880s (King 1984, 1990), though Saddlebacks already rare in NI before spread of mustelids (Atkinson & Campbell 1966; King 1984, 1990). Clearance of forest also a contributing factor, but

Saddlebacks gone from many districts even before habitats altered by settlement (Williams 1976; Oliver). Introduced mammalian predators caused extinction on many islands (Wilkinson & Wilkinson 1952; Merton 1965a, 1973, 1975; Turbott 1967; Atkinson 1973, 1985; Bell 1978; Mills & Williams 1979; Craig 1990; Lovegrove 1996a,b; Hooson & Jamieson 2003a; Medway 2004; Oliver), e.g. Little Barrier, Cuvier and Stephens Is (Feral Cats), Big South Cape, Pukeweka and Solomon Is (Black Rats), and Maud, Motukawanui, and Moturoa Is and, probably recently, Bauza I. (H. Edmonds) (Stoats). On Kapiti I., Brown Rats depredated many nests, incubating and brooding females and adults and young at roosting holes (Lovegrove 1996b), and Common Brushtail Possums *Trichosurus vulpecula* may have eaten eggs in at least one nest (Lovegrove 1982, 1996b; Brown *et al.* 1993). Also taken by Weka *Gallirallus australis* on Kapiti I. (where recently fledged young were killed) (Lovegrove 1982, 1996b) and Chetwode I. (Merton 1973; Lovegrove 1996a). Chicks also possibly killed by Common Mynas *Acridotheres tristis*, which built nests on top of active Saddleback nests in nest-boxes on Tiritiri Matangi (CSN 37). Between 1880 and 1900, when populations on mainland appeared to decline rapidly, there was considerable trade in skins of Saddlebacks with European museums (Oliver). Captive-breeding programs were established at Mt Bruce and Invercargill (Merton 1969, 1973, 1975; Roderick 1973, 1974; Williams 1976), but captive populations very small and mainly for research and display.

Readily use artificial nest- and roost-sites, such as derelict buildings on Cuvier I. (Lovegrove 1992) and muttonbirders' huts on the Big South Cape Is (Guthrie-Smith 1925). Nesting and roosting boxes used in final attempt to re-establish Saddlebacks on Kapiti I., after research showed high mortality of birds roosting below 1 m and of females in low nests, as a result of predation by Brown Rats (Lovegrove 1996b), and successful testing of boxes on Tiritiri Matangi and Stanley Is between 1984 and 1987 (Lovegrove 1992, 2004). Adults show fledged young where to roost and so use of roosting box can spread through a population through cultural transmission (Lovegrove 1992, 1996b, 2004). Nest-boxes were of conventional design, c. 30 cm deep  $\times$  20 cm  $\times$  20 cm, with large V-shaped top entrance-hole 14 cm deep  $\times$  14 cm wide. Roosting boxes were 30 cm  $\times$  20 cm  $\times$  20 cm and modelled on natural roosts and roosting holes in old buildings, which usually have large bottom entrance hole and dry sheltered perch above. Roost-boxes were attached to smooth, vertical tree-trunks, c. 1.5 m above ground, beyond easy reach of mainly terrestrial Brown Rats (Lovegrove 1992). Between 1987 and 1989, three translocations of 122 birds (including 58 that used roost-boxes and 64 that used natural roosts) from Stanley I. to Kapiti I. Birds released into habitat already furnished with roost- and nest-boxes (in ratio of four roost-boxes: one nest-box, with a minimum of c. 20 boxes per territory). Birds using roost- and nest-boxes had significantly higher survival than those using natural sites and, although population modelling showed that safe roost- and nest-sites in boxes were insufficient to prevent a slow decline in the population over a 50–70-year period (Lovegrove 1992), this enhanced survival in presence of Brown Rats sufficient to allow the small Kapiti I. population to survive till Rats finally eradicated in 1996 (Lovegrove 2004). Since Saddlebacks prefer to roost and nest in cavities, roost- and nest-boxes can also be used to enhance otherwise unsuitable scrub forest habitats that lack natural tree-holes (Lovegrove 1992). On Tiritiri Matangi, recorded using purpose built nest-boxes (Stamp *et al.* 2002) as well as nest-boxes provided for New Zealand Robins *Petroica australis* (Armstrong *et al.* 2000).

Known to be susceptible to poisoning from anticoagulant rodenticides. On Mokoia I., an aerial poison drop of cereal pellets containing Brodifacoum in 1996 killed some birds

(45% mortality over 6 weeks), and set back the expansion of the population by 1–2 years (Davidson & Armstrong 2002; Armstrong *et al.* 2005). On Stanley I. two of 43 colour-banded Saddlebacks (5% mortality over one month) disappeared during a similar poison drop in 1991 (Towns *et al.* 1993).

**MOVEMENTS** Based on contribution by T.G. Lovegrove. Sedentary (Jenkins 1978; Lovegrove 1980, 1996b; O'Callaghan 1980) with breeding pairs maintaining territories throughout year and from year to year, in which they breed and in which most foraging and, usually, roosting occurs. However, territories not always exclusive, with birds crossing into neighbouring territories to forage or drink before returning to own territories, though such movements usually only a few hundred metres (O'Callaghan 1980; Lovegrove & O'Callaghan 1982; Pierre 1999; see Social Organization: Territories).

Translocated birds entering vacant habitat may at first be more mobile than is typical (Pierre 1999; see below) and occupy larger territories (see Social Organization: Territories). On Kapiti I. (1965 ha), translocated birds established territories up to 3 km N and 5 km S of release point at Rangitira within 8 weeks of release. One locally bred juvenile on Kapiti I. dispersed up to 3 km, though eight of nine young of known origin settled within 1 km of core-area of natal territories (Lovegrove 1992). After release on Mokoia I., birds dispersed over most of 135 ha of island after 7 weeks (Armstrong & Craig 1995); and on Whale I., dispersed over 173 ha within 4 months of release (Brunton 2000). After release on Motuara I. (59 ha), dispersed widely through forest and established territories after 8–10 months (Pierre 1999, 2001). On Motuara I., territory-holders did not exhibit predictable patterns of movement within territories (Pierre 1999). Newly translocated adults and young form loose flocks near their release point and this temporary 'flocking behaviour' is possibly conducive to successful release in translocations (Lovegrove 1996a).

Some movements may be influenced by availability of water: on Cuvier I., seen travelling hundreds of metres outside territories to visit waterholes in dry years (Pierre 2001); and on Motuara I., occasionally leave territories to use water sources in other territories (Pierre 1999). While considered weak fliers (Merton 1975; Jenkins 1978) managed to cross 150 m of water from Whatupuke I. to Coppermine I., and a bird once reported on Middle Stack, 250 m offshore from Lady Alice I. and Whatupuke I. (Newman 1980). Saturation by translocated birds of existing habitat on Whatupuke I. may have precipitated movement to secure new breeding territory (Newman 1980). While generally avoid crossing open gaps in forest, preferring to move through vegetated corridors (T.G. Lovegrove), on Mokoia I., seen crossing grassy clearings 70–100 m wide (I. Castro).

**Banding** In a number of study populations, many birds have been colour-banded (e.g. Cuvier, Stanley, Tiritiri Matangi, Mokoia, Kapiti, Motuara and Ulva Is). Founding birds in translocated populations usually also banded. **LONGEVITY:** Established territorial birds often very long-lived. Oldest known bird, a female, reached 21 years and a bonded male and female reached 18 and 17 on Tiritiri Matangi I. (B. Walter). On Cuvier I. three females reached 20, 19 and 18, while two males reached 17 (T.G. Lovegrove).

**FOOD** Based on contribution by T.G. Lovegrove. Mainly insects and berries, also other invertebrates and nectar and occasionally buds. **Behaviour** Forage at all levels in forests: on soil, in leaf-litter and decaying timber on ground; and among branches and live and dead foliage of trees and shrubs from near ground to canopy (Atkinson 1964, 1966; Blackburn 1964, 1967; Atkinson & Campbell 1966; Merton 1966a,b; Lovegrove 1980; O'Callaghan 1980; Lovegrove & O'Callaghan 1982; Jamieson & Spencer 1996; Moorhouse 1996; Stamp

1999; Pierre 2000, 2001; Oliver). **DETAILED STUDIES:** On Hen I. (Atkinson & Campbell 1966), including Aug. 1963 (Atkinson 1964), Jan. 1964 (Merton 1966a), May 1965 (Atkinson 1966), and Nov. 1965 (Blackburn 1967); on Cuvier I., Aug. 1978–Dec. 1979 (Lovegrove 1980; O'Callaghan 1980; Lovegrove & O'Callaghan 1982); on Kapiti I., Nov. 1981–Feb. 1982 (Lovegrove 1982), and Mar. 1982–May 1982 (Ruarus 1982); on Motuara I., Nov. 1994–Jan. 1995 (Pierre 1995, 2000, 2001); and on Tiritiri Matangi I., July 1997–Dec. 1998 (Stamp 1999). **FORAGING ASSOCIATIONS:** Usually forage singly or in pairs, very occasionally in larger groups (Wilkinson 1927; Sibson 1949; Heather 1957; Lovegrove 1980; O'Callaghan 1980; see Social Organization), in late summer, independent young may temporarily form loose feeding flocks, of five or so, up to ten birds (T.G. Lovegrove). On Mokoia I., groups of up to eight birds, probably young non-territorial birds, seen foraging in territories of other birds (I. Castro; also see Agonistic behaviour). On Cuvier I., did not congregate into feeding flocks in winter (O'Callaghan 1980). However, in late summer, one loose congregation of possibly c. 100 birds spread over a wide area (T.G. Lovegrove). Often observed foraging with Grey Fantails, which feed on insects disturbed by foraging Saddlebacks (Wilson 1959; Blackburn 1964, 1967; Merton 1966a; Reed 1976; O'Callaghan 1980; McLean 1989; Heather & Robertson 2000; CSN 28). Among foliage, Fantails hover above Saddlebacks to catch escaping insects (Blackburn 1964); when Saddlebacks foraging on bark, Fantails usually perch 30–60 cm below Saddleback to catch falling invertebrates (Blackburn 1964; McLean 1984). On Cuvier I., position of Fantails in relation to Saddlebacks when foraging in association (n=203 obs.): 46.3% directly below, 37.4% behind and below, 10.8% directly behind, 4.4% above and behind, and 1.0% directly above. Distance between Saddlebacks and Fantails when foraging in association (n=203 obs.): 20–220 cm, mostly (c. 70% of obs.) 30–80 cm (McLean 1984). Saddlebacks and Fantails rarely seen foraging together on ground. Association usually occurs outside breeding seasons of both species: on Cuvier I., of 123 observations of foraging Fantails during Nov.–Dec. (breeding season), 8% with Saddlebacks; of 202 observations May–Aug. (non-breeding), 32% with Saddlebacks. Saddlebacks may also benefit from association with Fantails; Saddlebacks probably taken by New Zealand Falcons *Falco novaeseelandiae*, historically and currently, and Fantails may alert Saddlebacks to presence of Falcons (McLean 1984). Also forage in association with Whiteheads, to collect insects disturbed by one or other species; in 1800s, said that pairs would accompany or follow large flocks of Yellowheads or Whiteheads (Smith 1889, 1910); also said Whiteheads follow Saddlebacks (Heather & Robertson 2000; Oliver; D.P. Armstrong; see Social Behaviour). See Social Organization and Behaviour for details of territories and territorial behaviour. **FORAGING HEIGHTS:** Forage from ground to canopy in a wide range of trees and forest-types up to 25 m above ground (Atkinson 1964, 1966; Blackburn 1965, 1967; Atkinson & Campbell 1966; Lovegrove 1980; O'Callaghan 1980; Craig 1994; Pierre 1995, 2000, 2001; D. Anthony; see Habitat). For summary of foraging heights on three islands, see Table 3. **FORAGING SITES:** Use wide variety of sites. Often forage on ground and just below surface, from foliage, on rotted logs, among leaf-litter, and on humus and soil. Also forage much in vegetation: on live and dead foliage in shrub layer, subcanopy, canopy and epiphytes, including crowns of cabbage tree *Cordyline*, tree-ferns and Nikau *Rhopalostylis sapida*, and dead fronds and frond-bases of Nikau and tree-ferns; from on and under bark of live and dead trunks, branches and twigs of plants, from branch axils, and from fissures and holes in trees and shrubs; and on flowers, fruit and vine stems. Occasionally forage aerially (Atkinson 1964, 1966; Blackburn 1965, 1967; Atkinson & Campbell 1966; Merton 1966a,b;

**Table 3.** Foraging heights on Cuvier I. (three pairs, Feb.–Mar., May, Aug. and Nov. 1979) (Lovegrove 1980, 1985b, 1992), Little Barrier I. (Nov. 1984–Mar. 1985) and Kapiti I. (Nov. 1984–Mar. 1985) (Lovegrove 1985b). N = number of 1-min feeding observations; figures are percentages of total observations.

	Cuvier I.	Little Barrier I.	Kapiti I.
Ground	34.7	33.4	39.1
1–2 m	17.1	15.6	13.0
3–4 m	19.8	15.2	16.6
5–6 m	15.5	12.8	17.7
7–8 m	5.1	8.0	6.5
>9 m	7.8	15.0	7.1
N	11,104	461	770

Jenkins 1976, 1978; Reed 1976; Lovegrove 1980, 1982, 1985b, 1992; O'Callaghan 1980; Lovegrove & O'Callaghan 1982; Ruarus 1982; Heather & Robertson 2000; Pierre 2000, 2001; D. Anthony; I. Castro). Also use artificial feeders (I. Castro). On Hen I., ground foraging, often among leaf-litter, a major component of behaviour, accounts for 15–22% of foraging observations, and 31–47% of total foraging time (Atkinson 1964, 1966; Merton 1966a; Blackburn 1967). On Hen I. (563 obs. of foraging, Jan. 1964, May 1965 and Aug 1963): 29% on branches, limbs and twigs; 22% foliage; 18% on ground; 9% on dead branches, limbs, fissures and holes; 7% on trunks; 6% fruit; 5% dead foliage; 2% flowers; 1% buds; and <1% aerial feeding (Atkinson & Campbell 1966). On Hen I., did not appear to forage in particular sites at different times of day (Atkinson 1966). On Cuvier I. (11,104 × 1-min obs. of foraging, of three pairs, Feb.–Mar., May, Aug. and Nov. 1979): 24.6% of observations on branches, limbs, dead branches, trunks and holes; 20.6% on foliage; 43.1% on ground; and 11.7% fruit (Lovegrove 1980, 1985b). On Little Barrier I. (461 × 1-min obs. of foraging, of various birds, Nov. 1984–Mar. 1985): 6.3% observations on branches, limbs and twigs; 11.9% from foliage; 33.0% on ground; 12.8% on dead branches, limbs, fissures and holes; 2.0% from trunks; 16.9% fruit; 15.8% from dead foliage; and 1.3% flowers (Lovegrove 1985b). On Kapiti I. (770 × 1-min obs. foraging, of various birds, Nov. 1984–Mar. 1985): 9.1% on branches, limbs and twigs; 12.1% from foliage; 39.1% on ground; 20.4% on dead branches, limbs, fissures and holes; 12.1% fruit; and 7.2% on dead foliage; not observed foraging on trunks or flowers (Lovegrove 1985b). On Motuara I., foraged more on wood than foliage, and preferred to forage on live plant material (Pierre 1999, 2000, 2001). On Cuvier I., independent juveniles fed mainly on and near ground, possibly to reduce agonistic encounters with territorial adults (Jenkins 1976); of 429 observations of foraging by adults and 122 by juveniles (heights estimated to nearest metre): 29.1% of adult observations and 55.7% of

## Plate 29

(D. Onley)

Kokako *Callaeas cinerea* (page 965)

NOMINATE CINEREA: 1 Adult

SUBSPECIES WILSONI: 2 Adult; 3 Immature; 4 Adult

Saddleback *Philesturnus carunculatus* (page 986)

NOMINATE CARUNCULATUS: 5 Adult; 6 Juvenile

SUBSPECIES RUFUSATER: 7 Adult; 8 Immature

Piopio *Turnagra capensis* (page 958)

NOMINATE CAPENSIS: 9 Immature

SUBSPECIES TANAGRA: 10 Adult

juvenile observations on ground; 6.8% and 11.5% at 1 m; 14.5% and 13.9% at 2 m; 10.5% and 6.6% at 3 m; 13.8% and 5.7% at 4 m; 7.7% and 0.8% at 5 m; 6.3% and 2.5% at 6 m; 8.2% and 3.3% at 7–8 m; and 3.3% and 0% at 10–15 m (O'Callaghan 1980). Also on Cuvier I., of 468 observations of adults feeding alone (without Grey Fantails), 34.5% were of ground-foraging; of 216 observations of foraging by juveniles, 78% on ground (McLean 1984). **FORAGING METHODS:** Use great variety of methods for search and attack. Actively search substrates for invertebrate prey, moving noisily among dead foliage, stripping bark and hammering woodpecker-like at rotted wood (Jenkins 1976; I. Castro; see below). Often call (see Sequestration Singing in Voice) when foraging (Blackburn 1964; D.P. Armstrong), though on Mokoia I., foraging can be largely silent, with calls made at intervals of c. 30 min (I. Castro). **SEARCH:** Forage methodically through forest. When foraging in trees, make short, noisy flights between branches (Jenkins 1976). On Cuvier I., after feeding for some time in a certain area, birds fly-glide or hop rapidly up to 50 m or more to another part of territory to begin foraging again (O'Callaghan 1980). Forage with bill open or closed; upper mandible may be used alone as a skewer; also used for zirkelning (forcibly opening bill) (Atkinson 1964; Blackburn 1964; Lovegrove 1980; Heather & Robertson 2000; Pierre 2000; see below). Search for invertebrates beneath bark, and strip bark (Heather 1957; Atkinson 1964, 1966; Blackburn 1964; Merton 1965b; Jenkins 1976; Reed 1976; Lovegrove 1980; McLean 1984; Rasch & McClelland 1993; Moorhouse 1996; Stamp 1999; Pierre 2000; D. Anthony), removing bark by grasping it with bill and using weight to pull it off, by inserting closed bill behind bark and forcing bill open (Atkinson 1966; Heather & Robertson 2000; Pierre 2000), or by scraping vertically with open bill (Pierre 2000). Probe dead timber in trees and on ground (I. Castro); decayed branches broken apart by inserting bill into a crack and then opening it (Blackburn 1964; Turbott 1967; Heather & Robertson 2000); rotten logs and timber may also be smashed open woodpecker-like by striking with closed bill (Reischek 1885; Smith 1889; Atkinson 1964, 1966; Jenkins 1976; Lovegrove 1980; Pierre 2000; D.P. Armstrong). Probe forks, crevices and knot-holes in branches and tree-trunks, and beneath lichen, with bill (Atkinson 1964, 1966; Blackburn 1964; Stamp 1999; Heather & Robertson 2000; Pierre 2000). In foliage examine clusters of leaves with tip of bill or by scraping sideways with single mandible (Blackburn 1964, 1967; Lovegrove 1980; Falla *et al.* 1981; Pierre 2000) and lift and search beneath fronds and leaves, both living or dead, in plants or on ground (I. Castro); bill also used to prise apart leaves of Nikau, which then probed at base (Blackburn 1964). Clutch onto trunks or pendent

leaves of cabbage-tree crowns, and then circle round, searching for invertebrates (Blackburn 1964). On ground, toss leaves like a Common Blackbird *Turdus merula* and turn dead wood with bill, also occasionally scratching (Wilson 1959; Atkinson 1964; Blackburn 1964; Lovegrove 1980; Heather & Robertson 2000; Pierre 2000). Probe soil (Atkinson 1964, 1966; Pierre 2000; I. Castro) and crevices of rocks (Atkinson 1964); also search under rocks, which are lifted with bill (Pierre 2000). Rolled leaves opened (Heather & Robertson 2000; I. Castro) by using bill like a paperknife (Atkinson 1966). Also use foot-trembling on ground in manner similar to that of New Zealand Robin (I. Castro). **ATTACK:** Largely by gleaning. Usually glean scale from leaves with bill held sideways but also glean using tip of bill (Blackburn 1967; Pierre 2000). Glean (pluck) fruits and flower buds from branches (Atkinson 1964; CSN 43; I. Castro), though some fruits (e.g. Karaka, Kawakawa) eaten *in situ* by pecking off pieces of flesh (I. Castro). Insects sometimes taken by hang-gleaning to examine the undersides of leaves (Atkinson 1966); also by flutter-chase from ground while foraging (Atkinson 1964). Peck at spider web (Atkinson 1964). Pursue and lunge at weta *Hemideina*, attempting to puncture abdomen (Merton 1965b); extraction of weta often involves lengthy attacks on dead wood (Jenkins 1976). Probe flowers for nectar, which is sucked out in manner of honeyeater (Reischek 1885; Atkinson 1964, 1966; Blackburn 1964). **HANDLING OF FOOD:** Use feet much during foraging and feeding and very dextrous. Dead leaves from ground and fruit and leaf-clusters picked from trees held with one foot, often against branch, while they are examined or eaten (Wilson 1959; Atkinson 1964, 1966; Blackburn 1964, 1967; Merton 1966a; Lovegrove 1980, Stamp 1999; Pierre 2000; CSN 43; I. Castro). Insects often held in one foot while being dismembered and eaten (I. Castro; see below). When found, large wetas are flicked from holes and let fall to ground. Bird then gives several sharp jabs to subdue prey, before grasping it firmly under one foot and pulling it apart; head, thorax and larger spiny legs often discarded and rest eaten. Weta nymphs extracted from hollow Rangiora *Brachyglottis repanda* and Kawakawa *Macropiper excelsum* stems by poking bill down hollow and forcing apart, then swallowed whole (Wilkinson 1927; Merton 1965b; Lovegrove 1980; Heather & Robertson 2000; Pierre 2000; Oliver). Bird listens for movements at larger hollow stems (diameter 2–3 cm), then punches hole through side of stem where prey is hiding (Lovegrove 1980). Devour moths by standing on their wings and pecking out and eating eyes and abdomen (D. Anthony). Caterpillars swallowed whole, or held in bill and smashed against branch before being eaten (Blackburn 1964). On Hen I., one held case-moth cocoon in its foot and picked a hole in end to get at caterpillar (Atkinson 1964). Earthworms stretched between bill and foot several times before being eaten, and occasionally broken in two (Merton 1965b). **TIMES OF FORAGING:** Spend most of day foraging (Jenkins 1976; I. Castro); on Cuvier I., of 240 h 40 min observation, 93.6% spent foraging for themselves or juveniles or both (minimum of 77.6% of time spent foraging in Mar., and maximum of 98.5% in May–June) (O'Callaghan 1980, which see for further details). **SEASONAL VARIATION:** On Cuvier I., as on Hen I., foraging heights and foods differ seasonally; foraging on ground for invertebrates, in leaf-litter and rotted wood, at peak in winter and declined in summer, when birds spent more time feeding on invertebrates on foliage at higher levels in the forest; foraging for invertebrates on trunks and branches important during late summer, autumn and winter but declined in importance in spring–summer; fruit important in diet from late summer through to early winter (Lovegrove 1980, 1992; see Tables 4, 5). During late summer and autumn on Cuvier I. when fruit an important food, much foraging 2–6 m above ground as many fruit-bearing plants are shrub-layer and subcanopy species; use of shrub-layer

## Plate 30

(K. Franklin)

Singing Bushlark *Mirafra javanica* (page 1021)  
 SUBSPECIES WOODWARDII: 1 Adult; 2 Juvenile; 3 Adult  
 SUBSPECIES HALLI: 4, 5 Adult  
 SUBSPECIES FORRESTI: 6 Adult  
 SUBSPECIES SODERBERGI: 7 Adult  
 SUBSPECIES MELVILLENSIS: 8 Adult  
 SUBSPECIES ATHERTONENSIS: 9 Adult  
 SUBSPECIES RUFESCENS: 10 Adult  
 SUBSPECIES HORSFIELDII: 11 Adult (worn plumage);  
 12 Adult (fresh plumage); 13 Juvenile; 14, 15 Adult  
 SUBSPECIES SECUNDA: 16 Adult

Skylark *Alauda arvensis* (page 1039)  
 17 Adult; 18 Juvenile; 19, 20 Adult



**Table 4.** Seasonal distribution of foraging heights on Cuvier I. (% of foraging obs.; n=11,104 1-min obs. of foraging of three pairs) (Lovegrove 1980, 1992).

Height	Feb.–Mar.	May	Aug.	Nov.
Ground	28.5	33.2	61.9	15.2
1–2 m	20.9	20.7	14.6	12.1
3–4 m	22.2	23.0	11.3	22.7
5–6 m	17.6	15.6	7.1	22.0
7–8 m	5.2	5.2	3.2	6.5
>9 m	5.8	2.3	1.9	21.5
N	4447	3604	2110	943

**Table 5.** Seasonal use of foraging substrate and site on Cuvier I. (% foraging obs.; N for each period as Table 4) (Lovegrove 1980, 1992).

Feeding substrate	Feb.–Mar.	May	Aug.	Nov.
Fruit	21.0	19.6	0.6	5.8
Invertebrates on foliage	12.3	2.6	7.6	59.7
Invertebrates on tree-trunks and branches	28.7	34.8	22.9	12.2
Invertebrates on ground in rotted logs and leaf-litter	38.0	43.0	68.9	22.3

and subcanopy declines in autumn as fruiting ends, corresponding with increase in ground feeding as invertebrates become important (Tables 4, 5). During May–June, in some years may feed almost exclusively on fruit of *Kohekohe* *Dysoxylum spectabile*, resulting in heavy use of layer 6–8 m above ground, though fruit usually carried to ground before being eaten (O’Callaghan 1980). On Cuvier I., small quantities of nectar eaten, mostly in early summer (Lovegrove 1980). On Hen I., most canopy foraging in Nov. and Jan. (cf. Cuvier I.), probably abundance of insects and fruit higher; ground-foraging important throughout year; while searching branches and twigs for pupae is concentrated in colder months (cf. Cuvier I.) and provide major source of food in winter (Atkinson 1966; Merton 1966a; Blackburn 1967). On Little Barrier and Kapiti Is, diet between Nov. and Mar. broadly similar to that on Cuvier I. (Lovegrove 1985b). **SEXUAL DIFFERENCES:** On Cuvier I., members of pairs show vertical and horizontal separation of foraging substrate and site, suggesting niche separation and allowing individuals to maximise resources in territory. Males and females often foraged at different levels; in one pair, male foraged mostly in canopy and subcanopy while female fed mostly on ground, while in two other pairs, males fed mainly on ground while females foraged mostly in subcanopy and canopy. Preference for use of different heights possibly individual rather than sexual, though sample size only three pairs. In some pairs, individuals spent disproportionate amounts of time feeding in certain parts of territory with little horizontal overlap with their partners (Lovegrove 1980; O’Callaghan 1980; Lovegrove & O’Callaghan 1982). On Motuara I., males took more prey from ground (44.4±15.7%) than females (21.0±7.7%); and females took more fruit from Five-Finger, the other preferred food source (56.5±9.3%) than males (30.4±9.2%); as on Cuvier I., difference in usage may prevent intersexual competition (Pierre 2000; Pierre 2001; *contra* Stamp 1999). On Hen I., suggested that males spent more time on ground (Blackburn 1964). **ADAPTATIONS:** Strong, chisel-shaped bill used to loosen bark and chip away rotted wood; also used to prise open insect tunnels in wood by

forcibly opening bill (zirkelning) (Turbott 1967; Fleming 1985; Jamieson & Spencer 1996; Heather & Robertson 2000; Oliver). As with *Huia heteralocha acutirostris*, the skull and associated muscles well developed for gaping bill (Fleming 1985; Jamieson & Spencer 1996; Worthy & Holdaway 2002). Foraging behaviour of Saddlebacks considered similar to that of extinct *Huia*; and similarities in structure of skull indicate they may have occupied similar ecological niches (Atkinson 1964; Blackburn 1964; Worthy & Holdaway 2002). **DRINKING:** In hot weather, often drink (and bathe) at waterholes, and will enter territories of other birds to obtain water (Pierre 2001). Drink raindrops from undersides of *Coprosma* leaves, from among clusters of Five-Finger berries and from a fallen Karaka leaf (Blackburn 1964; Atkinson 1966; Merton 1966a); and sip water from tree-holes, from bases of fallen fronds of *Nikau* and from leaf-bases of large clumps of epiphytic *Collospermum*. These epiphytes can be an important water source during droughts. Drink by lowering bill into water and lifting head to swallow (Atkinson 1966; Merton 1966a).

**Plants** Fruit<sup>8,13,16,17,18,19,20,22,23,26,27,36</sup>, flowers and nectar<sup>1,8,13,16,17,18,19,20,22,26,27,30,36</sup>, flower buds<sup>18</sup>, apical buds<sup>18</sup>. **GYMNOSPERMS:** Podocarpaceae: *Dacrycarpus dacrydioides* fru.<sup>37</sup>. **MONOCOTYLEDONS:** Agavaceae: *Phormium cookianum* nectar<sup>28,29</sup>; *P. tenax* nectar<sup>2,16,18,19</sup>; *Cordylina australis* fru.<sup>37</sup>; Gramineae: *Gahnia setifolia* seeds<sup>18,19</sup>; *G. lacera* seeds<sup>18,19</sup>; Liliaceae: *Collospermum hastatum* fru.<sup>19</sup>; Smilacaceae: *Ripogonum scandens* fru.<sup>9,18,19</sup>. **DICOTYLEDONS:** Araliaceae: *Pseudopanax* fru.<sup>21,26</sup>; *P. arboreum* fl. Buds<sup>18</sup>, fl.<sup>6,7,18,19,26</sup>, fru.<sup>4,7,10,11,15,16,18,19,22,26,28,33</sup>; *P. lessonii* fru.<sup>7,14,16,18,19,22</sup>; *P. crassifolium* fru.<sup>18,19</sup>; *Schefflera digitata* fru.<sup>7,18,19,21,22,24,28</sup>; *Coriariaceae* *Coriaria arborea* fru.<sup>19</sup>; *Cornaceae*: *Griselinia lucida* fru.<sup>18,19</sup>; *Corynocarpaceae*: *Corynocarpus laevigatus* fru.<sup>11,16,18,19,28</sup>; *Epacridaceae*: *Leucopogon fasciculatus* fru.<sup>19</sup>; *Cyathodes juniperina* fru.<sup>18,19</sup>; *Gesneriaceae*: *Rhabdothamnus solandri* nectar<sup>16,18,19</sup>; *Icacinaceae*: *Pennantia corymbosa* fru.<sup>19</sup>; *Loganiaceae*: *Geniostoma rupestre* fru.<sup>11,16,18,19,26</sup>; *Meliaceae*: *Dysoxylum spectabile* nectar<sup>16,18,19</sup>, fru.<sup>16,18,19,20,28</sup>; *Monimiaceae*: *Hedycarya arborea* fru.<sup>18,19</sup>; *Myoporaceae*: *Myoporum laetum* fru.<sup>18,19</sup>; *Myrsinaceae*: *Myrsine salicina* nectar<sup>19</sup>; *Myrsine australis* fl.<sup>6</sup>, fru.<sup>18,19</sup>, apical buds<sup>18,28,32</sup>; *Myrtaceae*: *Metrosideros excelsa* nectar<sup>16,18,19,33</sup>; *M. robusta* nectar<sup>18,19</sup>; *Phytolaccaceae*: *Phytolacca octandra* fru.<sup>7,18,19</sup>; *Oleaceae*: *Nestegis cunninghamii* fru.<sup>18,19</sup>; *N. apetalata* fru.<sup>18,19</sup>; *Onagraceae*: *Fuchsia* nectar<sup>35</sup>; *F. excorticata* nectar<sup>18</sup>; *Piperaceae*: *Macropiper excelsum* catkins<sup>15</sup>, fru.<sup>14,16,18,19,22,28,30</sup>; *Pittosporaceae*: *Pittosporum crassifolium* nectar<sup>19</sup>, fru.<sup>18,19</sup>; *P. eugenioides* fru.<sup>19</sup>; *P. tenuifolium* nectar<sup>19</sup>, fru.<sup>16,18,19</sup>; *P. umbellatum* fru.<sup>34</sup>; *Proteaceae*: *Knightsia excelsa* nectar<sup>16,18,19,35</sup>, sds<sup>7</sup>; *Ranunculaceae*: *Clematis paniculata* nectar<sup>6,16,18,19</sup>; *Rosaceae*: *Rubus* fru.<sup>9</sup>; *Rubus australis* fru.<sup>18,19</sup>; *Rubiaceae*: *Coprosma* fru.<sup>14,15,24,26,28</sup>; *C. grandifolia* fru.<sup>19</sup>; *C. lucida* fru.<sup>18,19</sup>; *C. robusta* fru.<sup>18,19</sup>; *C. macrocarpa* fru.<sup>11,16,18,19</sup>; *C. repens* fru.<sup>11,19,26</sup>; *C. rhamnoides* fru.<sup>18,19</sup>; *Rutaceae*: *Melicope ternata* fru.<sup>16,18,19,28</sup>; *Santalaceae* *Mida salicifolia* fru.<sup>18,19</sup>; *Sapindaceae*: *Alectryon excelsus* fru.<sup>19</sup>; *Sapotaceae*: *Pouteria costata* fru.<sup>19</sup>; *Solanaceae*: *Solanum nodiflorum* fru.<sup>6,7,8,18,19,26</sup>; *Verbenaceae*: *Vitex lucens* fl.<sup>7</sup>, nectar<sup>19</sup>, fru.<sup>19</sup>; *Violaceae*: *Meliccytus ramiflorus* fl.<sup>15</sup>, fru.<sup>14,15,16,18,19,24,28,31,32</sup>. **Animals** **ANNELIDS:** Oligochaetes<sup>12</sup>. **MOLLUSCS:** Slugs<sup>16,36</sup>. **SPIDERS:** 6,9,11,15,16,26,28,36. **CHILOPODS:** 6,11. **INSECTS:** 1,5,10,12,13, 14,15,16,20,22,26,28,30,36. **larv.** 5,6,10,13,14, 16,20,26; **Blattodea:** egg cases<sup>6</sup>, ads<sup>6,10,28</sup>; **Blattellidae:** *Parellipsidion latipennis*<sup>14,16</sup>; **Coleoptera:** ads<sup>6,26,36</sup>, larv.<sup>6,7</sup>; **Cerambycidae:** *Prionopus reticularis* larv.<sup>30,36</sup>; **Tenebrionidae:** *Chrysopeplus expoliatus*<sup>6</sup>; **Diptera:** *Culicidae*<sup>36</sup>; **Hemiptera:** spittle bugs<sup>36</sup>; **Aphididae**<sup>36</sup>; **Cicadidae**<sup>16,36</sup>; **Coccidae**<sup>9,28</sup>; **Psyllidae:** lerp<sup>28</sup>; **Hymenoptera:** *Formicidae:* pupae<sup>10</sup>; **Lepidoptera:** ads<sup>6</sup>, larv.<sup>6,7,8,9,11,15,16,28,36</sup>; **Psychidae:** larv.<sup>20</sup>, pupae<sup>7</sup>; *Oeceticus omnivorus* larv.<sup>14,16,18</sup>; **Orthoptera:** *Anostomatidae*<sup>9,10,11,16,20,26,27,28,30,36</sup>; *Hemidrusus similis*<sup>28</sup>; *Hemideina crassidens*<sup>3,28</sup>,

*H. megacephala*<sup>10,14,16</sup>; Phasmatodea: Phasmatidae<sup>20</sup>: *Clitarchus hookeri*<sup>14,16</sup>. **Other matter** During translocations a wide range of supplementary foods given. Basic captive diet successfully used in many translocations consists of insect cultures of Mealworms *Tenebrio molitor*, Waxmoths *Galleria melonella*, young locusts *Locusta migratoria*, Complan, honey and jam mixes, Saddleback buns, grated cheese, crushed hard-boiled egg-yolk, tomato, orange and kiwi fruit halves, soaked sultanas or raisins<sup>16,25</sup>. Mash of oatmeal, breadcrumbs, broken biscuits, milk powder and raw eggs, mixed with milk has also been used<sup>10</sup>.

REFERENCES: Reischek<sup>1</sup> 1885, <sup>2</sup> 1887; <sup>3</sup> Wilkinson 1927; <sup>4</sup> Sibson 1949; <sup>5</sup> Heather 1957; Atkinson<sup>6</sup> 1964, <sup>7</sup> 1966; Blackburn<sup>8</sup> 1964, <sup>9</sup> 1967; Merton<sup>10</sup> 1965b, <sup>11</sup> 1966a, <sup>12</sup> 1966b; <sup>13</sup> Turbott 1967; <sup>14</sup> Jenkins 1976; <sup>15</sup> Reed 1976; Lovegrove<sup>16</sup> 1980, <sup>17</sup> 1982, <sup>18</sup> 1985b, <sup>19</sup> 1992; <sup>20</sup> O'Callaghan 1980; <sup>21</sup> Dunn 1981; <sup>22</sup> Falla *et al.* 1981; <sup>23</sup> Ruarus 1982; <sup>24</sup> Rasch & McClelland 1993; <sup>25</sup> Lovegrove & Veitch 1994; <sup>26</sup> Stamp 1999; <sup>27</sup> Heather & Robertson 2000; <sup>28</sup> Pierre 2000; <sup>29</sup> Hooson & Jamieson 2003b; <sup>30</sup> Oliver; CSN<sup>31</sup> 38, <sup>32</sup> 39, <sup>33</sup> 41, <sup>34</sup> 43; <sup>35</sup> D. Anthony; <sup>36</sup> I. Castro; <sup>37</sup> T.G. Lovegrove.

**Young** Nestlings and fledgelings fed by both parents, with male actively feeding nestlings from soon after hatching (see Breeding). Parents carry food for young in bill and back of throat; birds gathering food for young have distinct bulge in throat as they approach nest (I. Castro, T.G. Lovegrove), and gathering behaviour is distinctive, with birds clearly not swallowing food (T.G. Lovegrove). Chicks fed grubs and small beetles (Blackburn 1966); on Cuvier I. small nestlings fed macerated invertebrate material, while larger nestlings fed scale insects *Ctenochiton viridis* (see photo in Lovegrove [2004]: p. 88), cicadas *Kikihia* and *Amphipsalta*, blowflies *Calliphora*, caterpillars *Selidosema*, small stick-insects *Clitarchus hookeri*, wetas *Hemideina*, large and small moths, and fruit including Kawakawa and Karamu *Coprosma macrocarpa* (T.G. Lovegrove). On Solomon I., nestling diet consisted almost entirely of grubs (Guthrie-Smith 1925); on Tiritiri Matangi, Motuara, Ulva and Breaksea Is, young were fed small insects, caterpillars and grubs, often macerated (Stamp 1999; Hooson & Jamieson 2003b), though on Mokoia I., insect prey appeared to be fed whole (I. Castro).

**SOCIAL ORGANIZATION** Based on contribution by T.G. Lovegrove. Well known. Detailed studies: on Cuvier I., over 4 years, 1970–74, using banded birds, examining social organization including pair-bonds, territories and roosting patterns (Jenkins 1976); and subsequent study 1978–79, examining use and maintenance of territories (O'Callaghan 1980) and aspects of pair-bond and breeding behaviour (Lovegrove 1980); and on Tiritiri Matangi I., 1987–88, examining influence of social structure on development of Song (Murphy 1989). **GREGARIOUSNESS:** Often seen in pairs during breeding season, often accompanied by young (e.g. Wilkinson 1927; Blackburn 1964; Skegg 1964; Merton 1966a; Jenkins 1976; Lovegrove 1980), though males also seen singly, particularly when females incubating or brooding (Skegg 1964; Reed 1976; Lovegrove 1980). After breeding, can occur in parties of three or four, usually of parents with juveniles (e.g. Blackburn 1964; Skegg 1964; Merton 1966a; Jenkins 1976; Reed 1976; Lovegrove 1980; Stamp 1999; Oliver) and independent young may form temporary foraging flocks of up to ten birds (see Food). However, most observations of larger groups, of up to eight (Blackburn 1964; Skegg 1964; Williams 1976; Oliver), probably usually territorial boundary interactions among neighbouring pairs, and not family groups (see Social Behaviour: Bow-Fan-Warble Assemblies). Newly translocated adults and young may form loose flocks near their release point and this temporary 'flocking behaviour' is possibly

conducive to successful release in translocations (Lovegrove 1996a). Some-times associate with flocks of Whiteheads, Yellowheads and Brown Creepers (Smith 1889, 1910; McLean 1911; Williams 1960; Blackburn 1964; Turbott 1967; Dean 1990; Oliver). On Kapiti I., young birds recorded in mixed-species flock with Whiteheads and young Stitchbirds *Notiomystis cincta* (I. Castro). Grey Fantails often associate with foraging Saddlebacks (see Food).

**Bonds** Monogamous; pair-bond usually permanent and maintained throughout year (Blackburn 1964; Jenkins 1975, 1976; Williams 1976; Lovegrove 1980, 1992; O'Callaghan 1980). Most pair-bonds are stable and last for life once pair breeds for first time and, as they are long lived, some pair-bonds last many years, e.g. among colour-banded birds on Cuvier I., two pairs together for 12 years, one for 13 years and two for 14 years (P.F. Jenkins & T.G. Lovegrove). However, divorce occurs very occasionally: on Mokoia I., one pair divorced when female paired with neighbouring male; the second male had larger wattles than the first (I. Castro). Members of a pair usually remain together during day and forage within a few metres of each other, or within earshot, except during breeding when female quiet. Members of pairs roost separately and meet again in morning. When member of a pair dies, surviving partner tends to stay in its territory and new pair forms very rapidly if other birds available. In low-density populations, widowed birds may move elsewhere to search for new mate (T.G. Lovegrove). Juveniles may form pairs as early as 6 months old, and birds can breed in their first year (Lovegrove 1985b; D.P. Armstrong; also see Breeding). On Cuvier I., whenever two wandering juveniles met, some form of bonding interaction took place between them. Usually, bonds between juveniles (Trial Pairs) not permanent and birds can separate after several months. Birds from a yearling Trial Pair may re-pair with older bird with which to breed in second season. Yearlings may breed if they bond with a widowed older bird (Jenkins 1976) and may breed before attaining full adult plumage (Turbott 1967; Oliver). **Parental care** Incubation and brooding by female only, but male assists in feeding nestlings and fledgelings (Williams 1976; Lovegrove 1980; Hooson & Jamieson 2003b; see Breeding). On Mokoia I., fledgelings usually remain with parents for at least 6 weeks (Armstrong *et al.* 2005); and on Kapiti I., young usually independent c. 1 month after fledging, at about time eggs of subsequent brood hatched and when male switches to helping female feed next brood (T.G. Lovegrove). However, claimed that young of final brood of a season may remain with parents for several months (Falla *et al.* 1981). Family groups break up when fledgelings independent and offspring usually move away (Blackburn 1967; Jenkins 1976, 1978). In at least early part of independence, young move widely, and may form loose flocks with other independent juveniles. On Cuvier I. they usually moved away from natal territories before settling down (Jenkins 1976, 1978). On Cuvier I., young males moved outside parental song-dialect area before settling, perhaps using Male Rhythmical Song (MRS) dialects (see below) as a reference system to avoid risk of mating with close relatives (Jenkins 1976, 1978).

**Breeding dispersion** Nest solitarily (Jenkins 1976; Lovegrove 1980; O'Callaghan 1980; Hooson & Jamieson 2003b). **Territories** Paired adults maintain a territory throughout year, and from year to year, and in which they breed, and in which most foraging and, usually, roosting occurs (Blackburn 1964; Skegg 1964; Merton 1966a; Jenkins 1976, 1978; Williams 1976; Lovegrove 1980, 1992, 1996b; Newman 1980; O'Callaghan 1980; Moorhouse 1996; Heather & Robertson 2000; Pierre 2001). However, territories not always exclusive, as birds sometimes cross into neighbouring territories to forage or drink before returning to own territories (O'Callaghan 1980; Lovegrove & O'Callaghan 1982; see

below); territorial incursions recorded in both subspecies, by adults and subadults and at high and low density, without defence by holder of territory if intruders not detected (but see also foraging with dependent young below) (Pierre 1999; T.G. Lovegrove). On Cuvier I. birds sometimes wandered outside territory into neighbouring territories when foraging (Jenkins 1976). On Cuvier I., for most of year (Mar.–Dec.), trespass into neighbouring territories rare, though birds occasionally foraged within territorial boundaries of neighbouring pairs in zones of territorial overlap, which, for one male, represented mean 12.9% of total territory throughout year (excluding Jan.–Feb.). During Jan.–Feb., when juveniles being fed, degree of overlap increased dramatically as adults that had bred successfully foraged well beyond normal territorial boundaries; one male increased total foraging area from 0.89 ha in Nov.–Dec. to 1.22 ha in Feb., though female of this pair continued to forage within normal boundaries, showing a negligible increase in total range during this period from 0.59 to 0.61 ha (O'Callaghan 1980). On Mokoia I., pairs appeared always to forage within their territories, but groups of up to eight birds, thought to be young non-territorial birds, foraged in territories of other birds (I. Castro). On Cuvier I., seen travelling hundreds of metres outside territories to visit waterholes in dry years (Pierre 2001); and on Motuara I., occasionally left territories to forage or use water sources in other territories (Pierre 1999). Boundary defence during the year reaches a peak during Nov.–Dec. (O'Callaghan 1980); when feeding fledgelings during Jan.–Feb., strong territorial behaviour appears to weaken in some pairs, with intruding birds being tolerated by resident pair (Blackburn 1967; O'Callaghan 1980). Adult pairs have permanent site-attachment. When one of a pair dies, remaining bird usually stays in territory and new partner joins it there (but see also Bonds above), so that territory is maintained (Jenkins 1976; O'Callaghan 1980; Lovegrove & O'Callaghan 1982). **SIZE OF TERRITORIES:** On Hen I., territory of one pair 0.57 ha (Skegg 1964); another pair in favourable habitat appeared to have territory c. 70 m in diameter (0.42 ha) whereas in less favourable habitat, average territory estimated to be 165 m across (2.13 ha) (Blackburn 1964). On Cuvier I., territories (defined as the area pairs exploited for food [O'Callaghan 1980]) ranged from 0.34 ha to 0.99 ha, with an average estimated size of 0.48 ha; birds found regularly in only 78% of total area of territory and 75% of all observations in only 36% of total area of territory. Appear to extend territory boundaries with time, and so may increase size of territory the longer it is maintained (O'Callaghan 1980). On Mokoia I., territories can be as small as 0.03 ha (I. Castro). Translocated birds entering vacant habitat may occupy larger territories, at least at first: on Kapiti I., founding birds' territories 4.89 ha (3.06; 2.0–16.0; 22) (Lovegrove 1982, 1983, 1984, 1985a); and on Little Barrier I., 5.15 ha (2.61; 2–10; 13) (Lovegrove 1985b). After release on Motuara I., birds established territories of 1.9–8.8 ha after 8–10 months (Pierre 1999); territories thought to be larger than 'necessary' compared with other observations of territory size, probably because population density low immediately after release (Pierre 2001). There is a stratification of age in which unpaired birds up to 1 year old are vertically restricted to lower 3 m of vegetation, while bonded territorial adults spend a greater proportion of their time above 3 m (Jenkins 1975, 1976; O'Callaghan 1980; see Food: Foraging Heights and Sites).

**Roosting** Paired birds usually roost within territory (Jenkins 1976), though birds will roost away from territory if no suitable sites available inside it, such as in young forest lacking tree-holes (Lovegrove 1980, 1992, 1996b). Usually roost in tree-holes, beneath large epiphytes or in ground-cavities if tree-holes lacking. Other roost-sites include: under or behind pendent dead leaves of large epiphytes (e.g. *Collospermum* or *Astelia*) growing on boughs or overhanging banks or bluffs; on

roots that loop down into gap beneath overhanging banks, bluffs or stream banks; on ground among dense vegetation, such as ferns; in crotches between two or more large boughs (Jenkins 1976; Lovegrove 1980, 1984, 1992, 1996b). Will also use artificial roost-boxes (see Threats and Human Interactions). Of 80 roosts on Cuvier I.: 70 in cavities or holes in Pohutukawa *Metrosideros excelsa* trunks and boughs, two behind pendent dead *Collospermum* leaves on Pohutukawa boughs, two among ferns on Kohekohe *Dysoxylum spectabile* bough, four on ground among dense ferns, and two on ledge in derelict building. Of 35 roosts in tree-cavities, entrance holes ranged from 7 × 7 cm to 50 × 70 cm, and internal cavities (depth, height, width) from c. 13 × 17 × 13 cm to c. 80 × 90 × 26 cm (T.G. Lovegrove). Mean height of roost-sites on Cuvier I. 2.5 m (1.6; 0–8.5; 80) (Lovegrove 1996b). Of 168 roosts on Kapiti I.: 50 beneath *Collospermum* clumps on ground or in trees, 31 under overhanging bluffs and banks, 22 in secluded sites on ground, 19 in dense vegetation on or near ground, 16 in cavities or holes in trees, 15 on branches among dense foliage, ten under large fallen logs on ground, three in rock crevices in bluffs, and two in crotches between boughs of Kanuka (T.G. Lovegrove). Mean height for roosts on Kapiti I. 1.1 m (2.5; 0–12; 168) with 70.8% of roosts on ground or <1 m above ground. All roosts in tree-cavities and most under epiphytes, overhanging banks and logs were dry and very sheltered; and many had entrances beside or below an internal perch. These key features were used in design of roost-boxes (see Threats and Human Interactions). On Kapiti I., birds that roosted high had a greater chance of avoiding predation by Brown Rats, while birds roosting on ground, in rocky crevices or beneath overhanging banks and epiphytes or in leaning hollow tree-trunks were more likely to be killed by these Rats. On Cuvier I., Kiore did not prey on roosting Saddlebacks (Lovegrove 1996b). Since young fledgelings fly poorly, they may be physically incapable of reaching a high or secure roost, so many roost on ground for first few nights after leaving nest (Jenkins 1976; Lovegrove 1996b). A single roost may be used for several months or even years (Lovegrove 1996b), though birds often have several alternative roost-sites (Jenkins 1976). Birds spend much time at roosts. Usually roost at sunset and emerge just before, or at, sunrise. During winter on Kapiti I., may roost as early as 15:30 and not emerge till 08:00 (Lovegrove 1996b). When going to roost, family parties break up and each bird usually goes to roost separately. Before roosting, adults with dependent young often show offspring where to roost, by repeatedly entering and leaving roost while giving soft Chuttering calls (Jenkins 1976; Lovegrove 1992, 1996b). Older fledgelings, which know where to roost, are simply left while parents fly briskly off to their separate roosts. Fledgelings often roost in same cavity as siblings, and sometimes with a parent (Jenkins 1976; Lovegrove 1980, 1984). Jenkins (1976) describes three sequences of events at roosting: Pre-roosting Feeding Phase, Separation Phase and Final Approach to Roost Hole. The vigorous Pre-roosting Feeding Phase occurs in last 30–60 min before roosting, when birds call very little, and pairs with young often feed on or near ground (cf. Blackburn 1970a). Separation Phase: After Pre-roosting Feeding Phase and as time to roost approaches, birds abruptly start a long series of loud Chatter Songs (Roosting Chatter), characteristic of roosting period. These Songs may be initiated by either male or female and are self-stimulative, with other surrounding birds joining in the general commotion, like the roosting calls of Common Blackbirds. Roosting Chatter seems to express anxiety at changeover from daytime social behaviour to solitary night-time behaviour; and may be part of self-stimulation needed to stop behaving possessively towards territories and socially towards mates; possibly also functions to inhibit all forms of calling in dependent young, which tend to enter roosts silently. Roosting birds also fly

nervously and jerkily short distances in all directions and run back and forth through trees with same loping gait, which they so characteristically use under conditions of social stress; and vigorous foraging, in which little eaten, may also be observed. There may also be frequent Bow-Fan-Warble interactions (see BFW Display below) with neighbouring birds, especially if roost-sites concentrated near territorial borders. Local territory-holders may evict other birds seen entering roosts, even though roost-site is not their own. Birds may also spend considerable time preening. In Final Approach to Roost Hole, birds often sing high in canopy, then descend abruptly towards roost-sites, often giving Roosting Chatter as they enter, with the last few calls sometimes given from inside roost (Jenkins 1976). If disturbed soon after roosting, bird will emerge, leave hole briefly and return, or fly off, sometimes calling, to an alternative site (Jenkins 1976; Lovegrove 1980). Inside roost, birds usually perch on one leg and head is tucked in, with bill under longer feathers of mantle. With a cautious approach, roosting birds can easily be caught by hand (Jenkins 1976; Lovegrove 1992). On Cuvier I., several very large Pohutukawa trees along or near territorial boundaries were used by a number of adjacent territorial birds, all using widely spaced holes in the same trees (Lovegrove 1980; O'Callaghan 1980). **AWAKENING:** Since birds usually roost separately, and roosts may be widely spaced in territories, each morning paired birds must relocate each other, re-establish each other's identity and re-form pair or family bonds. When they emerge at or about dawn, loud Chatter Songs or MRS given. Members of pair gradually move closer together if roosts are well separated and when they meet they often greet each other with sexually dimorphic Quiet Songs and courtship feeding characteristic of interactions between bonded individuals (Jenkins 1976; Lovegrove 1980).

**SOCIAL BEHAVIOUR** Based on contribution by T.G. Lovegrove & P.F. Jenkins. Well known. Detailed studies: on Cuvier I., over 4 years, 1970–74, which included study of vocal behaviour and song learning, territory and pair-bond maintenance behaviour and agonistic behaviour (Jenkins 1976, 1978); and subsequent studies 1978–79, which examined use of space (O'Callaghan 1980) and pair-bonds and breeding behaviour (Lovegrove 1980); and on Tiritiri Matangi I., 1987–88, examining influence of social structure on development of song (Murphy 1989). Also some earlier observations on pair-bond maintenance (Wilkinson 1927), agonistic behaviour, pair-bond maintenance and other sexual behaviour (Blackburn 1964), and behaviour of nesting birds (Blackburn 1966). Some of the conclusions from observations before 1970 may be suspect owing to lack of knowledge about easy sexing of birds using the sexually dimorphic Quiet Songs and loud Male Rhythmic Songs (MRS). Moreover, sexing on size of wattle can also be unreliable (Jenkins 1976). Birds easy to locate and observe as they forage noisily, and often sing and call. They exhibit both a lack of fear of and an interest in people; they are extremely tolerant of close and continuous observation, showing no reaction to a careful observer at distances as close as 2 m, thus making observations on behaviour easy; presence of observers appears to make no difference to birds' behaviour (Blackburn 1964; Jenkins 1976; Lovegrove 1980; O'Callaghan 1980). Historical observations on mainland of two or more Saddlebacks associating with Whiteheads or Yellowheads, usually following flocks of them, possibly to feed on insects disturbed by them (see Food: Foraging associations). These observations suggest local territorial pairs following these flocks or perhaps *vice versa* (cf. Saddleback–Grey Fantail foraging association) as flocks pass through Saddleback territories. Observations of more than two Saddlebacks accompanying Whiteheads or Yellowheads possibly pairs plus young or loose flocks of independent young (T.G. Lovegrove). **Maintenance**

**behaviour** Often pause during feeding to preen, and also sun themselves on ground or branches, raising wing to expose flank and underwing (T.G. Lovegrove). Often drink and bathe at waterholes during hottest part of day. When bathing squat in shallow water while dip head under to throw water over back and flap wings to send up showers of spray. Following this, adopt a more upright stance to assist drainage of wet plumage. After hurried ruffling of plumage immediately return to cover, and may spend considerable time preening on a nearby branch (Merton 1966a; T.G. Lovegrove). **ANTING:** In July 1979 on Cuvier I., a male foraging in leaf-litter seen several times to rub a small round insect on ground and then through plumages of underwing; item then eaten (T.G. Lovegrove).

**Agonistic behaviour Individual distance** Sequestrative behaviour occurs to space out pairs by mutual avoidance. Throughout day, pairs call in territories at frequent but irregular intervals, showing no tendency to move towards each other's Songs and moving about so as to avoid each other, using vocalizations to guide avoidance. Sequestrative Singing performed randomly without reference to any particular neighbour. Spacing system thus operates with reference to other individuals rather than to topographic features. There is a marked increase in frequency of Sequestrative Singing with onset of autumn, continuing steadily throughout rest of autumn and winter and into the middle of spring, but it reverses suddenly at beginning of breeding season early in Nov. Level of Sequestrative Singing lowest in Feb., when successful breeders devote almost all time to foraging and providing food for young. Sequestrative Singing is important in first 30 min or so after leaving roosts in morning, during which all birds relocate each other, and particularly evident in birds using closely spaced roosts (Jenkins 1976; O'Callaghan 1980; see Roosting). **Threat displays** Give Loud and Quiet Songs (see Voice) to advertise territory to neighbours (Blackburn 1964; Kendrick 1964; Jenkins 1975, 1976, 1978; O'Callaghan 1980). Songs may be given from within foliage, on lower branches, or when feeding among ground-litter (Blackburn 1964; Jenkins 1975, 1976). Birds also perform bouts of more co-ordinated Counter-singing, especially in early morning and late afternoon and usually between males: two males in adjacent territories alternately sing against each other, Song for Song, with Songs sometimes overlapping; bouts usually rather brief exchange of similar Song-patterns. Birds usually a long way apart, c. 50 m, and appear not to be able to see each other through dense vegetation. Chain Counter-singing occurs when members of three or four territories participate. Counter-singing more likely to occur when aggressiveness likely to be greatest: during early part of breeding season and during rhythmical singing peak c. 30 min after waking in morning. Frequency also increases in Mar, when most juveniles have been abandoned and adults appear to be reaffirming territory ownership. There was also a general tendency for younger males to engage in Counter-singing against established birds, whereas old birds have come to rely among themselves on less energetic Sequestrative Singing (Jenkins 1976). When an intruder enters a pair's territory or when two foraging pairs come close together at territorial boundaries, both members of a pair give an agonistic call, usually one of the Quiet Songs, sometimes followed by male of pair giving a Loud Song, which may be answered by intruding male; female continues to give Quiet Songs or loud Chatter Songs. First male may fly or bound towards the other male, and once visual contact has been made, considerable tension develops and birds move close together. At this point, males face each other and, at a distance of  $\leq 1-2$  m, begin BOW-FAN-WARBLE (BFW) DISPLAY. This is bowing display described by Blackburn (1964), and contexts and associated calls and behaviour described in greater detail by Jenkins (1976) and described and illustrated by Lovegrove (1980). BFW Display occurs in

several contexts: (1) between birds of a bonded pair and between opponents during intense territorial disputes, usually along or near territorial boundaries, called **BOW-FAN-WARBLE (BFW) ASSEMBLIES**; (2) between a single territorial bird and an intruder or human observer; (3) between birds of a bonded pair as a pair-reinforcement and greeting ceremony, and sometimes accompanied by courtship feeding; and (4) by male near nest when calling female off to be fed, or after feeding nestlings. When performing BFW Display, bird perches on a branch and leans whole body forward and down till head points almost vertically towards ground and tail almost directly up in air; when Display given on ground, top of head may even be rested on ground. Plumage of abdomen is fluffed out, while that of head and neck are sleeked, so that bird appears to increase in size and assumes a curious pear shape; wattles dilate rapidly, at least doubling in size, become bright red and even more pendulous and wobbly, and as they dilate they curve outward and face forward of gape rather than resting against sides of throat (as when bird relaxed). The tail-feathers are widely fanned and simultaneously the male Four-note Warble (4NW) or female Triple-note Call (TNC) or GPW Song (see Voice) given. During this display, in agonistic encounters, bright saddle is presented at its full expanse to opponent, with effect often enhanced by tilting body and raising opposite wing slightly if opponent is to one side, and calls are delivered precisely at the point of maximal presentation. In greeting between members of a bonded pair, a single BFW Display is usual; during BFW Assemblies, BFW Displays may be given repeatedly for 15 min or more, while the *mêlée* of birds, in a highly agitated state, with bright-red and dilated wattles, sleeked plumage, angular postures and tilted tails, bound rapidly up and down branches, or along ground, or make short noisy flights from branch to branch, pausing often to courtship-feed, give Beak-and-wattle Presentation (see below), call and display. Vigorous foraging, in which little or nothing is eaten, also occurs, often right in front of an opponent; birds moving in a jerky, mechanical manner with dilated wobbly red wattles, and peck furiously at bark or ground, flinging large pieces aside. Vocalizations during BFW Assemblies are highly characteristic, involving all of the Quiet Song group (see Voice): 4NW, Whiu, Sree-ree and Clarinet Songs from males and TNC, GPW, Growl and Piping from females. Some Chatter Songs and MRS Patterns are also given during BFW Assemblies, but these are clearly less important than Quiet Songs (Jenkins 1976). During BFW Assemblies, a bird will occasionally fly out and strike an opponent with its body. These intense displays may occur between three, four or five pairs from contiguous territories. Displays usually end at or near territorial boundaries, with no obvious win or lose outcome, with dispersing birds giving loud Chatter Songs and MRS Patterns as they retreat to respective territories. When directed at an intruder, one BFW Display may be sufficient to cause intruder to retreat swiftly without returning Display. During BFW Assemblies the intense BFW Display occurs often between two males, or between two females, and between male and female of a pair. Female version of the BFW Display differs from that of male in that bow is usually not so deep, tail is not fanned as wide, and call given is quite different (Blackburn 1964; Merton 1965b; Jenkins 1976; Lovegrove 1980; O'Callaghan 1980; Lovegrove & O'Callaghan 1982). During such aggressive encounters, members of each pair often move aside a few metres and perform mutual BFW Displays, Beak-and-wattle Presentation (see below) and courtship-feed (Jenkins 1976; Lovegrove 1980; see Sexual Behaviour: Courtship feeding). On Cuvier I., frequency of BFW Assemblies declines during winter when sequestrative spacing using Chatter Songs seems to be more important in maintaining territorial integrity (O'Callaghan 1980). Apart from direct displacement attacks, the closest approach to

overt aggression is **BEAK-AND-WATTLE PRESENTATION** display (which seen during intense BFW Display): two adult males, at what appears to be peak of aggression, approach each other head-on from opposite ends of a branch and each presents its bill towards the other, first to the right and then to the left. During the forward movement the head is waggled in a slightly circular motion, causing engorged red wattles to wobble from left to right precisely in front of eye of other bird. Whole performance lasts only a few seconds, is usually not repeated and both birds then briskly retreat (Blackburn 1964; Jenkins 1976; Lovegrove 1980; O'Callaghan 1980). A less intense version of this display occurs between paired birds as part of greeting and during BFW Assemblies. On Cuvier I., trespass into neighbouring territories involved marked change in behaviour: intruders foraged silently and close to ground, behaviour identical to that displayed by juveniles and non-territorial adults at all times (O'Callaghan 1980); on Mokoia I., groups of up to eight birds, thought to be young non-territorial individuals, foraged in territories of other birds: intruders were silent and inconspicuous, though they could be closely spaced; discovery by territory-owners resulted in much displaying by all birds, and some chasing or displacing, the latter involving territorial male landing close to intruder and forcing it to move on, repeating displacement several times to drive intruders off (I. Castro). **Attack and fighting** Highly elaborate avoidance component in territorial interactions with neighbours (as above), results in few overt acts of aggression, such as fighting (Jenkins 1976). Because their habitat is dense, several neighbours at once could trespass undetected and territory maintenance by physical aggression would be uneconomic in terms of time and energy (O'Callaghan 1980). Pairs still feeding fledged young were most aggressive. In response to mounted specimen in territory, birds approached specimen to within centimetres, and on one occasion a pair actually attacked it, knocking it to ground (Blackburn 1964). An adult seen several times to fly at a strange juvenile that tried to join a family party of a pair with their own fledgelings (Jenkins 1976). Most intense fighting seen during a male-removal experiment on Cuvier I. in 1979, when a paired male from a neighbouring territory paired with the newly singled female. Competing males grappled with each other as did the two females. While grappling on ground, males clutched opponent's breast with feet and stabbed at each other's chests and tugged each other's wattles with bills; fighting between females similarly intense but without tugging at wattles (Lovegrove 1980; O'Callaghan 1980). Birds with irregular, nicked or even missing wattles have probably been injured in such fights, though a male on Kapiti I., which had a hole in one wattle, gradually developed this after a patch in the centre darkened, possibly as a result of an infection (T.G. Lovegrove). **Submission** On Cuvier I., adults threaten and attack their offspring at about time of independence (see Relations within family group); in response, young gave submissive, dependent peeping calls, fled or assumed angular sleeked posture with partial bow and partly fanned tail, and attempted sexually dimorphic Quiet Songs (T.G. Lovegrove). **Interactions with other species** Occasionally make feeble aggressive jab at Bellbirds *Anthornis melanura* or Grey Fantails that forage too closely (Jenkins 1976); on Cuvier I., females seen to chase Bellbirds away from nests (T.G. Lovegrove). Along with other species, often mob Southern Boobooks *Ninox novaeseelandiae*, with a continuous chorus of Alarm Calls and Chatter Songs. Once on Hen I., mobbing went on for 12 min, with Bellbirds and a Blackbird joining in the attack (Blackburn 1964, 1967). Once, one male gave Alarm Calls and joined group of Bellbirds and Whiteheads in mobbing behaviour for several minutes; thought to be mobbing Stoat (D. Anthony). On Little Barrier a first-year male removed a 4–5-day-old (7.0 g) Whitehead chick from a nest 10 m above ground, carried it to nearby

branch and dropped it; the uninjured chick was returned to its nest by observers. Also seen to peck at chicks in two other nests (McLean *et al.* 1986). On Cuvier I., a small flock of 4–5 independent young persistently interfered with a Grey Fantail nest, with incubating Fantail feigning injury or death; the Fantail nest was deserted and empty the next day (T.G. Lovegrove). On Motuara I., Bellbirds seen to chase Saddlebacks on 15 occasions (females chased seven times, juveniles six). One female chased a Bellbird and Saddlebacks threatened Bellbirds five times (once by male, three by females and one by juvenile) by giving Quiet Songs and adopting BFW posture. A female and juvenile also seen to threaten robin, and a robin also seen to kleptoparasitize a weta dropped by female Saddleback. When Blackbirds give Alarm Calls, Saddlebacks looked up and checked surroundings but did not respond to alarm calls of other species (Pierre 1995).

**Sexual behaviour** **Courtship displays** Soon after young independent they can give full range of sexually dimorphic Quiet Songs (see below). Two solitary juveniles, meeting during foraging, typically approach and sometimes display to one another with a low bow, accompanied by calls closely connected with mutual indication of sex (i.e. Four-note Warble [4NW] in males and Triple-note Call [TNC] in females). Courtship feeding sometimes occurs between these young birds (Jenkins 1976). Once pair-bonds form, courtship feeding, accompanied by bowing and various quiet calls, occurs throughout year and continues between members of pairs throughout their lives, and is important in maintenance of pair-bond (Jenkins 1976; Lovegrove 1980). These courtship displays further described for NI (Wilkinson 1927; Blackburn 1964) and SI (Hooson & Jamieson 2003b). Male also feeds female throughout incubation period and some males continue to feed brooding females, releasing females from this energy expenditure (I. Castro; see Breeding). **ARCHANGEL DISPLAY:** Description from contribution by T.G. Lovegrove. Occurs throughout year but especially before nesting and during formation of new pairs; and along with duetting, courtship feeding and BFW Displays, is important in maintaining and reinforcing pair-bond and as a nest-invitation ceremony (Lovegrove 1980); first described by Blackburn (1964). Usually very brief, and easily missed. First sequences of display (below) may last only a few seconds, with full display, including hole-cleaning, lasting perhaps 10–15 s. Performed by both sexes but more often by males. Full display follows a particular sequence but display may comprise only part of sequence, depending on intensity: (1) While pair feeding near one another, one bird (usually male) plucks at grass or scales of tree-fern; (2) then picks these fibres up in bill and quickly drops them; (3) holds fibres in bill for longer, a few seconds, then drops them; (4) bird opens wings briefly while holding fibres in bill; (5) displays for longer with fibres in bill, wings spread, gives Zweet Calls and bounds along ground or branch with distinctive springy gait; up to this point other bird, usually female, feeding nearby often does not seem to show much interest, but bird performing display bounds ahead and often looks back over shoulder; (6) after performing previous actions (sequence 5), bird then approaches tree-cavity and leans into potential nest-hole or partly closes wings and enters hole, with partner approaching and showing interest; (7) displaying bird throws debris out of hole, and mate perches outside showing greater interest; (8) displaying bird performs actions 6 and 7, and mate looks into or enters hole with displaying bird; (9) one or both birds emerge after a few seconds, and display ends. On Cuvier I., 1979 (no obs. in June), 68 Archangel Displays seen: five in Feb.–Mar., three in May, none in July, 34 in Aug. (number probably enhanced by removal experiment), eight in Oct., and 18 in Nov. The only Displays performed by a female were seen during male-removal experiment in Aug. 1979,

when eight of 34 displays were given by female during first few days when bonding with new males; in all displays, female gathered fibres, and in two of eight, female bounded ahead with springy gait and wings opened fully (Lovegrove 1980). Archangel Display also noted for SI subspecies (Hooson & Jamieson 2003b). **Maintenance of pair-bond** Pair bonds usually permanent and maintained throughout year and, once pair first breed, typically maintained for life (Jenkins 1976, 1978; Lovegrove 1980; O'Callaghan 1980; Lovegrove & O'Callaghan 1982; see Social Organization: Bonds). Pair-bonds maintained by duetted loud Chatter Songs, sexually dimorphic Quiet Songs, Beak-and-wattle Presentation and courtship feeding (Jenkins 1975, 1976; Lovegrove 1980; Lovegrove & O'Callaghan 1982). Members of pair often forage only a few metres apart, maintaining contact with occasional sexually dimorphic Quiet Songs (e.g. TNC, 4NW) if close, or duetted loud Chatter Songs if farther apart (Jenkins 1976). During capture of birds on Hen I. in 1925 for a translocation to Kapiti I., it was noted that when one of pair was captured, the other would start calling and hopping about from branch to branch, appearing distressed, and even approach to within c. 1 m of captured partner or bird-catcher, and could also be caught (Wilkinson 1927). When one member of a pair is lost, remaining bird vocalizes incessantly and repeatedly, uttering one-half of duet call. If duet remains unanswered, this acts as a signal to surrounding birds of a vacancy in a territory (Jenkins 1976; Lovegrove 1980; O'Callaghan 1980; Murphy 1989). On Kapiti I., after females were killed by Rats at nests, bereaved males sang MRS Patterns and loud Chatter Songs incessantly, such singing providing observer with a clear indication that female was missing (T.G. Lovegrove). Duetting is a feature of bonded pairs. Duetting often occurred when pair disturbed, either by observer or by other birds. Duetting between a pair may also initiate or follow Counter-singing interaction between one of the pair and an intruder. Duetting probably functions, at least in part, as mutual stimulation between members of pair as part of ordinary method of visual display and for mutual reassurance after disturbance (Jenkins 1976). After a disturbance, male also often moves close to female and gives BFW Display, with female also giving BFW Display in response to male (Jenkins 1976). BFW Displays occur often between members of a pair during aggressive territorial BFW Assemblies and may also serve to test pair-bond strength (Jenkins 1976; Lovegrove 1980; see Agonistic Behaviour). **Greeting** As members of pair roost apart (see Roosting) they must relocate each other in morning and re-establish each other's identity and affirm pair. When birds emerge from roosts in morning they usually sing loud Chatter Songs till they make visual contact, when they begin Quiet Songs (4NW, TNC, GPW, Growl Song), harsh growls and courtship feeding (Jenkins 1976). **Courtship feeding** Recorded throughout year and appears to be important in maintaining pair-bond, but not known whether it ever precedes copulation (Blackburn 1964; Jenkins 1976). Pairs courtship-feed occasionally throughout day, and especially when the pair greet each other after emerging from roosts or periods of foraging apart but within earshot (Jenkins 1976; T.G. Lovegrove). Male usually feeds female (Wilkinson 1927; Blackburn 1964, 1967; Merton 1966a; Jenkins 1976; Williams 1976; Hooson & Jamieson 2003b) but female sometimes feeds male (Lovegrove 1980). In courtship feeding, bills aligned, with tips touching, and either one insect or grub offered and accepted, or two or more small insects fed in succession. Occasionally, inedible objects, such as hard green fruits, are passed back and forth several times in a ritualized manner (Lovegrove 1980; see BFW Display above). A common courtship feeding sequence (Jenkins 1976): female TNC, male 4NW, female Growl Song, then courtship feeding. The Growl Song from female seems to trigger courtship feeding behaviour

by male; he often moves rapidly towards female on hearing Grownl Song and usually approaches from above, female stretching her bill up towards male to be fed. On several occasions, wings were vibrated while extending bill (Jenkins 1976). Courtship feeding is also observed between members of lone pairs under undisturbed conditions. May also be triggered by disturbance such as a sudden intrusion of a third bird or by sudden disturbance by observer, in which case the female gives a Grownl Song and male immediately flies over to courtship-feed her (Jenkins 1976). Male also provisions female in or near nest during incubation (see Breeding: Incubation for details). **Allopreening** Once, after a territorial dispute, male flew to female and preened her back, after which they flew off together; another female seen preening rectrices of her mate (Blackburn 1964). On Cuvier I., of six observations of allopreening between members of pairs: female preened male in four, male preened female once, and both birds preened each other once (Lovegrove 1980). On Kapiti I. a female preened delicately around base of mate's bill. None of these interactions lasted long. Both sexes often preen dependent juveniles (T.G. Lovegrove). Allopreening seemed to occur too infrequently to be a significant part of pair-reinforcement, though it may be important in maintaining bonds between parents and offspring. Allopreening never seen in aggressive situations (Lovegrove 1980). **Copulation** During pre-copulatory behaviour in NI, birds perch side by side on branch a short distance apart and male repeatedly sidles towards female giving Chuttering and Sree-ree songs and may place one foot on female's back. In a copulation observed on Kapiti I., male mounted female for 5–10 s giving Sree-ree song, while female gave Swee-swee song. After male dismounted, female fluttered wings and tail rapidly in a circular motion like propellers, then preened for 5–10 min; shortly afterwards, she carried material to nearby nest-box. First egg laid 3 days later (T.G. Lovegrove). Before copulation in SI, both members of pair perch side by side, female vibrating wings and giving soft Peeps. As male approaches with vibrating wings, female bows and male, calling softly, then steps onto her back and flaps as cloacal contact is made (Hooson & Jamieson 2003b).

**Relations within family group** Male does not share incubation or brooding, but provisions female and assists in feeding of nestlings (see Breeding). Male feeds female close to nest-site during incubation and early stages of brooding after calling her off with a Quiet Song (Blackburn 1966; Lovegrove 1980). Normally on emerging from nest-hole, female pauses at exit, possibly to check for presence of predators or to adjust eyes to light. Her departure from nest when incubating or brooding is often silent till clear of immediate area. Return to nest after periods of feeding and preening can be extremely rapid compared with the more leisurely exit. Return usually announced with a repeated sharp *zit* (see Alarm Calls) or a series of Short Chatters, which sometimes given right up to entrance to nest or even from inside cavity. Once young hatch, birds usually silent on approach as they are carrying food, but often call near nest after feeding nestlings; males may pause, give low bow and 2, 3 or 4NW near entrance to nest, or both sexes give loud Chatter Songs from branches overhead or nearby. At a nest on Hen I., the male usually accompanied female while she was on ground and often fed her when she left nest-site (Blackburn 1966). Parents feed fledgelings for several weeks, during which family is a close-knit group. Both male and female produce almost continuous quiet interchange of vocalizations, especially Chutters, while fledgelings utter continuous very soft peeping; fledgelings give squealing calls and vibrate their wings when begging or while being fed, very similar to behaviour of incubating females when they are called off nest to be fed by mate. When young left alone, even when parents not far away but out of view, fledgeling calls change to louder and more persistent

Lost-contact-with-parents Call; and if out of contact with parents for longer periods, or they become more widely separated, they utter a disjointed loud chatter, which enables adults to locate their young in dense habitat (Jenkins 1976; Lovegrove 1980; also see Voice). At roosting time, young fledgelings repeatedly explore crevices and holes for roosting sites, parents appearing to help by indicating suitable sites (Jenkins 1976; Lovegrove 1996b); when several weeks old, young left to enter their own roosting holes while parents flew off to their separate roosts (Jenkins 1976). One male continued to feed chicks after his mate left him for neighbouring male (I. Castro); and at a nest on Kapiti I., after a male died while his mate was incubating, a new male bonded with female and adopted brood (T.G. Lovegrove). Fledgelings become independent about the time that eggs in subsequent nests hatch, and males switch attention to provisioning next brood. Nearly independent young tolerated for a few days at this time but are soon challenged and may be driven from territory (Blackburn 1967; T.G. Lovegrove). On Cuvier I., at about time of independence, adults seen to fly at, peck at and shove their young away, and also to perform threatening BFW Displays with Whiu and 4NW (males) and TNC and GPW Song (females) (Lovegrove 1980). In response to threats, young gave submissive, dependent peeping calls, fled or assumed angular sleeked posture with partial bow and partly fanned tail, and attempt sexually dimorphic Quiet Songs (T.G. Lovegrove). **Anti-predator strategies of young** Young can be very cryptic, and sombre colouring aids camouflage, especially when still and silent in deep shade or in leafy canopy. Between feeding visits by adults, young can be very difficult for observers to find. If danger threatens, adults give Alarm Calls and young either freeze on ground or move up into branches (Lovegrove 1996b; T.G. Lovegrove). **Parental anti-predator strategies** Pairs with dependent young defend territories vigorously (Blackburn 1964; Merton 1965b; also see Social Organization: Agonistic behaviour). If nest or young approached, males call loudly and rapidly (Turbott 1967) especially if Weka approach (Lovegrove 1996b). When Bellbirds and Tui come close to nests, males and females perform BFW Displays accompanied by 4NW, TNC and GPW Songs and may drive them away (Blackburn 1966; T.G. Lovegrove). On Cuvier I., a female with two 10-day-old nestlings in nest-cavity, with entrance <1 m above ground, threatened a Kiore by lowering head, raising wings and approaching to within 20–30 cm, without calling, causing Rat to retreat (Lovegrove 1996b). On Kapiti I., adults whose young had been caught by a Weka performed distraction display, calling loudly and fluttering on and near ground 1–2 m from Weka, and also shepherded surviving young higher in branches (Lovegrove 1996b). When adults with young saw Weka approach, they moved quickly off ground and usually gave loud Alarm Calls. When Swamp Harriers *Circus approximans* approached, Saddlebacks feeding in canopy gave Alarm Calls then dropped swiftly out of sight (Lovegrove 1996b). Usually, both subspecies very confiding and tame and rather indifferent to human observers. Normally when observer looks into a nest, incubating or brooding female leaves quietly and either remains close to nest or moves a short distance away (e.g. Sibson 1949). However, some females display little fear and stay put, even if lifted from eggs with fingers, and one on Cuvier I. (photo in Lovegrove 1980) would jump onto arm and wait until hand was withdrawn before returning to nest. Another female photographed on a nest in a Maori flax kit hanging in a muttonbirder's hut (Guthrie-Smith 1925) was 'so rapt in the ecstasy of brooding that she allowed me to lift the kit from its nail and carry her forth still sitting to show to my companions'.

**VOICE** Based on contribution by P.F. Jenkins and T.G. Lovegrove. NI subspecies *rufusater* well known. Detailed studies

of social organization and vocal behaviour on Cuvier I., 1970–74 (Jenkins 1976, 1978); of songs used in spatial and territorial behaviour on Cuvier I., 1978–79 (O'Callaghan 1980); of songs used in pair-bonding, 1978–79 (Lovegrove 1980); and influence of social structure on development of song on Tiritiri Matangi I., 1987–88 (Murphy 1989). Sonagrams in Jenkins (1976, 1978). Vocal behaviour of SI subspecies has not been studied in detail, but it shares Loud and Quiet Songs; Hooson & Jamieson (2003b) also mention soft whistles and pips, apparently similar to those of NI subspecies. A naturally very noisy bird, and when excited or alarmed, clamorous, with piercing metallic songs (Chambers *et al.* 1955; Turbott 1967; Falla *et al.* 1981). Songs classed as Loud or Quiet: Loud Songs (the *chee-per-per* or *cheet*, *te-te-te-te* of earlier observers [Andersen 1926; Kendrick 1964; Heather & Robertson 2000]), have a characteristic timbre and great carrying power, even through thick forest (Jenkins 1976, 1978). Quiet Songs are soft, flute-like sounds audible only at close quarters; they are strictly sexually dimorphic and much simpler and shorter than Loud Songs (Jenkins 1976, 1978). Quiet Songs usually mostly uttered with bill closed, or nearly so, and it is thus difficult during intense agonistic encounters to determine which bird is calling (Jenkins 1976). Loud Songs also variously described as loud, clear, melodious, beautiful, musical and flute-like; and Quiet Songs as soft, melodious and flute-like, audible only at close range (Wilkinson 1927; Kendrick 1964; Turbott 1967; Jenkins 1976, 1978; O'Callaghan 1980). Sequestrative Singing and Counter-sung Loud Songs form the cornerstone of Saddleback territorial maintenance in which avoidance component in agonistic relationships between residents is highly developed. Loud Songs also given in duet between members of pairs as part of pair-bond reinforcement and to advertise presence of intact pair-bond to both neighbouring territorial birds and intruders. The validity of long-distance signalling through Loud Song is put to the test by close-contact boundary interactions (BFW Assemblies) in which Quiet Songs are a key component (Jenkins 1976, 1978; Lovegrove 1980; O'Callaghan 1980; see Social Behaviour: Agonistic behaviour). ANNUAL PATTERN: Loud and Quiet Songs may be heard at any time of year, though frequency of Counter-sung Male Rhythmical Song (MRS) Patterns higher during breeding season and also at beginning of autumn (O'Callaghan 1980; Murphy 1989; see Counter-singing, Sequestrative Song, below). DIURNAL PATTERN: Song heard throughout day (Jenkins 1976; O'Callaghan 1980), but Counter-singing most often occurs in early morning, soon after birds emerge from roosts at dawn, or in late afternoon (Jenkins 1976; O'Callaghan 1980; Murphy 1989; see Counter-singing, Sequestrative Song, below). On Cuvier I., calls of 3–5 pairs usually heard over periods of 10 min and periods when no Saddleback Song heard averaged c. 4 min (usually 1–10 min), except at dawn and dusk when Song much more frequent (Jenkins 1976). However, can sometimes be rather silent, birds calling only every 30 min or so (I. Castro). Birds stopped singing when wind strong enough to cause loud background tree-top noise (Jenkins 1976). Often utter *zit* Alarm Calls or Loud Songs when disturbed by sudden noise, from observer or in environment, such as falling branches or sudden clap of thunder (Jenkins 1976; Pierre 2000; T.G. Lovegrove). DUETS: Pairs often sing duets in which females usually sing Short Chatter Song, and males sing MRS (Jenkins 1976; Falla *et al.* 1981; see below). Duets often interrupted by Counter-singing from another male (Jenkins 1976). COUNTER-SINGING: In Counter-singing, two males in adjacent territories alternately sing against each other, song for song, often with matched MRS Patterns. Counter-singing more intense than Sequestrative Singing (Jenkins 1976; see below). Counter-singing usually only a brief exchange. Sometimes takes form of rapid alternation between two males of single MRS phrases

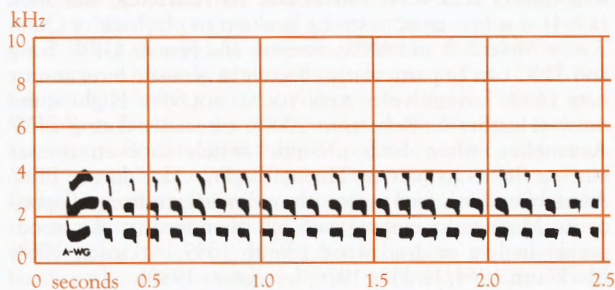
(see below), repeated for 3–4 phrases; at other times, males sing whole MRS, including introductory *zeet* notes (see below), and the two males alternate several times. Occasionally Counter-singing would last for 15–20 alternate songs. Birds often c. 50 m apart when Counter-singing and usually cannot see each other through dense forest. Counter-singing performed only by males, and there was a tendency for younger males to Counter-sing against older established males (Jenkins 1976). Counter-singing peaked during early part of breeding season (Nov.–Dec.) when building of nest and laying; little heard during latter part of breeding season when pairs have nestlings and fledgelings (Jan.–Feb.); slight increase in Counter-singing in Mar., before lull at end of breeding season; very little Counter-singing heard in winter; increases again in spring (Oct.). During Nov.–Dec. there was peak in Counter-singing in morning during first hour after leaving roosts, and a dramatic decrease in second hour; for rest of day, frequency of Counter-singing averages c. 25% of that of dawn chorus, though there were two minor peaks of activity round mid-morning and mid-afternoon. In c. 27% bouts of Counter-singing, males matched the song-type they used. Chain Counter-singing involving four or five males was more common than simple Counter-singing between two males; in Nov.–Dec., 59.8% of Counter-singing involved chained events (O'Callaghan 1980). SEQUESTRATIVE SONG: A series of songs given at irregular intervals by both males and females and that do not appear to elicit any response from others (O'Callaghan 1980). Thought to aid in territorial maintenance by keeping birds apart through mutual repulsion (Jenkins 1976; O'Callaghan 1980). Song used in this way usually Chatter or MRS (see below); Short Chatter commonest in autumn and especially winter (Jenkins 1976). On Cuvier I., from a low in late summer, there was marked increase in frequency of Sequestrative Singing through winter, peaking in spring, e.g. mean songs/h 39.4 in Feb.; 57.5 in Mar.; 58.5 in May–June; 61.1 in July; 87.3 in Oct.; and 44.8 in Nov.–Dec. (O'Callaghan 1980). DIALECTS: The highly distinctive Male Rhythmical Songs (MRS) occur in small coherent patches forming a series of microgeographical song dialects (also see Male Rhythmical Songs, below). Where MRS Patterns overlap, neighbouring males sing patterns in common, with each male singing 1–5 different patterns (Jenkins 1976, 1978; O'Callaghan 1980; and see below). New MRS Patterns emerge through mistakes in copying, and these in turn are copied accurately by neighbouring males, resulting in new dialects forming (Jenkins 1976, 1978). In an experiment during translocation from Cuvier I. to Tiritiri Matangi I. in 1984, several small forest blocks were seeded with founding males singing certain MRS Patterns. While there has been some divergence since, with new songs evolving on Tiritiri Matangi I., in 2005 many of the original Cuvier I. MRS Patterns still exist where founding birds were released (T.G. Lovegrove; K.A. Parker). MIMICRY: On Kapiti I., some males mimicked alarm call of Tui (CSN 32), while on Tiritiri Matangi I., heard mimicking Bellbird and Tui alarm calls and local Bellbird song-dialect (CSN 34). RESPONSE TO PLAYBACK: Kendrick (1964) was first to note strong reaction to playback of Quiet Songs. Male 2, 3 and 4NW, Sree-ree and Female GPW Song and TNC can be particularly effective as acoustic lures at mist nets (T.G. Lovegrove). NON-VOCAL SOUNDS: Flight quite noisy (Heather & Robertson 2000), especially during BFW Assemblies, when birds abruptly switch to even noisier buzzing flights as part of Threat Display. Also during BFW Assemblies, birds feed vigorously and noisily in front of opponents. Make noisy tapping with bill when feeding like woodpecker in live or dead wood (Smith 1889; Atkinson 1964; Blackburn 1964; Jenkins 1976; Lovegrove 1980).

**Adult male Songs** Utter a variety of songs, which can be divided into Loud and Quiet Songs (as above). In NI, males

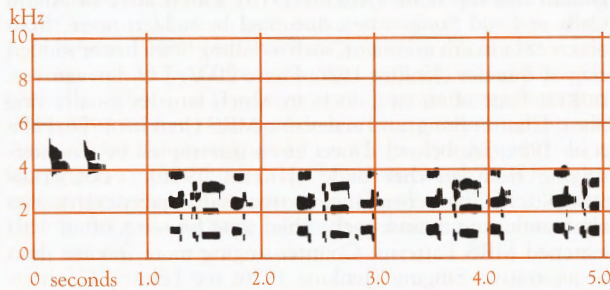


have two types of *LOUD SONGS*: (1) four types of Chatter Songs, which vary little from bird to bird; and (2) Male Rhythmical Song (MRS), which comprise a number of distinctive learned patterns, and which are given only by site-attached and paired males; on Cuvier I., each male sang 1–5 distinctively different MRS Patterns, which young birds learnt by copying neighbours (Jenkins 1976, 1978; O'Callaghan 1980). *QUIET SONGS* include: Two, Three and Four-note Warbles, Whius, Sree-ree Song, Clarinet Song, Chuttering and, possibly, Piping (Jenkins 1976, 1978; O'Callaghan 1980). *CHATTER SONGS*: Loud, penetrating chatter *cheet, te-te-te-te...*; with as many as 30 short notes following long, steady-toned introductory note (Turbott 1967; Jenkins 1976, 1978; Falla *et al.* 1981; Heather & Robertson 2000). There are four types of male and female Chatter Songs: Long Chatter, Short Chatter, Roosting Chatter and Mobbing Chatter (Jenkins 1976); unlike the distinct MRS patterns, there are usually no regular patterns of variation within each type of Chatter Song (Jenkins 1976, 1978; O'Callaghan 1980). Sonagram A shows Long Chatter Song. *LONG CHATTER* as described above, a single long accentuated note, often of a steady tone, but sometimes also with a slight variation of pitch, followed by a long series of short notes, usually at a slightly lower tone but varying little in average pitch. Long Chatter given by all birds, male and female, year-round, and no regular variation from bird to bird. Observations of development of song in young birds show that this song-form is the first to crystallize from the almost random chattering of newly fledged young. Long Chatter is thus thought to represent the primitive genetically determined loud song-form in this species (Jenkins 1976). *SHORT CHATTER* starts with the long introductory note described for Long Chatter but is followed by only 2–3 short notes; Short Chatter is one of commonest Loud Songs, being heard at all times of the year and from birds of both sexes. It invariably constitutes the female contribution to duets between pair-bonded birds (Jenkins 1976). *ROOSTING CHATTER* is heard in the 15–30 min immediately before roosting in evening and for a similar period after emerging in morning; both males and females sing a particularly long-continued randomly interspersed mixture of Short and Long Chatter Songs in which there may be 40–50 repeated short notes. Characteristically, the short notes are delivered more rapidly and in a way that is subtly, but not immediately, distinguishable from ordinary Long Chatter Song. Roosting Chatter may also consist of 4–5 introductory notes of same tone followed by two emphatic higher notes (Moncrieff 1929; also see Oliver). Roosting Chatter is infectious in that all birds in the area join in to form a sort of dispersed chorus (Jenkins 1976; see Social Organization [Roosting]). *MOBBING CHATTER* is a highly characteristic form of Long Chatter used in mobbing displays against Southern Boobooks or other predators, such as Weka. The notes of Mobbing Chatter have an unmistakable tonal quality combined with an emphatic delivery that appear to human observers to express a mood of urgency (Jenkins 1976). In calm weather, Loud Chatter Songs can be heard up to 400 m

(O'Callaghan 1980), or up to 150 m through dense vegetation (Jenkins 1978). Given in wide variety of circumstances (see Social Organization and Behaviour for full details of use); in addition to those just described, both Long and Short Chatter given in Sequestrative Singing (see above); and in pair-bond maintenance (e.g. female Short Chatter given with MRS in duets); both Long and Short Chatter used to re-establish contact with mate after leaving roost in morning and to maintain contact between members of pairs when they are not close together; Long Chatter may also be given (along with MRS) by males after loss of mates (see Social Behaviour: Sexual behaviour). Occasionally given in agonistic circumstances, during BFW Assemblies (but less important than Quiet Songs) and at end of BFW Displays and Assemblies when birds disperse (see Social Behaviour: Agonistic behaviour). *MALE RHYTHMICAL SONGS (MRS)*: Loud rhythmical song, usually consisting of two high-pitched, pure-toned whistles rendered as *zeet*, followed by 3–7 similar repeated phrases, the latter varying greatly from song to song (Jenkins 1976, 1978; Falla *et al.* 1981); see sonagram B. Repeated phrases often complex and delivered in stereotyped pattern with characteristic and unvarying pauses between successive notes and phrases; sounds carefully contrived and rehearsed (Jenkins 1976, 1978). Usually uttered only by site-attached paired males (Jenkins 1976, 1978; O'Callaghan 1980). One study on Cuvier I. found each male sang 1–4 patterns (Jenkins 1976, 1978); while another found each male sang 2–5 different patterns (O'Callaghan 1980). Each MRS Pattern can be sung by several or many neighbouring males, with the result that the area is divided into a number of microgeographic, overlapping song-dialects (see Dialects above). MRS Patterns influenced by neighbours, and both young and long-established males can learn new patterns, e.g. when one male moved territories, it modified song to match those of new set of neighbours and abandoned two MRS Patterns (Jenkins 1976, 1978). On Cuvier I., Jenkins (1976, 1978) discovered that locally bred males, which established territories around founding birds, copied MRS Patterns from founders. This posed the question of whether locally bred birds acquired songs genetically from fathers or whether they learned them. Young of colour-banded males, whose song behaviour was known, were banded, and in every case when young males settled, they developed songs of their territorial neighbours and not those of their fathers. Saddleback is one of the few species in which song-learning in wild birds has been clearly demonstrated (Jenkins 1976, 1978). Given in Sequestrative Singing (see above); and usual male component of Duets and Counter-singing (see above). Occasionally given in agonistic circumstances, during BFW Assemblies (but less important than Quiet Songs), especially at end when birds dispersing back into own territories (see Social Behaviour: Agonistic behaviour). Also given by males after loss of mates (see Social Behaviour: Sexual behaviour). After a period of silence, MRS can often be elicited by a disturbance, such as snap of twig (Jenkins 1976). *FOUR-NOTE WARBLE (4NW)*: Quiet, remarkably melodious song with poor



A Long Chatter Song (After Jenkins [1976])

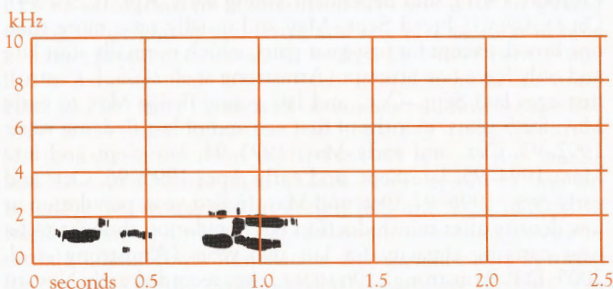


B Male Rhythmical Song (After Jenkins [1976])

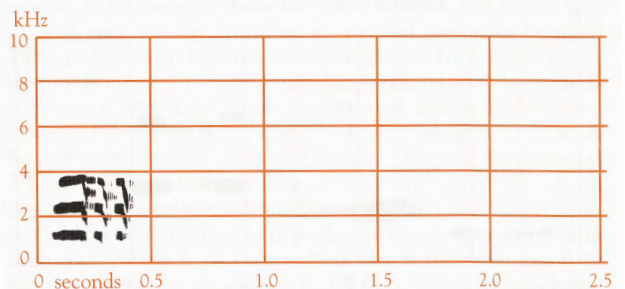
carrying power (Jenkins 1976; O'Callaghan 1980). Often consists of four soft, low-pitched and melodious flute-like notes (Sonagram C) (Jenkins 1976), though also often shortened to two or three notes when given in agonistic or sexual contexts (Jenkins 1976; also see Blackburn 1967; Lovegrove 1980; T.G. Lovegrove). Usually given during BFW Displays (including when displaying to Bellbirds or Tui close to nests); but also used to maintain contact with female when they are foraging close together, to greet female when pair see one another in morning after leaving roost, and in courtship feeding; often uttered when leaving nest after feeding nestlings; and also given by independent young (immatures) meeting immature female while foraging, or when confronted by a territorial bird (Jenkins 1976; Lovegrove 1980; O'Callaghan 1980; see Social Behaviour). Whispered flute call and pipe organ calls given when male confronts another male, or when feeding female (Blackburn 1964, 1967), probably describe 4NW. **SREE-REE SONG:** Repeated sequence of two or three notes: one or two soft, low-pitched whistles of 1–2 kHz, followed by note that rises abruptly to peak of c. 3.5 kHz and falls again. Repetition gives sibilant lilting effect. Delivered with bill closed. Often given when in close company with female during intense agonistic BFW Assemblies and may accompany Beak-and-wattle Presentation and courtship feeding (Jenkins 1976; Lovegrove 1980). Also given before copulation, given softly by male when calling female from nest to be fed, when calling fledging young from nest and when calling dependent young to be fed (T.G. Lovegrove). **WHIU:** A reedy whistle given by males during intense agonistic BFW Displays and Assemblies. Also given by both adults and independent young as a threat when alone and when intruder encountered. May also be used to threaten young when they reach point of independence, to drive them from territory (T.G. Lovegrove; see Social Behaviour). **CLARINET SONG:** Low-pitched harmonious song, normally consisting of two notes: the first a steady tone consisting of four harmonics, followed by a second almost pure-toned whistle (Jenkins 1976). Sometimes given during BFW Displays (O'Callaghan 1980; see Social Behaviour). **PIPING:** A high-pitched, pure tone whistle; given in short bursts, usually not loudly, and with bill closed. Given only very occasionally: sometimes heard when two or more pairs come together during intense agonistic encounter; and usually followed frequent courtship feeding. Not certainly known to be given by males (Jenkins 1976; see Adult female below). **CHUTTERING:** A very soft song, audible only at close range. Usually associated with courtship feeding (Jenkins 1976); also used when calling young from nest when fledging, as a contact call with fledgelings, and when showing young where to roost (T.G. Lovegrove). Soft pips described by Kendrick (1964) and soft calls given by male before copulation in SI (Hooson & Jamieson 2003b) probably Chuttering. **ZWEET:** A whispering call, rendered as *zweet zweet zweet* or *zweit zwit zee* given softly by males during Archangel Display (Lovegrove 1980; see Sexual behaviour). **Alarm Calls** **GET-UP CALL:** A loud, abrupt exclamation, given by both sexes, in alarm and some-

times by females when returning to nest: consists of a short, loud, strongly accented note with marked descending cadence, followed by much weaker note, as if saying *GET-up*, and which is almost always followed by a Short Chatter (Jenkins 1976). Quick series of agitated notes, rendered as *tit-tee-ta-tee-ta-tee* repeated a few times, to presence of Southern Boobook (Blackburn 1964; Kendrick 1964; Oliver) possibly same as Get-up Call. **ZIT NOTE:** In anxiety, often give an irregularly repeated, high-pitched *zit* or *seet*, which is difficult to locate. Often uttered when approached by people and the first call an observer may hear when Saddleback found or disturbed (e.g. Jenkins 1976; Falla *et al.* 1981). Also see adult female below. **Other vocalizations** Other renditions of songs and calls (e.g. Kendrick 1964; Turbott 1967; Falla *et al.* 1981; Oliver) no doubt describing those above but not always possible to allocate to contemporary understanding of vocalizations.

**Adult female Songs** As adult male, adult female utters several types of song that can be separated into Loud Songs and Quiet Songs. However, the only Loud Songs given by female are several types of Chatter Songs, the most distinctive of which is Short Chatter; female does not give MRS. Quiet Songs of female include Triple-note Call (TNC), GPW Song, Growl Song, Chuttering, Piping and Sweet-sweet (Jenkins 1976; Lovegrove 1980; T.G. Lovegrove). **CHATTER SONGS:** Have four types of Chatter Songs (Long, Short, Mobbing and Roosting Chatter) that sound similar to those of male and used in the same circumstances (see above). The most distinctive is Short Chatter which, although similar to male Short Chatter on a sonagram, has a distinctive timbre and is often given during duets of pair, announcing presence of intact pair-bond to both neighbouring territorial birds and intruders (see Social Behaviour; also see Duets above). Sonagram D shows Short Chatter Song of a female from Cuvier I. Females thought to be responsible for Short Chatter Sequestrative Singing during winter (Jenkins 1976). Short Chatter may also be given when returning to nest after period of foraging and preening (see Relations within family group). Calls rendered as sharp *cheee cheee cheee* (Hooson & Jamieson 2003b) or *chee-chee-chee* call (Blackburn 1966) may refer to female Short Chatter. **TRIPLE-NOTE CALL (TNC):** Distinctive song of three notes, each higher pitched and louder than the last, and finishing with strong whistle that swells in volume at the end; very occasionally, the last note repeated (Sonagram E). Carries farther than other female Quiet Songs (Jenkins 1976). The 'low, musical whistle, repeated once or twice' described by Buller (Turbott 1967) probably this call. Often given with low bow and slight fanning of tail during BFW Displays with mate (including when displaying to Bellbirds or Tui close to nests) and during BFW Assemblies; to maintain contact with male when they are foraging close together, to greet male when pair see one another in morning after leaving roost, and in courtship feeding (O'Callaghan 1980; Lovegrove 1980; see also Social Behaviour). Also given by independent young (immatures) meeting an immature male while foraging



C Four Note Warble (After Jenkins [1976])



D Short Chatter Song (After Jenkins [1976])

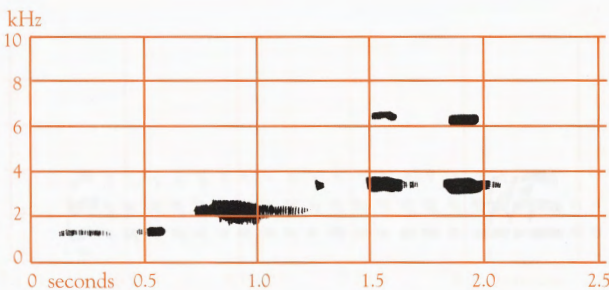
(see Sexual behaviour). **GPW SONG:** Consists of two buzzing notes followed by plosive sound that merges into slightly descending whistle. First buzzing note usually longer than second (Jenkins 1976). Usually given with low bow and slight tail fan. May be given during BFW Display (including when displaying to Bellbirds or Tui close to nests). Sometimes given strongly and harshly by female if foraging alone and she encounters intruder in territory, thus alerting male, who arrives quickly to join in territorial defence; as a result this call may initiate a BFW Assembly. Softer version of call also given when calling fledging young from nest (T.G. Lovegrove). **GROWL SONG:** Harsh growl-like sounds that start with short, simple, rapid vibratory note followed by lower-pitched buzzing tone with much slower modulation, and ending with longer rapid vibratory sequence that can sometimes be broken down into two or three notes (Jenkins 1976). Sometimes given with head stretched out and lowered slightly during BFW Displays; also given in response to intrusion by another bird or other disturbance, male responding immediately and feeding female (Jenkins 1976; O'Callaghan 1980; see Social Behaviour). **CHUTTERING:** Very soft song, audible only at close quarters. Usually associated with courtship feeding (Jenkins 1976). Also used when calling young from nest when fledging, as a contact call with fledgelings and when showing young where to roost (T.G. Lovegrove). Soft pips described by Kendrick (1964) and peeps given by female shortly before copulation in SI (Hooson & Jamieson 2003b) probably Chuttering. **PIPING:** Given by female at times of peak intensity during BFW Assemblies, often when male is close alongside (T.G. Lovegrove); also see comments in Adult male above. **SWEE-SWEE:** Given by female just before copulation in response to Chuttering and Sree-ree call from male (NI) (T.G. Lovegrove). **Alarm calls** As those of adult male (q.v.). Zit Note as male but also given at intervals when returning to nest to incubate or brood (Blackburn 1966; see Relations within family group). **BEGGING CALL:** When incubating female is called from nest to be fed by male, she squeals and vibrates wings in manner of a young bird while being fed (T.G. Lovegrove). **Other vocalizations** Other renditions of female songs and calls (e.g. Kendrick 1964; Blackburn 1966) no doubt describing those above, but not always possible to allocate them to these descriptions.

**Young** (See also Relations within Family Group above) Fledgelings utter continuous, very soft, peeping sounds and squeal and vibrate wings when begging or while being fed (cf. incubating female above). When young are left alone, even when parents not far away, but out of view, fledgeling calls change to one of mild alarm *cherp...cherp...cherp*. This is the Lost-Contact-With-Parents call, which is much louder and more persistent than the peeping call. When fledgelings lost contact with parents for longer periods they uttered a disjointed loud chatter, like that given by adults, but sounding quite unpractised (Jenkins 1976; Lovegrove 1980). When juveniles c. 7 months old, practically full range of adult quiet songs heard; males give 4NW, Whiu and Sree-ree, and females

give TNC, GPW, Chuttering and Growl. On Lady Alice I., one juvenile pair was heard to give all the above songs at 4 months of age. When juveniles meet each other, males give 2, 3 or 4NW, and females give TNC; each vocalization restricted to sex (Jenkins 1976).

**BREEDING** Based on contribution by T.G. Lovegrove. Reasonably well known. Many DETAILED STUDIES: NI: On Hen I. Jan. 1964 and Nov. 1965 (Blackburn 1964, 1966); on Cuvier I., 1978–79 (Lovegrove 1980); on Kapiti I., 1981–85 and 1987–90, on Cuvier I., 1986–87, and on Little Barrier I., 1984–85 (Lovegrove 1982, 1983, 1984, 1985a,b, 1992, 1996b); and on Mokoia I., 1992–97 (Armstrong *et al.* 2005). SI: On Motuara, Ulva and Breaksea Is, Sept. 2001–Feb. 2002 (Hooson & Jamieson 2003b, 2004).

**Season** Varies, both annually and with location (see below); number of clutches and broods raised per season also varies (see Laying for details). For all studied populations combined, clutches recorded early Aug. to mid-Apr.; and fledging or dependent young, or breeding, generally recorded till Mar.–Apr., though fledging recorded as late as May on Mokoia I. (see below for details). Duration of season and number of clutches per season possibly influenced by density of population: in low-density populations following translocation, breeding season can be prolonged (Lovegrove 1984; Craig 1994; Heather & Robertson 2000; Hooson & Jamieson 2003b) and pairs usually lay more than one (and up to four) clutch per season (see Laying). In established high-density populations (c. 5–10 years after translocation, e.g. Cuvier I.), usually lay only one clutch per season (Lovegrove 1980, 1996b). NI: In long-established population on CUVIER I., breeding extends from Nov. to Mar., and birds normally single-brooded. In 1986–87, start of incubation ranged from 4 Nov. to 19 Dec. (n=54 clutches); allowing 45 days for incubation and nestling periods combined, and 30–40+ days for young to become independent (Lovegrove 1996b), last broods would have become independent in mid- to late Mar. During 1978–79 season, incubation recorded from mid- to late Nov., and many young were independent by second week in Mar. (Lovegrove 1980). In low-density population on KAPITI I., 1981–84 and 1987–90, breeding season longer than on Cuvier I. and birds usually raised multiple broods. Start of incubation varied from year to year; start of incubation of first and last nests for seven seasons as follows: 1981–82, 10 Nov. and 21 Mar. (n=21 clutches); 1982–83, 8 Aug. and 8 Feb. (n=19); 1983–84, 9 Sept. and 12 Apr. (n=24); 1984–85, 3 Oct. and 2 Mar. (n=15); 1987–88, 31 Oct. and 10 Apr. (n=13); 1988–89, 26 Aug. and 31 Mar. (n=49); 1989–90, 29 Sept. and 20 Mar. (n=52) (Lovegrove 1982, 1983, 1984, 1985a; T.G. Lovegrove). Other records: fledgelings late Jan. to early Apr. (Wilkinson 1927; Wilkinson & Wilkinson 1952). At low density on LITTLE BARRIER I., in first season after release, in 1984–85 (cf. Kapiti I. in same season; see above) start of incubation of first and last clutches, 3 Oct. and 25 Dec. (n=13 clutches) (T.G. Lovegrove). Other records: eggs late Dec. (Turbott 1967), and dependent young early Apr. (CSN 34). On MOKOIA I., breed Sept.–May and usually raise more than one brood, except for first-year pairs, which normally start late and only have one attempt (Armstrong *et al.* 2005; I. Castro); first eggs laid Sept.–Oct., and last young fledge Mar. to early May; for 5 years, months of first egg and of last fledging were: 1992–93, Oct. and early May; 1993–94, late Sept. and late Mar.; 1994–95, late Sept. and early Apr.; 1995–96, Oct. and early Apr.; 1996–97, Oct. and May. In first year, population at low density after reintroduction but population thought to be near carrying capacity for last two years (Armstrong *et al.* 2005; D.P. Armstrong). On HEN I., eggs recorded early Nov. to late Jan. (Blackburn 1964, 1966; CSN 1); and nestlings Dec. (CSN 1); dependent fledged young Nov. (Blackburn 1966,



E Triple-note Call (After Jenkins [1976]).

1967) and Jan. to early Feb. (Blackburn 1964; Merton 1965b). On Tiritiri Matangi I., eggs laid from late Sept. (Stamp 1999; CSN 34) with young recorded in Oct. (Stamp 1999) and Jan. (CSN 37). On Whale I., nestlings recorded from mid-Nov. (Brunton 2000). At Mt Bruce National Wildlife Reserve, a captive pair laid in early Sept. and young fledged in mid-Oct. (Merton 1965b). SI (nominative *carunculatus*): On MOTUARA I., clutches (n=12) late Oct. to mid-Dec.; nestlings Dec.–Jan.; and fledged young Dec. to late Jan.; breeding may have been delayed in 2001–02 season as a result of dry weather (Hooson & Jamieson 2003b, 2004). On ULVA I., clutches (n=17) recorded late Sept. to early Feb.; and fledged young in late Mar. On BREAKSEA I., clutches (n=12) early Oct. to late Nov.; and fledged young in early Jan. (Hooson & Jamieson 2003b) and Mar. (Rasch & McClelland 1993). Elsewhere round STEWART I., breeding recorded late Oct. to late Dec. (Solomon I.) with eggs and young in Nov. (Guthrie-Smith 1925), and fledgelings in late Feb. (Big I., Big South Cape I.) (Blackburn 1965).

**Site** Nests usually built in a hole or cavity in trunk or major branch of trees, such as Pohutukawa *Metrosideros excelsa*, Puriri *Vitex lucens*, Kohekohe *Dysoxylum spectabile*, Mahoe *Meliclytus ramiflorus*, Karaka *Corynocarpus laevigatus* and Snares Tree-daisy *Olearia lyallii*. Also often nest in other secluded sites, such as crevices between rocks or in cliff-faces; in or beneath large clumps of epiphytes, such as *Collospermum* and *Astelia*; crowns of tree-ferns *Cyathea*; among or at base of clumps of flax *Phormium*; or in hollows in ground, banks or beneath roots of trees. Occasionally in other sites, including: dense mass of coppicing shoots at base of Puriri tree; on ground among dense vegetation; and in artificial sites, such as inside derelict buildings (Mathews 1930; Sibson 1949; Wilson 1949; Blackburn 1964, 1965, 1966; Turbott 1967; Jenkins 1976; Lovegrove 1980, 1992, 1996b, 2004; Stamp 1999; Brunton 2000; Heather & Robertson 2000; Oliver; D.P. Armstrong; see below). Also readily use nest-boxes (Lovegrove 1991, 1992, 1996b, 2004; Pierre 1999; Stamp 1999; Stamp *et al.* 2002; Armstrong *et al.* 2005); on Tiritiri Matangi I., many birds use nest-boxes and such use has increased owing to shortage of natural cavities; design and position of boxes affect likelihood of use, with smaller boxes with larger entrances (14–16 cm high) with a northerly aspect (and thus possibly higher light intensities within), having greatest probability of being used (Stamp *et al.* 2002) (see Threats and Human Interactions for further discussion of nest-boxes). Usually nest close to, or on, ground (Falla *et al.* 1981; Heather & Robertson 2000; Oliver; see Measurements). On Breaksea I., where birds nested in exposed positions, nest openings faced from NE through E to SW, away from prevailing weather; nests on Motuara and Ulva Is less exposed, and nest openings more randomly distributed (see Hooson & Jamieson 2003b for further details). NI: On CUVIER I., of 89 nests in 1978–79 and 1986–87 seasons: 67 (75.3%) in holes and cavities in Pohutukawa trunks and branches; seven (7.9%) among leaf-bases of epiphytic *Collospermum* clumps; six (6.7%) in crowns of Silver Fern *Cyathea dealbata*; three (3.4%) in cavities in Mahoe trunks; two (2.2%) on ground among dense grasses and ferns; and one (1.1%) each in hole in Puriri branch, in cavity in broken-off Silver Fern trunk, inside hanging dead Nikau Palm *Rhopalostylis sapida* frond base, and in cavity inside wall of derelict building (Lovegrove 1980, 2004 [photo of nest in building]; T.G. Lovegrove). On LITTLE BARRIER I., of ten nests, 1984–85 season: five among leaf-bases of *Collospermum* clumps (both epiphytic and on ground); two in cavities in banks; and one each in hole in trunk of large Northern Rata *Metrosideros robusta*, cavity in rotted trunk of Towai *Weinmannia silvicola*, and cavity in rotted Rewarewa *Knightsia excelsa* stump (Lovegrove 1985b). On KAPITI I., of 66 nests, 1981–85, before introduction of nest-boxes: 18 (27.3%) in cavities in trunks and branches of

Mahoe; 15 (22.7%) among leaf-bases of *Collospermum* clumps (both epiphytic and on ground); six (9.1%) in holes or rotted cavities in trunks of Northern Rata; three (4.5%) in cavities in rotted stumps; three (4.5%) in cavities in trunks of Pukatea *Laurelia novae-zelandiae*; three (4.5%) in cavities in trunks of Kohekohe; three (4.5%) in cavities and crevices in banks and rocky bluffs; two (3.0%) in broken-off trunks of Mamaku *Cyathea medullaris*; two (3.0%) in cavities in trunks of Broadleaf *Griselinia littoralis*; and one (1.5%) each in crotch between Northern Rata branches, in crown of Mamaku, in hole in trunk of Akiraho *Olearia paniculata*, in hole in trunk of Hinau *Elaeocarpus dentatus*, in cavity in rotted Tawa *Beilschmiedia tawa* stump, in hole in trunk of Tarata *Pittosporum eugenioides*, and among leaf-bases of epiphytic Wharawhara *Astelia banksii*. Of 110 nests, 1987–90, after introduction of nest-boxes: 65 (59.1%) in nest-boxes; 18 (16.4%) in cavities in trunks and boughs of Mahoe; 14 (12.7%) among leaf-bases of *Collospermum* clumps (both epiphytic and on ground); three (2.7%) in roost-boxes; two (1.8%) in broken off Silver Fern stumps; two (1.8%) in cavities in banks; and one (0.9%) each in cavity in Northern Rata stump, in hole in trunk of Karaka, in cavity in trunk of Kohekohe, in cavity among aerial roots of Pohutukawa, in hole in trunk of Five-Finger *Pseudopanax arboreus*, and in cavity in base of trunk of Broadleaf. SI: On MOTUARA I., of 13 nests: six in hollows (three in Mahoe, two in fallen log and one in rock bluff); three in nest-boxes; and one each in flax, on ground, beneath debris caught in vegetation and in crown of tree-fern. On ULVA I., of ten nests: eight in hollows (four in Southern Rata *Metrosideros umbellata*; two in Kamahi *Weinmannia racemosa*; two in fallen logs); and one each under collected debris in vegetation and in crown of tree-fern. On BREAKSEA I., of 15 nests: ten in flax bushes; four in hollows (two in fallen logs, one in Kamahi, and one in unidentified tree); and one on ground. Reported to nest in muttonbirders' buildings on Big and Kundy Is, and one found in flax kit in muttonbirders' hut on Solomon I. (Guthrie-Smith 1925; also see Parental anti-predator strategies). **RE-USE OF SITES:** Re-use of natural nest-cavities seldom seen in NI subspecies (see below), *contra* earlier claim that re-use sites for many seasons (Buller 1888; Turbott 1967). One nest on Hen I. reported used in two successive years (Moncrieff 1929). Between 1981 and 1985 on Kapiti I., only two of 66 sites (3.0%) were re-used; in both cases these were used for second and third attempts in same season, and both were cavities in hollow Mahoe trees. After 1987, when nest-boxes provided on Kapiti I., of 65 nests in boxes, five (7.7%) were re-used either in same or consecutive seasons. One female used same box in all three seasons 1987–90, even though nest in 1987–88 was depredated by a Southern Boobook and nest in 1988–89 season failed as a result of a mite infestation; in 1989–90, second and third broods fledged successfully from this nest-box. This female also re-used another box nearby consecutively in 1988–89 and 1989–90 seasons. Two other females re-used boxes in consecutive seasons, while a third re-used a box in first and third season. In all cases for these last three females, first broods had fledged successfully. None of 45 natural nest-sites between 1987 and 1990 on Kapiti I. was re-used. On Tiritiri Matangi I., natural cavities scarce, and nest-boxes often re-used regardless of previous mite infestations (Stamp *et al.* 2002). On Motuara, Ulva and Breaksea Is, no sites (n=38, including three in nest-boxes) were re-used within a season (Hooson & Jamieson 2003b). **MEASUREMENTS: HEIGHT OF NESTS (m):** Depends on age and height of forest, and thus availability of holes in trees. NI: Height of natural sites (nest-boxes mostly placed 1.5–2 m high, out of reach of Brown Rats but within easy reach of human observers): on Cuvier I., 3.4 (5.5; 0–8.0; 54); on Little Barrier I., 4.8 (5.3; 0–15; 10); on Kapiti I., 2.5 (3.1; 0–18.0; 109). Including nest-boxes, combined height distribution for

Little Barrier, Cuvier and Kapiti Is (n=241 nests, including 68 in nest-boxes): 14.9%, 0–1 above ground; 36.1%, 1–2 (including 41 in nest-boxes); 25.7%, 2–3 (including 26 in nest-boxes); 5.8%, 3–4 (including 1 in nest-box); 3.3%, 4–5; 5.0%, 5–6; 3.3%, 6–7; 1.2%, 7–8; 1.2%, 8–9; 0.4%, 9–10; and 2.9%, >10 (Lovegrove 1996a; T.G. Lovegrove). Also on Cuvier I., 1970–74, 3.0 (1.63; 1.0–5.0; 4) (Jenkins 1976); and Kapiti I., 1925–31, up to 6.1 (Wilkinson 1927). On Hen I., 3.7 (4.82; 0.5–15.2; 8) (Blackburn 1964, 1966; Oliver). **SI:** On Motuara, Ulva and Breaksea Is, 1.5 (1.46; 37); Motuara I., 1.6 (2.13; 0–7.55; 13 [including three in nest-boxes]); on Ulva I., 2.0 (0.82; 1.18–3.60; 10); on Breaksea I., 1.0 (0.71; 0–2.66; 14); no significant difference in height between the three islands (Hooson & Jamieson 2003b). On Solomon I., from several centi-metres to c. 3.7 m (Guthrie-Smith 1925; Oliver). **DIMENSIONS OF ENTRANCES TO NEST-HOLES (cm):** On Cuvier I., 1986–87 (sites in trees only): height of entrance, 27.0 (23.17; 6.5–90.0; 42) and width of entrance, 10.3 (7.1; 4.5–40.0; 42) (T.G. Lovegrove). On Motuara, Ulva and Breaksea Is: height of entrance 21.2 (17.4; 19) and width of entrance 17.6 (13.9; 19); on Motuara I., 15.7 (5.7; 10.2–28.0; 9) and 13.3 (5.1; 6.5–23.0; 9); on Ulva I., 30.1 (24.6; 10.0–88.0; 8) and 21.1 (20.4; 6.0–66.0; 8); on Breaksea I., 10.5 (7.0–14.0; 2) and 23.0 (17.0–24.0; 2); no significant difference in dimensions between the three islands (Hooson & Jamieson 2003b). **DISTANCE OF NESTS FROM ENTRANCE HOLES** (for nests in trees only where measurements possible [cm]): On Cuvier I., 1986–87: 34.3 (22.6; 10–110; 36) (T.G. Lovegrove). On Hen I., nests 22.9 (Sibson 1949), 45.7 (Blackburn 1966) and 61 (Oliver) from entrance hole.

**Nest, Materials** Nest cup-shaped, and made of plant materials available close at hand. Base loosely made of twigs up to 20.5 cm long (e.g. of Kanuka *Kunzea ericoides*, Manuka *Leptospermum scoparium*, Mahoe), bark, leaves and leaf-skeletons (e.g. of Mahoe), roots, root fibres and rootlets, fern pinnae (e.g. of Mamaku, Silver Fern) and fronds (e.g. of Thread Fern *Blechnum filiforme*, Common Shield Fern *Polystichum richardii*, filmy ferns *Hymenophyllum*), and dry leaves and fibres of Nikau Palm up to 64 cm long; moss or lichen may be added occasionally. Nest-cup usually lined with fine bark (e.g. papery inner bark of Lacebark *Hoheria populnea* and Whau *Entelea arborescens*), fine grasses (e.g. *Uncinia* and *Carex*), or scales of tree-ferns (e.g. Mamaku and Silver Fern) but may also be lined with leaf-stalks, feathers, twigs or liverwort (Hutton 1871; Hutton & Drummond 1904; Moncrieff 1925, 1929; Wilkinson 1927; Mathews 1930; Blackburn 1964, 1965, 1966; Turbott 1967; Jenkins 1976; Lovegrove 1980; Falla *et al.* 1981; Heather & Robertson 2000; Hooson & Jamieson 2003b; Oliver; see below). However, nests made primarily of plant material, with no feathers observed in any of 261 nests on Cuvier, Little Barrier and Kapiti Is (T.G. Lovegrove). On Hen I., some nests made entirely of fine bark of Kanuka and Lacebark; and one female twice seen gathering spider web from knotholes during nest-building (Blackburn 1966). **MATERIALS:** Of 37 nests on Motuara, Ulva and Breaksea Is, **MATERIAL IN BASES** included: Kanuka (recorded in 10 nests); Southern Rata (7); Mahoe (6); Rimu *Dacrydium cupressinum* (2); Turpentine Scrub *Dracophyllum longifolium* (2); Mountain Flax *Phormium cookianum* (9); unidentified ferns (8); Hound's Tongue Fern *Microsorium pustulatus* (6); Filmy Fern *Hymenophyllum dilatatum* (2); tree-ferns, including Wheki *Dicksonia squarrosa* and Soft Tree-fern *Cyathea smithii* (6); Tree Fuchsia *Fuchsia excorticata* (1); Mamaku (2); Kokomuka *Hebe elliptica* (2); Kiekie *Freyinetia banksii* (1); moss (3); lichen (2); *Uncinia* (1); dead leaves (5); and leaf-skeletons (5). Of these nests, **LINING MATERIAL** included: grasses (26), including *Uncinia* (12); tree-ferns (11); Kanuka (10); flax (8); Mamaku (2); Turpentine Scrub *Dracophyllum longifolium*; (2); Kiekie (2); Akiraho (1); Tree Fuchsia (1); Mahoe (1); *Carex* (1); unidentified fern (1); leaf-skeletons (2); and rotten wood (2)

(Hooson & Jamieson 2003b, which see for details of individual islands). **CONSTRUCTION:** Nest built by female only (Blackburn 1966; Lovegrove 1980; Stamp 1999; Hooson & Jamieson 2003b); female collects material and builds nest while male defends site and feeds female at frequent intervals. Material usually collected from a small area near nest; at one nest, female arrived with material at intervals of c. 6 min, remaining at nest for c. 1 min per visit; at another, female arrived every 2 min. Building mainly in morning; on Motuara, Ulva and Breaksea Is, building appeared most intense between 06:30 and 09:00, and was not observed after 11:30; at one nest on Hen I., building stopped c. 13:00. Time to complete nest not known; on Hen I. one pair seen building 11–13 Nov. and female incubating during afternoon of 15 Nov. (Blackburn 1966); and on Cuvier I., a partly completed nest, without lining, found 23 Nov., was lined with tree-fern scales by 26 Nov. and first egg laid by 09:00 on 28 Nov. (Lovegrove 1980). **MEASUREMENTS:** One nest on Hen I. was 4 cm deep with an inner diameter of 9.5 cm (Blackburn 1966).

**Eggs** Eggs of NI and SI subspecies similar in appearance (Stead 1936) but eggs of *rufusater* of NI slightly smaller than those of nominate *carunculatus* of SI (Oliver; see Measurements). Oval; ground-colour described as white, very pale brown, grey, pale grey, pinkish grey, and sometimes purplish grey (Hutton & Drummond 1904; Mathews 1930; Sibson 1949; Lovegrove 1980; Falla *et al.* 1981; Heather & Robertson 2000; Hooson & Jamieson 2003b; Oliver). Marked all over with spots, blotches and streaks, of several colours, generally more concentrated at larger end (Mathews 1930; Lovegrove 1980; Heather & Robertson 2000; Hooson & Jamieson 2003b; Oliver). Markings described variously as purplish pink, pale brown, reddish brown, brown, dark brown, purplish brown, mauve, violet, pale purple, dark purple, brownish grey and black (Hutton & Drummond 1904; Mathews 1930; Sibson 1949; Lovegrove 1980; Falla *et al.* 1981; Hooson & Jamieson 2003b). Ground-colour can sometimes be lighter at smaller end (Mathews 1930). One egg from set of two taken on Hen I. had much paler ground-colour than other egg of set (Sibson 1949), a phenomenon also seen elsewhere (T.G. Lovegrove). **MEASUREMENTS:** Subspecies differ; comparison of egg-lengths from various literature sources indicate eggs of *carunculatus* (SI) c. 2.5 mm longer on average than eggs of *rufusater* (NI) (Hooson & Jamieson 2003b, which see for sources of data). **NI:** Stanley and Kapiti Is combined, 28.9 (0.89; 24 eggs) × 22.3 (0.69); Stanley I., 28.9 (1.18; 26.9–30.1; 8) × 22.0 (0.93; 21.1–23.5); Kapiti I., 28.9 (0.79; 27.7–30.5; 16) × 22.3 (0.53; 21.5–23.6) (T.G. Lovegrove); Hen I., 30 × 21.4, 29.8 × 22.5; Little Barrier I., a clutch of three 29.2 × 22.9 (Oliver). **SI:** On Motuara, Ulva and Breaksea Is combined, 32.4 (1.31; 43 clutches [eggs within clutches were averaged]) × 22.2 (0.46); on Motuara I., 32.6 (1.25; 30.28–34.42; 12 clutches) × 22.5 (0.31; 22.06–23.02); on Ulva I., 31.4 (1.22; 30.20–33.38; 7 clutches) × 21.9 (0.37; 21.54–22.56); on Breaksea I., 32.5 (1.22; 30.26–34.78; 24 clutches) × 22.1 (1.76; 21.12–23.12) (Hooson & Jamieson 2003b). **SI,** 30.6 (1.2; 29.0–32.0; 6) × 21.7 (1.27; 20.0–23.5) (Oliver).

**Clutch-size** One to four, usually two, less often three (Mathews 1930; Turbott 1967; Falla *et al.* 1981; Craig 1994; Stamp 1999; Heather & Robertson 2000; Oliver; I. Castro). **NI:** On Kapiti I., 1981–90, 2.33 (0.6; 1–4; 140). On Cuvier I., 1986–87, 2.02 (0.3; 1–3; 44). On Little Barrier I. 1984–85, 2.50 (0.6; 2–3; 6) (Lovegrove 1996b). On Tiritiri Matangi I., 1984–86 and 1989–90, 2.39 (0.63; 1–4; 54) (T.G. Lovegrove & B. Walter); 1–4, usually 2–3 (n=41) (Stamp 1999). **SI:** On Motuara, Ulva and Breaksea Is, 2001–02, 1.95 (0.23; 37); C/1 × 2, C/2 × 35 (Hooson & Jamieson 2003b); on Motuara I., 2.0 (n=14); on Breaksea I., 1.9 (0.24; 16); on Ulva I., 2.0 (0.17; 11) (Hooson & Jamieson 2004 [includes all clutches from Hooson & Jamieson 2003b]).

**Laying** Probably at intervals of c. 24 h (Blackburn 1966; Lovegrove 1980). For three nests on Cuvier I.: (1) First egg laid by 09:30 on 28 Nov. and second between 09:00 and 14:00 on 29 Nov.; (2) Female very restless near nest-tree on evening of 25 Nov., and male fed female several times and also performed two brief Archangel Displays; first egg laid by 11:30 on 26 Nov. and second by 15:00 on 27 Nov.; (3) First egg laid by 12:00 on 6 Dec., and second by 08:00 on 7 Dec. (Lovegrove 1980). **DOUBLE-BROODING:** Re-lay after failure and success (e.g. Hooson & Jamieson 2003b), though number of clutches per season varies, possibly in part influenced by density of population. In low-density populations (e.g. following translocation), reproductive rate is high (Armstrong *et al.* 2005) and pairs commonly lay more than one, and up to three or four, clutches per season (Lovegrove 1984; Craig 1994; Heather & Robertson 2000; I. Jamieson; I. Castro; see below; also see Season); in established populations with higher densities (from c. 5 years after translocation, e.g. Tiritiri Matangi I., Mokoia I., Cuvier I.), reproductive rate declines (Hoyle 1993; Armstrong *et al.* 2005) and pairs usually produce only one clutch per season (Lovegrove 1980, 1996b). **NI:** Mean number of clutches per pair per season including failed nests (Kapiti, Cuvier and Little Barrier Islands): on Kapiti I., 2.29 (n=86 pairs); on Cuvier I., 1.08 (n=54); on Little Barrier I., 1.44 (n=9) (Lovegrove 1996b; T.G. Lovegrove); on Tiritiri Matangi I., 1.6 (n=43) (Stamp 1999). In another study on Cuvier I., two of 14 broods fledged were second broods of season (Jenkins 1976). On Mokoia I., up to three clutches laid per season (I. Castro). **SI:** Mean number of clutches per pair per season including failed nests: on Motuara I., 1.1 (0.26; 14); on Breaksea I., 1.0 (n=16); on Ulva I., 1.5 (0.53; 11). Birds on Ulva I. produced significantly more clutches/pair/season than those on Motuara or Breaksea Is (Hooson & Jamieson 2004). In earlier work on Motuara, Ulva and Breaksea Is, most pairs said to lay only a single clutch (Hooson & Jamieson 2003b), but these pairs were not followed for entire breeding season and double-brooding probably missed (I. Jamieson).

**Incubation** By female only (Blackburn 1966; Turbott 1967; Williams 1976; Lovegrove 1980; Stamp 1999; Heather & Robertson 2000; Hooson & Jamieson 2003b); early record of male apparently sharing incubation (Reischek 1887 [repeated in Oliver]) incorrect (Blackburn 1966). Incubation said to begin after laying of second egg (Falla *et al.* 1981), and in three nests on Cuvier I. (see Laying above), incubation began once second egg laid (Lovegrove 1980). At one site on Tiritiri Matangi I., a female attempted to incubate two nests simultaneously, alternating stints between them, but eventually abandoned both (CSN 34). On Cuvier (n=4 nests) and Hen (n=1) Is, 1978–79 (n=90 h 36 min obs. at five nests), mean length of incubation stints 35.8 min (8.13; 27.3–48.0) and mean absences 15.0 min (6.54; 9.9–25.7; 5). During drought on Cuvier I., 1986–87, incubation stints were shorter than above, e.g. at one nest on Day 7 of incubation (n=3 h 27 min obs.), stints 18.9 min (9.51; 5–31; 13) and absences 6.23 min (1.83; 3–9; 13); on Day 12 (8 h 7 min obs.), stints 17.2 min (8.76; 1–37; 20) and absences 7.15 min (3.53; 1–11; 20); on Day 18 (6 h 41 min obs.), stints 17.5 min (6.68; 5–27; 16) and absences 7.56 min (2.80; 4–13; 16). At a nest on Hen I.: 2 days before hatching, female incubated in stints of 42 min (27–59; 14) with average absences of 12 min (3–17); on following day, average incubation stint 49 min and average absence 14 min; on day of hatching, average stint remained 45 min (n=8) with absences of 10 min till noon, when eggs hatched, despite being much colder and with gale-force winds. First and last departure from nest over 3-day period varied from 05:43 to 05:46 and 18:11 to 18:16 respectively (Blackburn 1966). Male feeds female during incubation; usually near entrance to nest or close to nest (Blackburn 1966; Williams 1976; Falla *et al.* 1981; Lovegrove 1980; I. Castro;

T.G. Lovegrove); on Motuara, Ulva and Breaksea Is, males fed females within 1–3 m of nests (Hooson & Jamieson 2003b). Male calls female off nest with Quiet Songs (e.g. 2, 3 or 4NW, Sree-ree or Chuttering), and which often results in female taking a break from incubation. When fed by male, incubating female begs and flutters wings in an exaggerated manner and may squeal loudly, in manner of young bird being fed. After feeding female, male often performs BFW Display (with 2, 3 or 4NW), but bow usually less exaggerated than normal, tail not so fully fanned and Songs usually quiet. During absences from nest, female often feeds frenetically and is also often fed by male (Lovegrove 1980, T.G. Lovegrove). If not called off by male, female leaves nest quietly on her own and may give a few calls (Short Chatter or *zit* notes) only when well clear (20–30m) of nest (T.G. Lovegrove). During spells off nest, female often feeds frenetically and also often fed by male. When returning to nest, female often pauses briefly to preen and wipe bill, then returns quickly and directly, sometimes giving short Chatter Songs, *zit* or *Get-up* calls *en route*, with last few uttered at entrance to nest or even from within cavity (Lovegrove 1980; T.G. Lovegrove). On Motuara, Ulva and Breaksea Is, incubating females left eggs unattended for up to 14 min/h to forage with or be fed by male, or both; absences were less frequent during rain or colder weather. Incubating females also left nest twice when male absent, to drive off Bellbirds and another Saddleback (Hooson & Jamieson 2003b). Eggs sometimes found buried or partly buried in nest-material when female absent, but not known if this accidental or intentional (Guthrie-Smith 1925); many nests have deep cup with fluffy lining of fine, springy tree-fern scales, which when female absent, may tend to close over eggs, partly obscuring them (T.G. Lovegrove). **INCUBATION PERIOD:** *SUBSPECIES RUFUSATER:* c. 18 days (Heather & Robertson 2000; see below). For C/2 of a captive pair at Mt Bruce National Wildlife Reserve, 18 days, with both eggs hatching on same day (Merton 1965b). On Cuvier and Kapiti Is, c. 18 days (T.G. Lovegrove). **NOMINATE CARUNCULATUS:** c. 20 days (Heather & Robertson 2000); 20–21 days (Guthrie-Smith 1925; Oliver).

**Young** Altricial, nidicolous. Hatching appears synchronous. Both eggs of one C/2 said to have hatched at noon (Blackburn 1966). On Cuvier I.: in one nest, first egg hatched by 06:10 on 5 Jan., and eggshells carried from nest and dropped within c. 10 m at 13:25; second egg hatched between 13:15 and 18:25, when second chick was still wet and evidently just hatched (with half of eggshell still in nest); in another nest, one egg of C/2 hatched between 13:00 and 14:00, while other egg appeared to be infertile (T.G. Lovegrove). Naked and blind at hatching (Lovegrove 1985b). Young nestlings develop covering of down on head and back (Jenkins 1976). Three broods of two examined on Little Barrier I., 1984–85: Brood 1 at c. 4, 7 and 16 days old; Brood 2 at c. 12 days old; and Brood 3 at 20 days old. At c. 4 days (Brood 1), young had fine down on feather-tracts, with rest of head and body bare; remiges and rectrices undeveloped; eyes just slits; and obvious egg-tooth. At c. 7 days (Brood 1), down thicker, obscuring more of skin; remiges and rectrices in pin; eyes partly open; egg-tooth still conspicuous. At c. 12 days (Brood 2), black feathers of body and rufous feathers of upper-body beginning to show; remiges and rectrices just emerging from sheaths (e.g. p5 32.2 mm with 5 mm of vane showing); eyes open; egg-tooth still visible; small pips of wattles visible at gape; and legs and feet approaching adult size (i.e. big enough for banding with D-sized metal and PVC bands). At c. 16 days (Brood 1), black feathers of body and rufous upper-body feathers well developed, with c. 15 mm down adhering to head and back; remiges and rectrices emerged from sheaths (e.g. p5 34 mm long, with 14–15 mm of vane exposed); egg-tooth still visible; pips of wattles visible; eyes fully open; legs and feet roughly adult size. At c. 20 days, 6 days before these

young fledged (Brood 3), one chick noticeably larger than other in this brood, both with well-developed black-and-rufous contour-feathering, and some wisps of down remaining on nape and back; wing well grown; tail short (20–30 mm); eyes fully open; wattles, small pale-orange pips; legs and feet well developed; only larger chick stayed in nest when replaced with sibling (Lovegrove 1985b; see Plumages [Nestling] and Bare Parts for further details). Most down lost by time young fledge, but some remains adhering to sides of crown and nape, for c. 5 days after leaving nest (Jenkins 1976). Recommended age for banding at nest is 12–16 days, when 50–60 g and legs large and strong enough, but young not well enough developed to fledge prematurely (T.G. Lovegrove). **Growth WEIGHTS:** For three broods on Little Barrier I., 1984–85 (as above): Brood 1: at c. 4 days old, 18.5 and 21.0; at c. 7 days, 35.0 and 38.5; at c. 16 days, 58.3 and 65.2; Brood 2: at c. 12 days, 49.0 and 58.0; Brood 3: at c. 20 days, 48.5 and 62.0 (Lovegrove 1985b). **Parental care** All brooding by female (Blackburn 1966; Turbott 1967; Lovegrove 1980, 1992, 1996b; Falla *et al.* 1981; Hooson & Jamieson 2003b), who is fed both on and off nest by male during early stages of brooding period (Lovegrove 1980; Falla *et al.* 1981; Hooson & Jamieson 2003b; I. Jamieson; T.G. Lovegrove & C.R. Veitch), though on Mokoia I., male rarely feeds female after young hatch (I. Castro). Nestlings fed by both parents (Turbott 1967; Heather & Robertson 2000; Hooson & Jamieson 2003b; I. Castro; see below), though during first few days after hatching, male often passes food to female if she is on nest, and she in turn feeds chicks (Blackburn 1964, 1966; Falla *et al.* 1981; Stamp 1999; Hooson & Jamieson 2003b). However, male also feeds young directly when female away from nest, from first day after hatching (Lovegrove 1980; I. Castro; T.G. Lovegrove). **BROODING:** At one nest observed from day of hatching (eggs hatched at noon) to 07:10 the following day, average length of brooding stints 14.5 min (6–28; 21) and average absences from nest 7 min (2–14) (Blackburn 1966). At two other nests early in nestling phase on Hen I. ( $n=7$  h 58 min obs., Jan. 1979), mean length of brooding stints 32 min (17.4; 12–62; 6) and mean length of absences 29.4 min (10.67; 19–45; 9) (T.G. Lovegrove & C.R. Veitch). At one nest on Cuvier I. (Dec. 1979), mean length of stints of brooding and absences: 30.8 min (13.59; 15–59; 15) and 17.2 min (7.33; 10–35; 17) respectively on Days 3 and 4 of nestling period ( $n=12$  h 34 min obs.); and 20.3 min (8.47; 7–31; 9) and 17.7 min (7.91; 1–30; 9) on Days 6 and 8 ( $n=5$  h 42 min obs.) (T.G. Lovegrove & C.R. Veitch). At another nest on Cuvier I. (Dec. 1986), on Day 12 ( $n=8$  h 39 min obs.), excluding brief feeding visits, female probably on nest for total of 9 min only; on Days 17 (8 h 5 min), 23 (6 h 20 min) and Day 25 (2 h 15 min), adults visited nest only to feed young; young fledged on morning of Day 26. Female broods at night throughout nestling period, though towards end, female and young may roost perched on rim of nest or out of nest but still in nest-cavity (T.G. Lovegrove). **FEEDING:** At two nests on Cuvier I., rate of feeding increased over nestling phase. At one nest (Dec. 1979), parents made 2.96 feeding visits/h (27 by male, 20 by female; 15 h 54 min obs.) on Days 3 and 4; and 3.43 feeding visits/h (13, 11; 7 h obs.) on Days 6 and 8. At another nest (Dec. 1986), parents made 5.66 feeding visits/h (19, 30; 8 h 39 min obs.) on Day 12; 8.04 feeding visits/h (25, 40; 8 h 5 min obs.) on Day 17; 7.58 feeding visits/h (19, 29; 6 h 20 min obs.) on Day 23; 8.8 feeding visits/h (4, 7; 1 h 15 min obs.) on Day 25; and young fledged in morning of Day 26 (T.G. Lovegrove). **NEST-SANITATION:** By both sexes. Faecal sacs eaten or carried away; dirty nesting material removed. On Cuvier I., fresh nesting material occasionally added during incubation period, but none added after eggs hatched (Lovegrove 1980).

**Fledging to independence** **FLEDGING PERIOD:** Claim of c. 21 days (Heather & Robertson 1997) too short (D.P. Armstrong;

T.G. Lovegrove; see below). **SUBSPECIES RUFUSATER:** 22–24 days (Stamp 1999); 23–27 days (Lovegrove 1985b); normally 25–27 days but some may fledge earlier if forced from nests by starvation in dry years: on Cuvier I. in drought season of 1986–87, seven broods of two fledged between Days 21 and 23 but all except two of the young starved a few days after fledging (T.G. Lovegrove); a clutch raised in captivity fledged c. 27 days after hatching (Merton 1965b). Incubation and nestling periods combined, c. 45 days (Lovegrove 1996b; Stamp 1999), allowing c. 18 days for incubation and c. 27 days for nestling period (Lovegrove 1996b). **NOMINATE CARUNCULATUS:** Based on laying dates and weights and developmental stages, appears to correspond with period of 25–27 days recorded for *rufusater* (Hooson & Jamieson 2003b). At two nests on Cuvier I. (Jan. 1987): in one nest (observed 06:41–09:18) first chick fledged at 07:24 and second at 08:28; at second nest (observed 06:30–15:10), first fledged at 11:17 and second at 15:03 (T.G. Lovegrove). **Parental care** Adults call to young from just outside entrance with 4NW and Sree-ree Song (male) and GPW Song (female) and Chuttering (both sexes) to entice them to leave nest (T.G. Lovegrove). Newly fledged young can fly but not well (Lovegrove 1996b). In NI, fledgelings similar to adults in size but bill and tail noticeably shorter; one fledgeling had bill of 25 mm and tail of 66 mm (Merton 1965b). Fledgelings fed by both parents (Wilkinson & Wilkinson 1952; Turbott 1967; Lovegrove 1980; Heather & Robertson 2000; Hooson & Jamieson 2003b; Oliver). For three colour-banded pairs on Cuvier I. (1978–79), each with two colour-banded fledgelings, adults took one fledgeling each and always fed same one; adults occasionally seen to chase fledgelings being cared for by the other parent (Lovegrove 1980). In larger broods females often cared for two young and the male one, but reverse also seen. When females began incubating subsequent nests, males cared for young alone (Lovegrove 1984; Stamp 1999; Hooson & Jamieson 2003b). Fledgelings usually remain with parents for at least 4–6 weeks, which is about time eggs of subsequent brood hatch and males switch to helping female feed next brood; when there are no subsequent broods, fledgelings may remain with parents for several months (Falla *et al.* 1981; Lovegrove 1984; Armstrong *et al.* 2005; see Bonds [Parental care]). For behaviour of adults and young at independence, see Social Behaviour (Relations within family group).

**Success** **NI:** On KAPITI, CUVIER AND LITTLE BARRIER IS (Lovegrove 1996b), despite multiple clutches and prolonged breeding season, success was much lower on Kapiti I., where both Brown Rats and Kiore occur, than on Cuvier and Little Barrier Is, which support only Pacific Rat. On Kapiti I., of 156 nests (excluding those abandoned), 48 (30.8%) depredated, 191 young fledged, and 89 fledgelings lost. On Cuvier I., of 41 nests: six (14.6%) depredated, 65 young fledged and 11 fledgelings lost. On Little Barrier I., of 13 nests: three (23.1%) depredated, 20 young fledged and three fledgelings lost. Overall breeding success (probability of egg and nestling survival  $\times$  fledgeling survival to independence [assumed to become independent if survived to 30 days]) was  $0.68 \pm 0.003$  on Cuvier I.,  $0.52 \pm 0.006$  on Little Barrier I. and just  $0.22 \pm 0.003$  on Kapiti I. Nests on Cuvier I. were most likely to fledge young ( $0.83 \pm 0.03$ , cf.  $0.61 \pm 0.012$  and  $0.60 \pm 0.003$  on Little Barrier and Kapiti Is respectively); and fledgelings on Little Barrier ( $0.85 \pm 0.006$ ) and Cuvier ( $0.82 \pm 0.004$ ) Is had a much greater chance of surviving to independence than those on Kapiti I. ( $0.37 \pm 0.002$ ). On Kapiti I., most fledgeling mortality occurred during first 2 weeks after fledging (see Lovegrove 1996b: Fig. 2 for curve of survivorship from fledging to independence). Levels of predation similar for incubation and nestling periods at all three locations. Both Pacific and Brown Rats attacked nests, including nestlings, with Brown Rat the most important predator because, unlike Pacific Rats, they killed both adults

and young (Lovegrove 1996b). Also on *CUVIER I.*, pairs reared mean 1.86 fledgelings/brood (0.66; 1–3; 14) (Jenkins 1976). On *MOKOIA I.*, juvenile survival declined as population increased, and decline was closely correlated with number of breeding pairs. Older birds in better territories produced more young than younger birds, but overall success for all breeding pairs declined owing to density-dependent effects as population increased. Over 5 seasons, 1992–93 to 1996–97: pairs comprising two first-year birds fledged mean 1.7 (n=3), 0.9 (n=12), 0.6 (n=15), 1.1 (n=7) and 0.8 (n=5) young; pairs comprising one first-year bird and one adult (>1 year old) fledged mean of 2.5 (n=4), 2.9 (n=3), 2.0 (n=10), 1.9 (n=4) and 0 (n=2) young; and adult–adult pairs fledged mean 5.4 (n=6), 3.7 (n=11), 3.8 (n=23), 3.1 (n=20) and 3.4 (n=19) young. Overall decline in success for all pairs was associated with an increase in number of pairs from 14 in 1992 (the year of reintroduction) to c. 100 pairs in 1996 (Armstrong *et al.* 2005; D.P. Armstrong). **OTHER LOCATIONS:** On Tiritiri Matangi I., in 1985–86 season, nine breeding pairs produced 20 young (CSN 34); and in 1997–98 season, 42 pairs produced 39 young (Stamp 1999; Stamp *et al.* 2002); as the Tiritiri Matangi I. population increased, there was a density-dependent decline in juvenile survival (Hoyle 1993). On Motuara I., estimated ten fledgelings produced after introduction of 19 adults and seven subadults (Pierre 1999). On Breaksea I., at least 16 fledgelings reared after transfer of 59 birds the previous year (Rasch & McClelland 1993). On Hen I., in Jan. 1964, average size of broods of fledgelings may have been as low as one (Merton 1965b). **SI:** On *MOTUARA, BREAKSEA AND ULVA IS.*, during 2001–02 season: on Motuara I., pairs produced mean 2.0 eggs (0.0; n=14 clutches), 1.3 nestlings (0.76; 12) and 0.9 fledgelings/clutch/pair (0.80; 12) with total production 0.9 fledgelings/pair (0.80; 12); on Breaksea I., 1.9 eggs (0.24; 16 clutches), 1.1 nestlings (0.79; 14) and 0.6 fledgelings/clutch/pair (0.79; 7) with total production 0.6 fledgelings/pair (0.79; 7); and on Ulva I., 2.0 eggs (0.17; 11 clutches), 1.7 nestlings (0.40; 7) and 1.6 fledgelings/clutch/pair (0.51; 8) with total production 1.9 fledgelings/pair (0.89; 10). Pairs on Ulva I. produced significantly more fledgelings per clutch and per pair than those on Motuara or Breaksea Is. Hatching success lower on Motuara and Breaksea Is than on Ulva I., primarily as a result of greater incidence of egg infertility and embryonic death: on Motuara, of 28 eggs, 18% infertile and embryos died in 11%; on Breaksea I., of 30 eggs, 20% infertile and embryos died in 10%; and on Ulva I., of 30 eggs, 3.3% infertile and no embryonic deaths recorded. Failures resulting from nestling death were more common on Motuara (12.5%) than on Breaksea and Ulva Is (3% on both) (Hooson & Jamieson 2004, which see for additional measures of success). On Ulva I. during 2001–02 breeding season, adult–adult pairs produced mean 1.8 fledgelings/pair (1.18; 6), not significantly different from mean of 1.3 (1.50; 5) of adult female–yearling male pairs (Hooson & Jamieson 2003b). **PREDATORS OF YOUNG:** Pacific and Brown Rats (CSN 33, 34; as above); on Kapiti I., many fledgelings lost to unknown causes, and in view of known losses at ground roosts to Brown Rats, predation by these Rats at roosts suspected (Lovegrove 1996b). Avian nest-predators include Southern Boobooks and possibly Swamp Harriers and Weka (Hooson & Jamieson 2004; T.G. Lovegrove). Weka, which known to take fallen nestlings and active young on ground (Beauchamp 1996), seen to take fledgelings on Kapiti I.; fledgelings most vulnerable to Weka when they first left nest, when their flying skills were poor (Lovegrove 1996b). A Swamp Harrier took a juvenile on Cuvier I. (Lovegrove 1996b); and 17 nests known to have been depredated by Southern Boobooks (T.G. Lovegrove). Common Mynas also attacked nestlings on Tiritiri Matangi I. (CSN 37). Possums may also depredate nests; fur found clinging to entrance of a nest that had contained eggs (Lovegrove 1982; Brown *et al.*

1993). Nests and roosts vulnerable to predation because usually close to ground (see Social Organization: Roosting and Breeding [Site]); on Kapiti I., 81% of roosts (n=105) used by fledgelings and juveniles were  $\leq 1$  m from ground (Lovegrove 1996b). Young birds may select low roost-sites because of their poor flying ability, i.e. they are physically unable to reach elevated sites (Lovegrove 1996b).

**PREDATORS OF ADULTS:** Extinction from mainland caused mainly by spread of introduced mammals (see Threats and Human Interactions). Brown Rats kill nesting and roosting adults as well as young (Lovegrove 1996b; as above). Weka, Swamp Harriers and Southern Boobooks have all been recently recorded as predators of Saddlebacks and their young (Anderson 1992; Lovegrove 1996b; I. Castro) and New Zealand Falcons suspected in loss of some birds at Karori Wildlife Sanctuary (R.A. Empson). In pre-human times, predators were all birds and would likely have included Swamp Harrier, New Zealand Falcon, Weka, Laughing Owl *Sceloglaux albifacies*, Southern Boobook and, possibly, North Island Adzebills *Aptornis otidiformis* and South Island Adzebills *A. defosser* (McLean 1984; Worthy & Holdaway 2002).

**PLUMAGES** Prepared by J.S. Matthew. Probably naked at hatching. Nestling has down on head and upperparts by 4 days old. Fledge in juvenile plumage. Undergo a partial post-juvenile (first pre-basic) moult to first immature (first basic) plumage, starting when 1–2 months old. Acquire adult plumage in complete first immature post-breeding (second pre-basic) moult, when c. 1 year old. Thereafter, a complete post-breeding (pre-basic) moult each cycle produces successive adult (basic) plumages with no change in appearance. Two subspecies; nominate *carunculatus* described below based on examination of skins of 37 adults, nine first immatures and two juveniles from SI and islands round Stewart I. (AIM, AM, CM, MV, NMNZ).

**Adult (Definitive basic).** **HEAD AND NECK:** Entirely glossy black (glossy 89) with faint dark-bluish (ne) tinge in some lights. All feathers have concealed black-brown (119) or dark-brown (21) bases. **UPPERPARTS:** Extreme upper mantle, black (89), faintly glossy and with faint dark-bluish (ne) tinge visible in some lights; most feathers, black (89), those on lower mantle with broad red-brown (c132B, c32) tips that merge with rich red-brown (c132B, bright 32) rest of upperparts, which forms distinct saddle sharply demarcated from black of head and neck. All feathers have concealed grey (87) bases; feathers from mantle to uppertail-coverts also have concealed black-brown (119) band across centres. **UNDERPARTS:** Mostly black (89), tending slightly paler, black-brown (119) in centre of lower belly and vent, and with slight gloss and faint dark-bluish (ne) tinge to breast. Undertail-coverts, rich red-brown (bright 32). All feathers have concealed dark-grey (83) bases. **UPPERTAIL:** Rectrices, glossy black (89) with faint dark-bluish (ne) tinge in some lights. **UNDERTAIL:** Slightly paler than uppertail, glossy grey-black (c82) and lacks any hint of bluish tinge. **UPPERWING:** All marginal and median secondary coverts, glossy black (89) in centres, grading to blackish-brown (119) at bases, and with broad red-brown (c132B) tips. Greater secondary coverts, glossy black (89), grading to black-brown (119) at bases, and with broad rich red-brown (c132B) tips to outer webs and which extend narrowly to inner webs; innermost covert lacks red-brown tip, and outermost covert has only a small red-brown (c132B) subterminal spot to outer web. Secondary coverts combine to form large bright red-brown shoulder-patch which is continuous with concolorous saddle. Marginal and median primary coverts, glossy black (89). Greater primary coverts and alula, black-brown (119) with narrow glossy black (89) outer edges. Tertiaries: innermost, glossy black (89); outer two, black-brown (119) with glossy black (89) outer edges. Primaries and secondaries, black-brown



(119), fading to dark brown (121) with wear, and with concealed light-brown (c23) inner edges, and with narrow black (89) outer edges to all except p9 and p10. Shafts of remiges, dark red-brown (221A). **UNDERWING:** Most coverts, dark brown (21) with narrow blackish (c89) fringes at tips; marginal primary coverts, glossy black (89). Remiges, dark greyish-brown (ne) with light-brown (c25) shafts and narrow light-brown (c25) inner edges.

**Nestlings** Skin of nestling (AIM O4547) has dense cover of brown (223A) down on top of head and scapular area; down also described as black (I. Castro). For brood of two subspecies *rufusater* on Little Barrier I.: at c. 4 days old, down fine, black; at c. 7 days, down thicker, black; and at c. 16 days, c. 15 mm down still adhering to otherwise feathered head and back. For another brood of two on Little Barrier I., at c. 20 days, chicks had well-developed black and rufous contour-feathering and some wisps of down remaining on nape and back (Lovegrove 1985b). Down on top of head and on nape can persist in recently fledged birds (see below).

**Juvenile** Based on two skins (CM, NMNZ), one of which not fully grown. This is the Jackbird that confused early observers, who considered it another species *Creadion cinereus* (Buller 1888, Turbott 1967). Correctly identified as young of *carunculatus* by Potts (1873, 1882) and Guthrie-Smith (1925), and confirmed by Stead (1936). Differences from adult: Feathers of head and body softer and more loosely textured than in adult or first immature. **HEAD AND NECK:** Most of head and neck, dark brown (c223) with faint dark reddish-brown (c223A, 221A) tinge, richer dark red-brown (c32) on ear-coverts. Lores, eye-ring and anterior malar area, black-brown (119). Skin of another recently fledged bird, 38 days old (data from AIM), has traces of light-brown down on top of head; see also Jenkins (1976). **UPPERPARTS:** Entire upperparts, dark brown (c223A, c121) with faint red-brown (c32) wash, or faint and diffuse scalloping, from lower back to rump and uppertail-coverts; some scapulars have diffuse red-brown (c32) tips. **UNDERPARTS:** Entire underparts, warm brown (c23, c223A) with red-brown (132A) undertail-coverts. **UPPERTAIL:** Rectrices, dull black-brown (119) with diffuse warm-brown (c23, c223A) outer edges; shafts, red-brown (221A). Rectrices, narrower and more pointed at tips than in adult. **UNDERTAIL:** As uppertail, but ground-colour slightly paler (dark greyish [c83]); shafts, red-brown (221B). **UPPERWING:** All secondary coverts, marginal and median primary coverts, dark brown (c121) or blackish brown (c19) with warm-brown (23, 223A) fringes; lack red-brown shoulder-patch. Greater primary coverts and alula, blackish brown (c19) with narrow warm-brown (23) fringes. Remiges, dark brown (c219) with concealed light grey-brown (119D) inner edges, and narrow warm-brown (23) outer edges which are less distinct on outer 3–4 primaries. **UNDERWING:** All wing-coverts, greyish (c84) with warm-brown (23) fringes, which are very narrow on greater primary coverts. Remiges slightly paler than in adult, greyish brown (ne); inner edges as adult.

**First immature** (First basic). Description below based on birds with no active moult (i.e. not undergoing transition to adult plumage). First immatures also referred to as Jackbirds in the early literature. Very similar to juvenile, and this similarity has previously caused confusion over ageing and description of moult-cycles (Stead 1936; for NI birds see Jenkins & Veitch [1991] and Geographical Variation below). Differences from juvenile: Feathers of head and body textured as adult, less soft and not as loosely textured as juvenile. **HEAD AND NECK:** Slightly more olive-brown (c123) than juvenile. Most birds have patchy greyish-black (c82) feathering, contrasting with olive-brown feathers; some birds also have narrow light-brown (26) tips to some feathers. **UPPERPARTS:** Similar to juvenile but slightly more olive-brown (c123). In most birds, tips of scapulars, and most feathers of back, rump and uppertail-

coverts tend to richer red-brown (c32) or rufous-brown (ne), combining to form rufous-brown 'saddle' richer than in juvenile, but not as rich or prominent as in adult; some birds have 'saddle' no different from juvenile. **UNDERPARTS:** Slightly more olive-brown (c123) than juvenile. Most birds have varying greyish-black (c82) feathering, usually on breast; some birds also have narrow light-brown (26) tips to a few feathers. **TAIL:** Skins examined retained all juvenile rectrices. **UPPERWING:** All marginal and median coverts as adult. Some birds retain all juvenile greater secondary coverts but others replace these in post-juvenile moult; replaced coverts like those of adult, with red-brown (c132B) tips. Secondary-coverts combine to form small red-brown shoulder-patch which often mostly concealed by overlying scapulars. Most birds retain all juvenile greater primary coverts, alula and remiges, but some birds replace one or more tertials, with replaced tertials, glossy black, as in adult and contrasting with dark-brown retained juvenile tertials. **UNDERWING:** As adult but retain juvenile remiges.

**BARE PARTS** Based on photos (*Forest & Bird* No. 272: cover; and standard sources), museum labels (AM, MV) and other information as cited. Subspecies combined except where stated. **Adult** Bill, black (89). Iris, black-brown (c20); or dark brown (NMNZ). Orbital ring, dark grey (83); also described as yellowish grey (NMNZ). Facial wattle, pinkish red (10), orange-red (15) or orange (c16); on NI, described as usually bright orange or orange-red, becoming paler yellow when birds stressed (such as when handled) (Jenkins 1976), and becoming richer red when birds excited (such as in territorial encounters or courtship feeding) (Lovegrove 1980; T.G. Lovegrove). See Sexing for dimorphism in wattle size. Legs and feet, black (89) with grey (c84) or greyish-yellow (ne) soles. **Nestlings** Wattle not formed but gape thickened and yellow (Jenkins 1976). For three broods of two on Little Barrier I.: At c. 4 days old (Brood 1), bare skin, pink; and bill, yellow with obvious egg-tooth. At c. 7 days old (Brood 1), bare skin, pink; bill, yellow with darker base and with still conspicuous egg-tooth. At c. 12 days (Brood 2), bill, blackish at base with yellowish tip and cutting edge, and egg-tooth still visible; small pips of wattles at gapes; legs and feet, greyish black. At c. 16 days old (Brood 1), bill, black at base with yellowish tip and cutting edge, and egg-tooth still visible; definite pips of wattles visible; legs and feet, slaty black. At c. 20 days (Brood 3; 6 days before they fledged), eyes fully open; bill, black; wattles small pale-orange pips; legs and feet, slaty black (Lovegrove 1985b). **Juvenile** Largely as adult but wattle not fully developed. At fledging stage, wattle shows as small yellow papilla in soft tissue at angle of rictus (Jenkins 1976); in fledgeling, wattle also described as small pale orange papilla; and gape, yellow (T.G. Lovegrove). **First immature** As adult, but wattles not fully formed till 6–8 months old (Jenkins 1976). Wattles orange or orange-red in birds <1 year old and reddened and curve outward as in adults, during agonistic encounters (T.G. Lovegrove).

**MOULTS** Based on examination of skins of 19 adult, four first immature and one juvenile nominate; and 18 adult, eight first immature and five juvenile *rufusater* (AIM, AM, CM, NMNZ; all skins with dates) and other information as cited. Subspecies combined unless stated. **Adult post-breeding** (Third and subsequent pre-basic). Complete. Primaries outward, starting at p1; up to three primaries grow at once. From skins, active moult of primaries recorded: Jan. (3 of 7; PMS 8, 17, 17), Mar. (2 of 2; PMS 18, 49), Apr. (1 of 3; PMS 13), and June (1 of 8; PMS 35); other four in Jan., one in Feb., one in Apr., six in June, and 14 July–Dec., with all primaries worn (those from June with only slight wear); other six skins, May–Aug., with all primaries new. One skin from Apr. had

inner five primaries new and rest of primaries worn, and with no active moult; this bird possibly suspended or arrested moult of primaries, or did a partial post-breeding moult. These results suggest some timing of moult of primaries usually occurs from about Jan. to Apr., but varies and sometimes still active in June or even later. Nillson (1978) states that nominate moult in autumn. One skin from NI (no date given) had active moult of primaries (PMS 16) and tertials, and starting moult of secondaries (at s1), greater secondary coverts, tail (at t1) and body. Moult of tail centrifugal; one starting moult of tail (t1 about half grown, t2-t6 worn) when PMS 18; other skin starting moult of tail discussed above; one with PMS 35 nearly finished moult of tail. Timing of moult of body much as primaries. **Post-juvenile** (First pre-basic). Partial. Involves all or most feathers of body, marginal and median coverts, and varying number of greater secondary coverts or tertials or both. Jenkins & Veitch (1991) state that birds undergo their first moult of body at 12-15 months old, but close examination of skins (this study) indicates this incorrect. Skin (AIM 9166) of 38-day-old fledgeling (banded as nestling), collected in Dec. from Tiritiri Matangi I., NI, had just started post-juvenile moult of body and marginal upperwing-coverts. Another skin from NI (NMNZ 12161), collected Apr., had started moult of body at c. 3 months old (date of hatching known.). One (AIM 2193) *rufusater*, from Cuvier I., had nearly finished post-juvenile moult by late Feb. Post-juvenile moult results in first immature plumage that superficially resembles juvenile (see Plumages above) and this is probably basis for previous confusion with ageing. **First immature post-breeding** (Second pre-basic). Complete. Acquire adult plumage in this moult. Stead (1936) suggested some nominate do not acquire adult plumage till third year but no direct evidence for this (this study). Jenkins & Veitch (1991) state that adult plumage acquired in first moult of body, which occurs at 12-15 month old; they are correct in stating that this is when adult plumage acquired, but not in first moult of body (see Post-juvenile moult above). Active moult of primaries recorded from one in Feb. (PMS 42) and one in Mar. (PMS 36).

**MEASUREMENTS** WATTLE = length of facial wattle in skins (wattle dried and probably smaller than in live birds). **NOMINATE CARUNCULATUS**, SI and islands to SW of Stewart I.: (1-2) Skins (AIM, AM, CM, MV, NMNZ): (1) Adults; (2) First immatures.

	MALES	FEMALES	
WING	(1) 99.4 (1.33; 97-103; 17) (2) 97.8 (2.99; 94-102; 6)	97.3 (2.41; 94-100; 10) 97, 98, 103	**
TAIL	(1) 92.1 (1.78; 90-96; 17) (2) 90.8 (5.23; 82-97; 6)	87.3 (4.53; 77-91; 9) 82, 91, 93	**
BILL S	(1) 40.0 (1.44; 36.0-41.7; 17) (2) 37.9 (3.01; 33.9-41.5; 5)	37.0 (1.15; 35.2-39.0; 9) 35.1, 37.9, 41.5	**
WATTLE	(1) 8.4 (2.04; 4.5-11.1; 13) (2) 4.5 (3.27; 2.0-10.2; 5)	6.8 (1.24; 5.5-9.5; 8) 2.7, 6.5	ns
TARSUS	(1) 40.6 (1.31; 37.5-42.8; 17) (2) 41.4 (1.40; 39.5-42.7; 6)	37.5 (2.30; 32.1-39.9; 9) 38.9, 40.0, 42.5	**

Unsexed juvenile skin (CM) has following measurements: Wing 91; Tail 80; Bill S 33.2; Tarsus 36.0.

**SUBSPECIES RUFUSATER**, NI, NZ: (3-5) Skins (AIM, CM, NMNZ): (3) Adults; (4) First immatures; (5) Juveniles. (6-8) Cuvier I., live, sexed by behaviour and vocalizations: (6-7) (Jenkins & Veitch 1991): (6) Adults; (7) Juveniles (probably first immatures and juveniles combined). (8) Adults (Jenkins 1976).

	MALES	FEMALES	
WING	(3) 95.3 (3.47; 89-100; 12) (4) 100 (5) 95	94.2 (4.20; 90-103; 13) 91, 92, 95 92	ns

TAIL	(8) 91.2 (2.30; 86-96; 34) (3) 86.2 (5.42; 76-95; 12) (4) 86 (5) 84	86.7 (1.85; 83-91; 29) 80.7 (5.33; 72-91; 11) 81, 83, 84 83	** *
BILL S	(3) 38.2 (1.58; 35.2-39.6; 12) (4) 37.0 (5) 34.5	36.0 (1.27; 34.0-37.9; 11) 31.1, 33.8, 37.9 33.3	**
WATTLE	(3) 9.9 (2.72; 6.3-13.2; 5) (8) 10.6 (1.11; 8.2-12.5; 54)	6.2 (1.33; 4.1-7.6; 6) 8.9 (1.07; 7.5-11.4; 41)	* **
TARSUS	(3) 40.0 (2.01; 35.4-43.5; 11) (4) 39.9 (5) 40.1 (6) 41.9 (0.80; 139) (7) 41.6 (0.70; 21)	38.2 (2.48; 34.9-43.0; 12) 38.1, 38.2, 38.2 35.7 38.8 (0.80; 83) 38.7 (0.80; 23)	ns   **

On Cuvier I., NI, live juveniles (sexes combined, and probably including first immatures; Jenkins [1976]) have Wing 88.0 (2.36; 82-92; 33). Jenkins (1976) found that wattle-length in adults was slightly shorter (by 1.1-2.3 mm) in late summer-autumn than in spring (breeding season), based on repeat measurements of six individuals.

**WEIGHTS** **NOMINATE CARUNCULATUS**, SI: (1) Adults, from museum labels (MV, NMNZ). (2-4) Big South Cape I., live (Nillson 1978): (2) Adults >16 months old; (3) Adults, 16 months old; (4) Juveniles (probably includes first immatures). **SUBSPECIES RUFUSATER**, NI: (5) From museum labels (NMNZ). (6-8) Cuvier I., live, sexed by behaviour and vocalizations: (6-7) (Jenkins & Veitch 1991): (6) Adults; (7) Juveniles (probably includes first immatures); (8) Adults (Jenkins 1976). (9) Mokoia I. (I. Castro).

	MALES	FEMALES	
(1)	84.8 (6.77; 77.3-93.7; 4)	73.8	
(2)	83.8 (80-88; 13)	73.8 (71-78; 10)	
(3)	79, 84	74, 76	
(4)	82.5 (81-85; 4)	67, 72	
(5)	72.8 (12.97; 60-89; 4)	66.5, 67.2	
(6)	80.7 (4.60; 138)	69.2 (4.00; 83)	**
(7)	78.5 (5.60; 20)	68.0 (4.10; 23)	**
(8)	80.0 (4.37; 70-88; 34)	66.7 (3.31; 61-75; 29)	**
(9)	77.5 (4.2; 22)	69.0 (5.5; 18)	

**STRUCTURE** Wing rather short; tip of longest primary falls to less than one-third length of tail when wing folded. Ten primaries: p5 and p6 longest (sometimes p4 =); p10 35-42 mm shorter, p9 20-23, p8 8-11, p7 2-3, p4 0-3, p3 3-6, p2 5-8, p1 8-10. Very slight emargination to outer webs of p6 and p7. Nine secondaries, including three tertials; tip of longest tertial falls short of tip of secondaries on folded wing. Tail long, rather square or slightly forked at tip when closed; 12 rectrices; t1-t3 longest, t6 7-13 mm shorter; shafts of rectrices project as small points; juvenile rectrices narrower and more acute at tip than in adult. Bill long, c. 1.5 x length of head, rather straight and dagger-like; culmen flattened in profile; nostrils operculate and about one-sixth length of exposed culmen. In adult, distinct fleshy wattle arises from edge of gape, formed by outward growth of lining epithelium of mouth (see Ageing for development of wattle). Tarsus long, compressed laterally; scaling laminiplantar. Tibia fully feathered. Middle toe with claw longest, 30.6 (0.83; 29.5-31.5; 5); outer and inner toes 75-85% of middle, hindtoe 75-90%. Hindclaw, c. 12 mm long.

**AGEING** Juveniles distinguished from adults by plumage (see Plumages for nominate, Geographical Variation for *rufusater*). Size and colour of wattle useful ageing characters: at fledging, wattle only visible when mouth fully open, as a small yellow papilla at angle of rictus; wattles grow steadily over first year of life, possibly more rapidly in males, and become brighter orange and droop downward with age (Jenkins 1976).

On Cuvier I., NI, juveniles captured Jan.–Feb. (aged 1–3 months) or May (4–6 months old; these probably first immatures according to Plumages above) had wattles 4.7–6.9 mm long (sexes combined), and when recaptured as adults  $\geq 1$  year later had wattles 7.1–12.0 mm long (Jenkins 1976). See Bare Parts for behaviourally related changes in size and colour of wattles. First immature differs only slightly from juvenile in plumage (see Plumages); birds in winter and spring with contrasting dark-brown and blackish feathers on head or body, or both, distinguishable as first immatures; it is possible that adults undergoing moult (in summer–autumn) could show similar contrast between new black feathers and very worn paler feathers. Some first immatures difficult to distinguish from juveniles on colour of plumage, but all first immatures have less softly textured feathers of head and body compared with juveniles (this probably only visible in the hand). Also, juveniles are unlikely to occur in the wild in winter as post-juvenile moult probably usually finished by then.

**SEXING** Live birds from NI can be reliably sexed on tarsal length: adult males have Tarsus  $\geq 40.2$  mm, adult females  $\leq 40.2$  mm. Slightly more overlap between juvenile males and females (including those undergoing post-juvenile moult): males have Tarsus  $\geq 39.7$  mm, females  $\leq 40.7$ . There is extensive overlap between males and females in bill-length (entire culmen), wattle-length and weight (Jenkins & Veitch 1991). In bonded pairs, males usually have larger wattles than females (see Measurements), but old females can have wattles as large as, or larger than, mate (Jenkins 1976).

**GEOGRAPHICAL VARIATION** Two subspecies: nominate from SI and islands off Stewart I. (described fully in Plumages); and subspecies *rufusater* from NI. Holdaway *et al.* (2001) split Saddleback into two species, *P. rufusater* and *P. carunculatus*, and cite an earlier precedent for doing so.

**SUBSPECIES RUFUSATER:** Very similar to nominate but adult *rufusater* have shorter Wing ( $P < 0.01$  males,  $P < 0.05$  females) and Tail ( $P < 0.01$ , both sexes separately) than adult nominate. Plumage descriptions based on examination of skins of 25 adults, four first immatures and three juveniles (AIM, CM, NMNZ). Differences from nominate: **Adult** As nominate but with narrow (to 5 mm wide) rich brownish-yellow (c123C) band bordering entire anterior edge of rufous upperparts; in some lights band has slightly glossy appearance. **Juvenile** Much more similar to adult than juvenile is to adult nominate. Differences from adult *rufusater* by: (1) Feathers of head and body softer and more loosely textured; (2) head, neck, upper mantle and underparts, slightly paler than adult, blackish brown (c119) or dark brown (c121); one skin has narrow light-brown (c26) tips to most feathers of underparts and hindneck; (3) feathers from lower mantle to uppertail-coverts, slightly duller red-brown than in adult, combining to form duller reddish-brown 'saddle', less sharply demarcated from upper mantle; (4) lacks yellowish band bordering anterior edge of upperparts; (5) rectrices slightly duller blackish (c89), narrower and more pointed at tips than in adult; (6) remiges, greater primary coverts and alula, slightly duller, blackish (c89); and (7) greater secondary coverts with slightly duller and less sharply demarcated red-brown (c132B) tips than in adult. **First immature** Description based on birds with no active moult (i.e. not undergoing transition to adult plumage). Vary: some similar to juvenile, others closer to adult. Those more closely resembling juvenile have: patchy blackish (c89) feathering on head and body (where dark brown in juvenile); and richer red-brown saddle (though not as rich or extensive as in adult). Those more closely resembling adult have: mostly blackish (c89) head, neck and body, with patchy dark-brown (c121) feathering on these areas; slightly duller red-brown 'saddle', lacking yellowish band bordering anterior

edge. Extent of retained juvenile feathering as for first immature nominate; most birds retain all juvenile greater secondary coverts, but some replace outer few coverts which contrast slightly with adult-like coverts replaced in post-juvenile moult (these coverts blacker and with brighter and more sharply demarcated red-brown tips than in juvenile).

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Kokako *Callaeas cinerea* (page 965)

NOMINATE CINEREA: 1 Adult

SUBSPECIES WILSONI: 2 Adult; 3 Immature; 4 Adult

Saddleback *Philesturnus carunculatus* (page 986)

NOMINATE CARUNCULATUS: 5 Adult; 6 Juvenile

SUBSPECIES RUFUSATER: 7 Adult; 8 Immature

Piopio *Turnagra capensis* (page 958)

NOMINATE CAPENSIS: 9 Immature

SUBSPECIES TANAGRA: 10 Adult