

Order SPHENISCIFORMES

Family SPHENISCIDAE penguins

Well-defined group of flightless, medium-sized to large seabirds of s. hemisphere, highly specialized for marine life. Closest affinities with procellariiforms. Divergence from common ancestor happened probably by late Eocene c. 45ma, when specialized anatomy was fully developed (Simpson 1975). Seventeen or nineteen species in six genera, depending on treatment; except for genus *Spheniscus* (four species), all breed in our region. Though popularly associated with s. polar region, most species breed on subantarctic and even cool temperate islands and the species of *Spheniscus* breed on the coasts of South America and South Africa, N to the equator, in the Galápagos.

Large head, short neck and elongate body. Tail, short and wedge-shaped, with 14–18 stiff rectrices, but quite long in *Pygoscelis*; often used as a prop when standing on land. Legs short and stout with webbed feet, vestigial hind toe and large claws; set so far back that when on land, birds stand vertically, walk with upright waddling gait, and often prefer to toboggan on belly. Tarsus mostly feathered; area of bare skin near feet tends to be larger in penguins of warmer regions. When swimming, head is hunched into shoulders and feet trail behind, tucked against tail to form good streamlining. Feet and tail used to change direction but propulsion in water by wings so highly modified that they are always called flippers; lack normal remiges; wing bones much flattened and broadened; joint of elbow and wrist almost fused, forming rather rigid, strong, flat and narrow flippers. When swimming under water, move flippers in plane at right angle to long axis of body. Bill, generally straight, rather stout and slightly shorter than head; extremely heavy in *Eudyptes*. Mouth heavily lined with keratinous, backwardly-directed spines. Distinctive bill-plates in all species, as in petrels.

Long bones not pneumatic and airsacs reduced; this, with their short feathers, makes penguins only slightly lighter than the water they displace, reducing the energy needed for diving; gastroliths may also act as ballast. Physiological specializations for diving include an ability to reduce blood flow to muscles while underwater. Capacity to carry oxygen seems no better than that of other diving birds; mechanisms preventing 'the bends' unknown. Often swim fast enough to breathe by 'porpoising'; speed of swimming poorly known, but perhaps in some species 6–12 kph (Kooyman 1975). Heat-exchange system in flippers and legs, a well-defined fat-layer and low surface area – volume ratio improve thermal insulation in cold waters but, even so, probably cannot keep body temperature stable at sea for long without being active (Kooyman 1975). On land over-heating can be a problem, especially in lower latitudes.

Feathers highly specialized; short, with broad flat rachis, and closely spaced barbs, especially near rachis and tips; considerably less water-repellent than those of other waterbirds but probably prevent much water penetration (Rijke 1970); small downy after-feather forms a second layer of insulation. Efficiency underwater unknown. Feathers are not arranged in pterylea; the only apteria is the 'crissum' between the legs, used as brood-patch. Plumage blue-black to grey-blue above, and white below. Face and crown are often distinctive with long yellow to orange plumes or other colours on face; patterns of head are the most important characters for field identification at sea. Juveniles similar to adults but usually duller. Sexes similar; males larger with heavier bills. All species have one rapid complete moult per cycle; feathers replaced more or less simultaneously. Feed intensely at sea just before moult, putting on weight. Greater part of moult on land during 2–6 weeks when birds cannot swim, having impaired insulation, and must fast. Moult generally follows breeding in adults; in some *Spheniscus* species, precedes breeding. In cool temperate, subantarctic and Antarctic species, non-breeders moult first, successful breeders last; failed breeders may begin soon after eggs or chicks lost.

Restricted to cool oceanic waters of s. hemisphere, where distribution correlated with Antarctic currents. In low latitudes tend to feed within continental shelf. Usually wide post-juvenile dispersal; movements of thousands of kilometres can occur. Feed on crustaceans, fish and squid. Hunting mostly visual, may be helped by echolocation; mostly by day in shallow surface dives but nearly all can dive deep and long enough to follow any vertical daytime migrations of prey. Emperor Penguin has been recorded diving to 267m, and staying submerged for 18 minutes.

Most species fast for long periods during courtship, incubation, brooding and nesting; extreme is for 110–115 days by male Emperor Penguin while nesting in Antarctic winter, losing up to 45% of initial weight.

Highly social at sea and on land; have complex courting and mate-recognition behaviour; most developed in highly gregarious species such as *Pygoscelis* and some *Eudyptes*, in which densely packed colonies may contain tens of thousands of birds. Elaborate visual and vocal displays used to maintain small nesting territories.

Comfort behaviour: use of shade, panting, spreading of flippers to prevent overheating, tucking in of flippers when cold, and shivering.

Most species breed once a year, in spring and summer; breeding synchronized; best in subantarctic and some

Antarctic species; least in more temperate species. One species breeds over winter, and breeding cycle of King Penguin lasts longer than a year.

Monogamous, pair-bonds long-lasting and even lifelong. Breeding pairs well spaced or virtually solitary to dense colonies of thousands. Nests range from substantial piles of pebbles, debris and assorted materials to nothing in the Emperor Penguin that incubates its egg on its feet. Colonies on all sorts of terrain, near shore or at high altitudes well back, even many kilometres, from the sea, on ice and also in burrows, crevices or caves according to the species. Clutch-size, 1–2 white eggs; three eggs occasionally seen in some species but not satisfactorily proved to have been laid by one female. In eudyptids, the first chick is always noticeably smaller than the second, and the chick from the first egg invariably fails to survive unless that from the second egg is lost at an early stage. Eggs laid at intervals of 2–4 days. Both sexes incubate, except in the Emperor, in which only males incubate. Change-overs take place daily in some species or at long intervals in others. Incubation period varies from about 35 to about 65 days. The young are covered in down and brooded and guarded by both parents for varying periods before forming crèches; both parents feed the chicks by incomplete regurgitation, recognizing and feeding only their own chick, even when it has joined a crèche. Fledgelings independent of parents when they go to sea at different ages from about 6 weeks to about 6 months. First breeding, not before 2 years old in any species and often much longer.

Species of Antarctic and subantarctic are most abundant; temperate and tropical species less numerous; some populations worryingly small (e.g. Yellow-eyed). Adult survival (70–90%) low compared to other seabirds and may be inversely related to breeding success. Breeding success high in most Antarctic species, except in Emperor where only 19% of fledgelings survive first year.

Much uncontrolled taking of adults and eggs for food and bait by whalers and sealers, from eighteenth to early twentieth centuries, reduced or destroyed some populations, especially of King Penguins, in subantarctic and Antarctica; marked increases of some species in past 30 years, attributed to greater availability of krill following reduction of Antarctic whales. Effects of drift-netting unknown. In lower latitudes, some populations have declined through overfishing in inshore waters, human interference, and damage to breeding habitat.

REFERENCES

Kooyman, G.L. 1975. Pp 115–37. In: Stonehouse. 1975.
Rijke, R.M. 1970. *J. Exp. Biol.* 52: 469–79.

Simpson, G.G. 1975. Pp 19–41. In: Stonehouse. 1975.
Stonehouse, B. (Ed.) 1975. *The Biology of Penguins.*

Eudyptes pachyrhynchus Fiordland Penguin

COLOUR PLATE FACING PAGE 209

Eudyptes pachyrhynchus Gray, 1845, Richardson & Gray's Zool. Voy. 'Erebus' and 'Terror'. Birds: 17 — Waikowaiti, South Island, New Zealand.

The specific name refers to the thickness of the bill ($\pi\alpha\chi\upsilon\varsigma$ thick, and $\rho\acute{\upsilon}\gamma\chi\omicron\varsigma$ bill).

OTHER ENGLISH NAMES Thick-billed or Victoria Penguin, Fiordland, New Zealand or Drooping Crested Penguin, Crested Penguin.

Fiordland indicates centre of breeding distribution.

MONOTYPIC

FIELD IDENTIFICATION Length 55 cm; flipper 167–196 mm; bill 42–55 mm; weight: male 3.7 kg, female 3.4 kg. Medium-sized, stocky penguin with moderately large, bulbous orange bill. Broad sulphur-yellow superciliary stripe, becoming drooping crest behind eye. Before moult (Dec.–Mar.), dorsal plumage becomes brownish and superciliary stripe fades almost to white. Sexes similar but males generally larger with noticeably larger and more robust bill. No seasonal changes. Immatures separable, with difficulty.

DESCRIPTION ADULT. Head, blackish with conspicuous broad sulphur-yellow superciliary stripe starting near junction of culminicorn and latericorn and extending back horizontally over eye to back of head where it develops into silky plumes (<5 cm) that flare out from head and droop down sides of nape. Viewed from front, two superciliary stripes form diverging 'V' from base of bill. Cheeks, blackish or dark grey-black with whitish bases, often displayed as 3–6 white stripes more or less parallel with superciliary stripe. Flipper, blue-black dorsally with thin white trailing-edge. Dorsal plumage and tail, blue-black. Sharp demarcation across throat separates dark face from silky-white breast and abdomen. Underflipper, whitish with dark tip and posterior base and varying greyish strip along leading-edge. Bill, moderately large and heavy, orange-brown, with noticeably bulbous culminicorn when viewed from above and from side. Thin strip of black skin separates bill from feathers. Eye, brownish-red but varies from brownish grey to (rarely) vermilion. Feet and legs, pinkish-white, blackish brown behind tarsi, soles and front of webs. Claws, dark brown. At sea, look for moderately large orange bill, broad superciliary stripe running from naricorn horizontally over eye, absence of bare skin at base of bill, and presence of white cheek-stripes. Crests lie flat against head when wet. Before moult (Feb.), dorsal feathers become brownish and superciliary stripe and crests fade almost to white. Immediately after moult (Mar.), dorsal feathers shiny dark blue. Superciliary stripe often appears narrower. **FLEDGING.** Smaller than adult. Superciliary stripes, yellow and clearly defined but crests short and generally lie against head as continuation of stripe. Throat and cheeks, grey to almost white. Dorsal plumage, dark blue. Bill, blackish brown, browner distally with horn-coloured tip to both mandibles. Bill much less robust than adult (42 mm), tapering from base to tip. No pink skin at base of bill but may have small patch at gape. Eyes, dull brown. Feet and claws as adult. Birds of the year difficult to identify at sea, but look for clearly defined broad superciliary stripe that starts near naricorn and passes back horizontally over eye. Also look for absence of bare skin

at base of bill. **ONE-YEAR-OLD.** Smaller than adult. Superciliary stripe, broad and whitish; crests short. Cheeks and throat, grey to white. Dorsal plumage, brownish. Bill, less robust than adult, dull brownish-orange suffused with black. Culminicorn may appear parallel-sided (as in adult Erect-crested Penguin *E. sclateri*) when viewed from above. No pink fleshy margin to bill, but may show small patch of pink at gape. Eye, dull brown. Before moult (Jan.), yearlings appear pale brown on back, with broad white superciliary stripe. Most stragglers are of this age group. After moult, yearlings are small and slim with short yellow crests, dark chin and throat, and may show some white stripes on cheeks. Dorsal plumage bright blue-black. **TWO-YEAR-OLD.** As adult but crests shorter; bill duller and less robust.

SIMILAR SPECIES ADULT. Average size for genus; similar to Snares Penguin *E. robustus*; larger than Rockhopper Penguin *E. chrysocome*; smaller than Erect-crested, Macaroni *E. chrysolophus* and Royal *E. schlegeli* Penguins. Most similar to Snares and, as juvenile, to Rockhopper Penguin but resembles all other crested penguins. Adult **Snares** has longer, more robust bill, and prominent bare pink skin at base of latericorn and ramicorn. Superciliary stripes are narrower, deeper yellow, and crest-feathers usually longer. Cheek feathers black, showing few or no pale bases. **Erect-crested**, taller, with brownish, longer, less robust bill; culminicorn straight-sided when viewed from above and side; whitish skin round base of mandible and at gape. Superciliary stripe starts near gape and rises obliquely over eye. Crests erectile, brushy, and nearly parallel when seen from front or above. Head more dome-shaped and velvet-black, with large-chinned appearance in profile. Markings on underside of flipper bolder. **Rockhopper**, smaller, with smaller bill. Birds from some breeding islands (e.g. NZ subantarctic, Macquarie and Heard Is) have bare pink skin at base of bill but *E.c. moseleyi* and those from Cape Horn and Falkland Is do not. Eye, bright red (brownish-red in Fiordland Penguin). Superciliary stripe starts farther back from bill and is very narrow until behind eye. Crests longer and fibrous, including more black feathers, and joined across crown by black occipital crest. **Macaroni** and **Royal**, taller, with longer, more massive bills and very prominent dark-pink skin at base of bill and at gape. Chrome-yellow fibrous crest-feathers meet as yellow-orange patch on forehead. No clearly defined superciliary stripe. **JUVENILE.** One-year-old **Snares Penguin** leaner, with larger bill that has small pink fleshy margins. Superciliary stripe narrower and more yellow. Face usually darker grey. One-year-old **Erect-crested**, taller and more gangly; bill duller brown and slim-

mer. Superciliary stripes rise obliquely from near gape and appear parallel when viewed from front. Large grey chin extends further out towards bill tip; head has domed profile. Markings on underflipper bolder. One-year-old **Rockhopper**, smaller with smaller bill. Very thin, poorly developed superciliary stripe starts 1–2 cm from naricorn. Eye redder, and black occipital crest already noticeable. One-year-old **Macaroni** and **Royal**, taller with long slim bills and bright-pink triangle of skin at gape. Indistinct superciliary stripe, but messy patch of chrome-yellow and white feathers on forehead.

Breed in small colonies or as solitary pairs along sw. coast of SI and Stewart I., NZ. Absent from breeding grounds from Mar. to June but movements at sea unknown. Usually walk on land, but hop when hurried. Swim with head and part of back above water; porpoise when swimming fast. Feed in small groups or solitarily. Vagrants solitary or among other crested penguins. Voice less harsh than Snares Penguin, but more highly pitched and harsher than Erect-crested Penguin. More timid than other crested penguins.

HABITAT Marine in cool temperate waters round NZ, especially s. Westland, Fiordland and Stewart I. Breeding adults thought to forage near shore because chicks fed almost daily (J. Warham); in Fiordland, diet in breeding season indicates feeding limited to continental shelf waters within 10 km of shore (van Heezik 1989). Assumed to be pelagic outside breeding season because absent from breeding areas and adjacent inshore waters (Warham 1974), but winter distribution poorly known. May forage in areas of upwelling along Subtropical Convergence (Warham 1975).

Breed on mainland NZ and offshore islands. Colonies in temperate rainforest along shores of bays, fiords, headlands (Warham 1974); also along rocky coasts, in rock falls, caves, under overhangs. In forested areas, nest on slopes; generally steep (approximate average 45°) rising to cliffs in places. Extremes of temperature narrowed beneath forest canopy; during breeding season, temperature 2.2–15.5 °C; humidity seldom <80% and forest floor usually wet. Major cause of breeding failure heavy rainfall and frequent storms. Nesting slopes have dark, humus-rich soil, pockets of clay, few shingle fans and scattered boulders. In mature forest, canopy height 21 m; dominated by *Weinmannia racemosa*, *Metrosideros umbellata*, etc., with shrub-layer vines and ground cover mainly of pteridophytes, mosses and liverworts.

Landing beaches of large boulders and talus from slopes; routes to nesting area often follow drainage channels (Warham 1974). Adults moult at nest-sites; immatures at edges of nesting areas or along rocky coasts elsewhere. Depth of feeding dives not known.

At Jackson Head, NZ, breeding sites destroyed by road-widening and resulting rock and scree slips (Warham 1974).

DISTRIBUTION AND POPULATION Endemic to NZ; mostly SI, islands off SI and NI (NZCL). Breeds SI and offshore islands. Vagrant to Aust. Distribution at sea at all times poorly known. Recent observations mainly on w. and sw. coasts of SI and Stewart I.; vagrant elsewhere on NZ coasts.

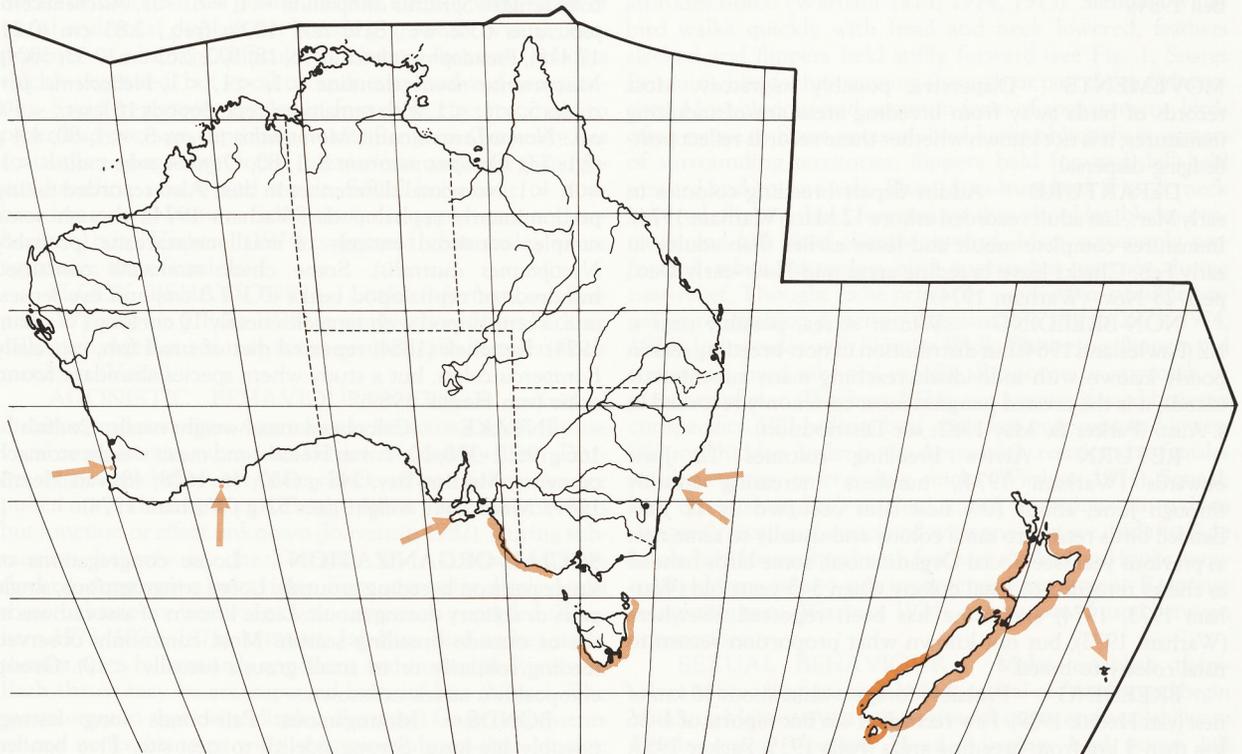
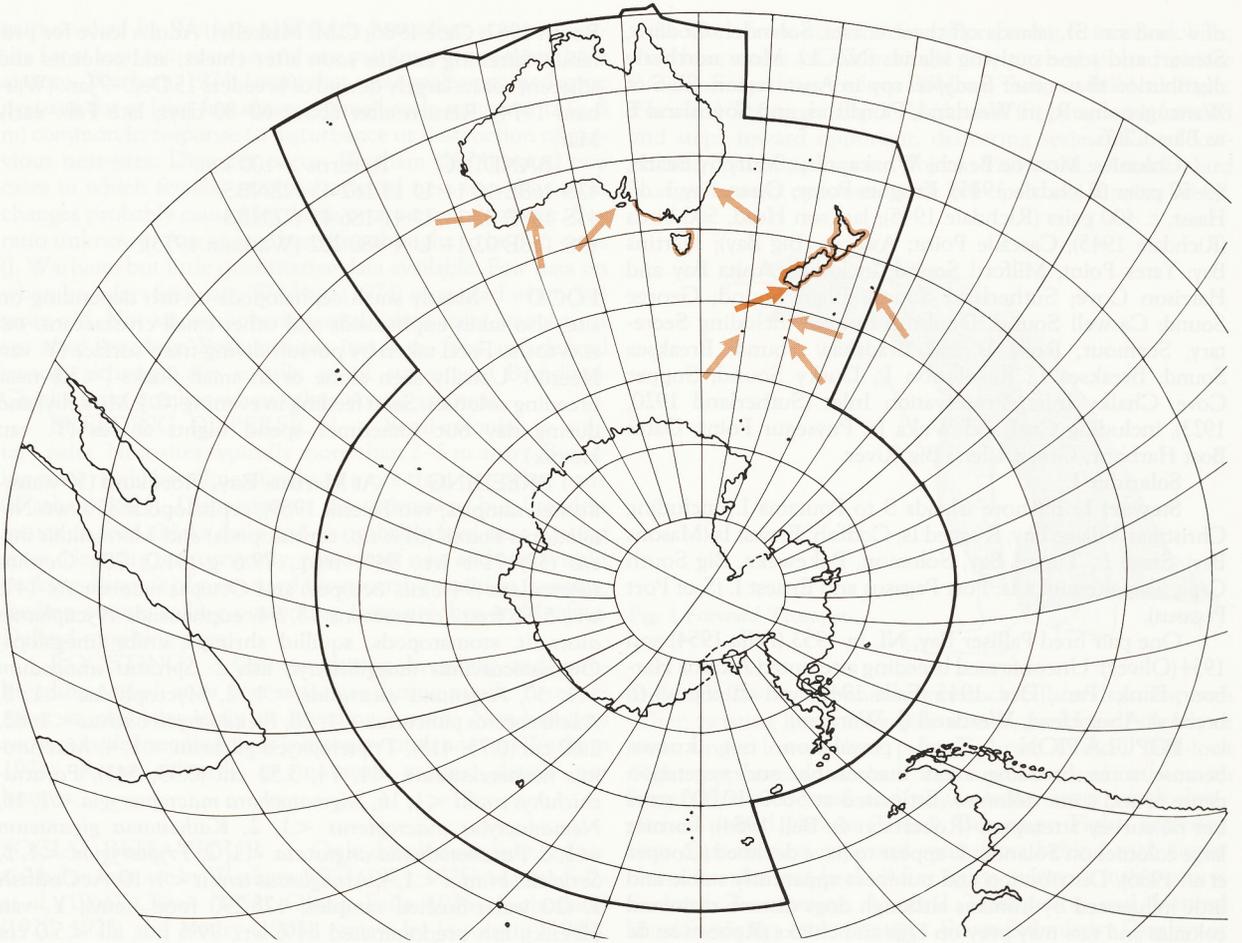
In breeding season, few records at sea but report of 20–30 seen porpoising offshore from breeding colonies, Nov. 1934 (Falla 1935); one, 3 km off C. Foulwind, 1 Jan. 1951 (Packer

1953); 36, Hall Arm/Secretary I. (Booth 1982); group of six and single bird, 3 km off Kopeka R., Stewart I., 26 Nov. 1984 (Gaze 1986; C.M. Miskelly). Most adults moult at or near breeding colonies. Immatures often moult away from breeding areas, e.g. Snares I. (c. 50/year) and round Southland and Otago coasts, especially Otago Pen. During moult (Dec.–early Mar.) birds often found farther afield, including Wellington occasionally, Canterbury, Westland and Campbell I. Moulting immatures recorded almost annually in se. Aust., mostly Vic. and Tas. After breeders complete moult, few records until return to breeding colonies in early July (Warham 1974). Winter distribution poorly known; birds recorded w. Wellington, Mar.–Apr. 1972 (Veitch 1980a), Kaikoura, July 1980 (Booth 1982), Canterbury S, July 1980 (Veitch 1982), Southland, Mar.–Apr. 1972 (Veitch 1980a); and Apr.–May–Aug. 1978 (Veitch 1980b). One reported near breeding colony, Knights Point, May 1984 (Gaze 1985). Two at Snares I., June and July 1972, including one banded adult male breeder from Jackson Head (Warham 1974). These records suggest wide distribution round s. NZ in winter.

AUST. **NSW:** Two specimens: AM 0.26096, 0.37004; 5 Dec. 1907, Broken Bay, and 2 Oct. 1938, Gerringong. Sight record, Aug. 1953, Kurnell (J.N. Hobbs). **Vic.** Five specimens: MV B104, B204, B225, B3976, B7889, s. coast Portland and Pt Lonsdale, 24 July 1933, 17 Apr. and 29 July 1936, 12 Aug. 1951 and 26 July 1961 respectively. Sight-records: s. coast W of Phillip I.: 16 Feb. 1951 (Learmonth 1952), July–Aug. 1953, Jan.–Mar. and Oct.–Nov. 1954, July 1959, Sept.–Nov. 1980 (Aust. Atlas); Lady Julia Percy I., 23 Jan. 1979 (Brown & Corrick 1979); Port Fairy, 9 Jan. 1984 (Adams 1984). **Tas.** Specimens: Hobart, 1891 (AMNH); c. 10, 1944–70 (June–Sept., Nov.) (QVM). At least eight beachcast, 1982–88 (Apr., June–Sept.) (Tas. Bird Reps 1983–87). About 20 sight-records (Aust. Atlas; Tas. Bird Reps 1980 onwards), all months except Mar., Apr., May. **SA.** Beachcast specimens: SAM B26730, Victor Harbour, Sept. 1963; B300631, C. St Alban, Kangaroo I., 22 July 1973; Lashmar Lagoon, Kangaroo I., July 1973; B30629, Salt Ck, Coorong, Mar. 1974; B31029, Canunda, July 1977; B33489, Goolwa, 8 July 1980; B33589, Coorong, 27 Aug. 1980. **WA.** At least four records SW to mid-1973 (Aust. CL); specimens from Scarborough, Leighton, Busselton (Serventy & Whittell 1976). Sight-record, May–July 1981 (Aust. Atlas). **NB.** Skeletal remains have been collected (Reilly 1974) near Baxter Cliffs (32°55'S, 124°32'E) and identified by G.F. van Tets (ANWC SPS23) as *E. pachyrhynchus*. Penguins, larger than Little Penguin *Eudyptula minor* have been seen in this area and local Aborigines claim that they breed there.

NZ **NI:** 1969–79: no records NI nor islands off NI, (NZ Atlas). Normal non-breeding range, S from Bay of Islands and Auckland (NZCL). **SI:** near Oamaru, Banks Pen., round Stewart I., from coast near L. Hakapoua to N of Haast (NZ Atlas). Solander, Codfish, Snares, Auckland and Campbell Is (NZCL). Records outside main distribution: Bay of Islands; Bay of Plenty (Oliver); Wainui (Gisborne), 8 Feb.–7 Mar. 1958 (Blackburn 1960); Dargaville, 26 Nov. 1977 (Sibson 1978); Kerekare, 16 Oct. 1930 (Falla 1935); Auckland, w. coast, Jan.–Mar. 1983, Mar.–Dec. 1984 (Powlesland 1985, 1986); Taranaki, 15 Oct. 1981 (Wheeler 1982); Chatham I. (Oliver); Auckland I.: Enderby I., Feb. 1944 (Bailey & Sorensen 1962); Campbell I., 15 Jan. 1945 (Bailey & Sorensen 1962), 21 Jan. 1969 (Kinsky 1969), 30 Jan. 1987 (G. Taylor); Macquarie I. (Powlesland 1984). Extralimital: skin in BMNH from Falkland I., which may be erroneous.

BREEDING In small colonies along much of coast



of w. and sw. SI, islands off these coasts, Solander, Codfish, Stewart and some outlying islands (NZCL). More northerly distribution than other *Eudyptes* spp in Aust. region. SI: S of Waitangi-toana R. in Westland, Fiordland, and Southland E to Blue Cliffs.

Colonies: Monroe Beach; Whakapohai; Murphy Beach, 40–50 pairs (Richdale 1945); Knights Point; Open Bay I. off Haast, c. 400 pairs (Richdale 1945); Jackson Head, 500 birds (Richdale 1945); Cascade Point; Awarua (Big Bay); Martins Bay; Yates Point; Milford Sound, including Anita Bay and Harrison Cove; Sutherland Sound; Bligh Sound; George Sound; Caswell Sound; Doubtful Sound: including Secretary, Seymour, Rolla Is and Bradshaw Sound; Breaksea Sound; Breaksea I.; Resolution I.; Dusky Sound; Supper Cove; Chalky Inlet; Preservation Inlet (Sutherland 1920, 1923), including Coal and Weka Is; Puysegur Point; Gates Boat Harbour; Green Islets; Big River.

Solander I.

Stewart I.: offshore islands S to Poutama I.: including Christmas Village Bay, Rugged Is, Codfish, Ernest Is (Masons Bay), Stage I., Tupari Bay, Solomon, Pukeweka, Big South Cape, Tamaitemioka Is, Port Pegasus and Ernest I. (S of Port Pegasus).

One pair bred Palliser Bay, NI, in 1953 (Falla 1954) and 1954 (Oliver). Unconfirmed breeding attempted Akaroa Harbour, Banks Pen., Dec. 1945 (Falla 1947) and attempted to breed at Abut Head, Westland (J. Warham).

POPULATION Total population not known because some breeding areas inaccessible and vegetation dense round some colonies. Estimated at 5000–10,000 pairs but no survey attempted (Robertson & Bell 1984). Former large colonies on Solander I. appear to have declined (Cooper *et al.* 1986). Distribution and numbers apparently stable and little influenced by humans although dogs disturb mainland colonies and rats may prey on eggs and chicks (Robertson & Bell 1984).

MOVEMENTS Dispersive, possibly migratory. Most records of birds away from breeding areas are of moulting immatures; it is not known whether these records reflect post-fledging dispersal.

DEPARTURE Adults depart breeding colonies in early Mar., last adult recorded ashore 12 Mar. (Warham 1974). Immatures complete moult and leave earlier than adults, in early Feb. Chicks leave breeding areas mid-Nov.–early Dec., peak 23 Nov. (Warham 1974).

NON-BREEDING Winter at sea, possibly near s. NZ (Powlesland 1984) but distribution in non-breeding season poorly known with individuals reaching many subantarctic islands; it is the crested penguin most commonly recorded in s. Aust. (Parker & May 1982; see Distribution).

RETURN Arrive breeding colonies 12 June onwards (Warham 1974), numbers increasing steadily through June; about 70% nest sites occupied by 12 July. Banded birds return to same colony and usually to same nest as previous year (see Social Organization); some birds banded as chicks returned to natal colony when 3–5 years old (Warham 1973, 1974) and none has been reported elsewhere (Warham 1973), but not known what proportion return to natal colony to breed.

BREEDING Probably forage within about 10 km of nest (van Heezik 1989). Few records at sea but reports of 1–36 less than 5 km from breeding areas (Falla 1935; Packer 1953;

Booth 1982; Gaze 1986; C.M. Miskelly). Adults leave for pre-moult fattening exodus soon after chicks, and colonies and adjacent coasts largely devoid of breeders 15 Dec.–9 Jan. (Warham 1974). Return after about 60–80 days, late Feb.–early Mar.

BANDING Returns >100 km:

43S 168E 10 1+ U 13 162 45 NZNBS

43S 168E 02 1+ U 41 186 45 NZNBS

43S 168E 02 1+ U 4 480 202 (Warham 1973).

FOOD Mostly small cephalopods or fish depending on site; also takes euphausiids and other small crustaceans. **BEHAVIOUR.** Food taken by pursuit diving from surface (Y. van Heezik). Usually seen alone or in small flocks (<30) near breeding colonies. Seen feeding in evening (C.J. Miskelly) and during day but sometimes spend nights at sea (Y. van Heezik).

BREEDING At **Martins Bay, Fiordland** (50 water-flushed samples; van Heezik 1989), cephalopods 85% wt: *Nototodarus sloanii* (61% no. cephalopods) and *Moroteuthis ingens* (39) 71% wt., 94% freq., 79.6 g (31.0; 78), *Ocythoe tuberculata* (94% no. octopus) and *Octopus maorum* (6) 14% wt., 52% freq.; crustaceans 13, 94: euphausiids *Nyctiphanes australis*, stomatopods, squillid shrimps, crabs (megalopa) *Ommatocarcinus macgillivrayi*; fish 2: *Sprattus antipodum* <1, 30, *Argentina australiae* <1, 2, Myctophidae <1, 8, *Auchenoceros punctatus* <1, 28, *Pseudophycis bachus* <1, 82, 2.80 cm (0.73; 418), *Tripterophycis gilchristi* <1, 4, *Macruronus novaehelandiae* <1, 74, 3.52 cm (0.55; 841), *Paratrachichthys trailli* <1, 16, *Stigmatophora macropterygia* <1, 16, *Nemadactylus macropterus* <1, 2, *Kathestoma giganteum* <1, 6, *Paranotothenia angustata* <1, 2, *Trypterygion* <1, 2, *Seriola brama* <1, 4, *Arnoglossus tenuis* <1, 10. At **Codfish I.** (20 water-flushed samples; 178 290 food items; Y. van Heezik), fish predominated 84% wt., 99% no., all <5.0 cm total length: *Sprattus antipodum* <1, <1, <1, *Auchenoceros punctatus* 63% wt., 81% no., 100% freq., 2.83 cm (0.21; 17 418), *Pseudophycis bachus* 16, 18, 100, 2.62 cm (0.35; 3804), *Macruronus novaehelandiae* <1, <1, <1, *Helicolenus percoides* 5, <1, <1; with remainder cephalopods 16% wt., <1% no.: *Nototodarus sloanii/Moroteuthis ingens* 8, <1, 80, 4.4 g (7.1; 73), *Octopus maorum* 8, 1, 80, *Ocythoe tuberculata* <1, <1, <1. No sexual differences in diet. Also recorded taking predominantly cephalopods (Warham 1974), though some samples consisted entirely of small crustaceans (probably *Nyctiphanes australis*). Some chick stomachs contained hundreds of cephalopod beaks (0.3–1.0 cm) and eye lenses; one, a cephalopod with tentacles nearly 10 cm long (Warham 1974). Reischek (1884) reported diet of small fish, especially *Paraperca colias*, but a study where species abundant found none (van Heezik 1989).

INTAKE Calculated mean weight meals, Codfish I., 166 g (96; 2–328; 20; Y. van Heezik) and mean weight stomach contents, Martins Bay, 348 g (330; 46–1608; 48; van Heezik 1989). Mean daily weight gain 52 g (Warham 1974).

SOCIAL ORGANIZATION Loose congregations or single pairs on breeding grounds. Loose congregations, single pairs or solitary during moult. Little known of associations at sea or outside breeding season. Most commonly observed feeding solitarily or in small groups (usually <10). Group composition at sea unknown.

BONDS Monogamous. Pair-bonds long lasting, possibly life-long. Strong fidelity to nest-site. Five banded

pairs studied by Warham (1974) bred together at same nest-site for at least two seasons and one pair for not less than three seasons. Warham (1974) found that some males retained same nest-site for at least five seasons. Small-scale movements (c. 8 m) common in response to disturbance or destruction of previous nest-sites. Divorces occur: Warham (1974) noted two cases in which females retained original nest-sites, but most changes probably caused by death or absence of partner. Sex ratio unknown. Age at first breeding thought to be 5–6 years (J. Warham) but little quantitative data available. Few data on when breeders first pair; Warham (1974) suggested when 3–4 years old. Not known whether established pairs associate at sea after breeding. Both parents incubate, feed and defend young, although not equally at all stages (see Breeding). Chicks form crèches when other young are near.

BREEDING DISPERSION Semi-colonial to solitary pairs. Nest-sites typically more than 2–3 m apart. Breeding pairs rarely have line of sight to more than two other pairs (Warham 1974). Dispersion at sea unknown, but breeders return to feed chicks daily and so probably feed near nesting areas. Nest-site territory only; consists of nest and area within pecking distance of nest; used for courtship, coition, nesting, feeding young, calling out young from crèches and loafing. Defend moulting-sites.

ROOSTING On sea during breeding and non-breeding period; at or near nest-sites during moult. Breeders roost at nest-sites early in breeding season. Non-breeders roost outside breeding areas but always under cover (Warham 1974). Roost solitarily or in small groups; details not known.

SOCIAL BEHAVIOUR Only detailed accounts of social behaviour are by Warham (1973, 1974, 1975); but see Falla *et al.* (1966), Oliver (1953), Oliver, Falla (1935), Sutherland (1920, 1923) and Henry (1903); review by Jouventin (1982). Social behaviour at sea poorly known. Employ wide range of visual and vocal displays on breeding grounds. Visual components of displays difficult to observe because habitats thickly vegetated, but vocal components loud and conspicuous. Social repertoire similar in form and circumstances to other *Eudyptes* spp, especially Snares Penguin. Generally less social than congeners. Social interactions common throughout breeding season and moult. Social behaviour of non-breeders poorly known. Sexes similar in appearance and behaviour but Warham (1974) suggested that males more aggressive than females.

FLOCK BEHAVIOUR Little information. Porpoise in groups (e.g. Falla 1935) or singly at sea. Short barking calls exchanged at sea may act as contact calls between flock members (Voice).

AGONISTIC BEHAVIOUR Defend individual distances and nest-sites. Aggressive behaviours commonly use vocal components; submissive behaviours usually silent. During aggressive behaviour, pale cheek stripes below eye are puffed out and conspicuous. Bright-yellow crests also obvious but function or effect unknown (Jouventin 1982). During submissive behaviour, cheek-stripes and contour-feathers sleeked. **Aggressive behaviour.** Four aggressive displays and three behaviours involving overt aggression recorded (Warham 1973, 1974, 1975). **THREAT.** **Jab-hiss:** bird arches neck, thrusts open bill towards opponent and immediately recoils. Each thrust may be accompanied by brief hiss (Voice). The most common aggressive display. **Forward Gape:** opponents extend necks, bringing wide open gapes almost into contact;

twist heads from side to side as if preparing to interlock bills; may hiss, snort or utter single low-pitched pulsed phrase (Voice). Sometimes leads to Bill-lock Twist or Bill-lock Fight. **Forward Trumpet** (Fig. 1): bird raises flippers, leans forward and steps toward opponent, delivering series of loud low-pitched pulsed phrases (Voice). **FIGHTING.** **Attack:** bird charges toward opponent with bill open and flippers raised.

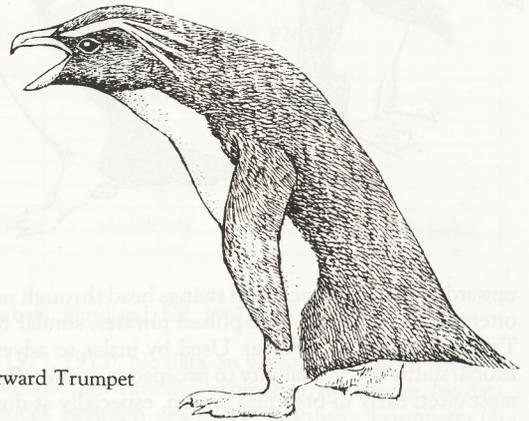


Fig. 1 Forward Trumpet

Bill-lock Twist: opponents interlock bills and pull at each other, twisting heads from side to side; performed silently or with single low-pitched pulsed phrase (Voice). **Bill-lock Fight:** opponents interlock bills and swat each other with flipper blows to head and upper body; utter harsh, low-pitched pulsed phrases (Voice). **Bite-nape Fight:** aggressor bites opponent on nape and swats from behind with flipper blows to sides and back. After fights, winners may perform Forward Trumpeting, Vertical Trumpeting and Vertical Head Swinging. **APPEASEMENT.** Seven Submissive Displays or attitudes noted (Warham 1973, 1974, 1975). **Slender Walk:** bird walks quickly with head and neck lowered, feathers sleeked and flippers held stiffly forward (see Fig. 1, Snares Penguin). Used when moving through or past defended nest-sites. Most obvious and common form of appeasement; birds often pause to **Stare-around:** bird looks obliquely at owners of surrounding territories; flippers held forward, bill held upward and to one side. **Shoulders-hunched** (Fig. 2): neck lowered, flippers held forward so that shoulder blades protrude and bill tilted slightly upward. Most commonly performed when incoming bird approaches partner during nest-relief. Thought to be primarily submissive; possible sexual or recognition function suggested (Warham 1973, 1974, 1975). Intergrades with Slender Walk. **Shivering:** flippers and sometimes head vibrated rapidly. Response to approach or presence of man (Warham 1974); not known if used between conspecifics. **Bill-hiding:** bird crouches over nest and lowers bill until hidden under body. Apparently restricted to females incubating eggs or brooding chicks (Warham 1974). **Squeal:** bird utters short high-pitched squeal in response to sudden danger (Voice); not associated with any posture. **Side-to-Side Look:** bird lowers head with feathers sleeked and looks, moving head from side-to-side in serpentine movement. Response to sighting man (Warham 1974); not known if used between conspecifics.

SEXUAL BEHAVIOUR Males establish themselves at breeding grounds before arrival of females and begin building. Males **ADVVERTISE** territorial status and availability to females using **Vertical Head-swinging:** bird points bill

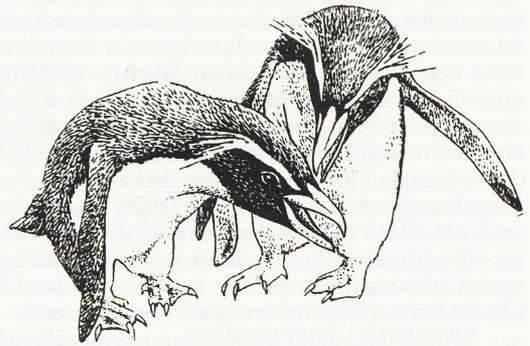
Fig. 2 Shoulders-hunched



Fig. 3 Mutual Vertical Head-swinging



Fig. 4 Mutual Bowing



upwards, extends flippers and swings head through rapid arcs; utters series of low-pitched pulsed phrases, similar to that of Trumpeting display (Voice). Used by males to advertise territorial status and availability to prospective mates. Performed most often early in breeding season, especially at dusk when females tend to arrive; but also commonly throughout breeding season. **Mutual Vertical Head-swinging** (Fig. 3): members of pair bow slightly, swinging heads into nest-bowl, and utter slow series of pulsed low-pitched phrases; birds stretch upward simultaneously, swing heads in wide arcs and utter increasingly rapid series of pulsed phrases (Voice). Both sexes perform solitarily; males more often than females (Warham 1975). Vertical Head-Swinging functions as male advertising display; also has territorial connotations in some circumstances. During PAIR-FORMATION and re-establishment of former pair-bonds, variety of sexual displays noted (Warham 1973, 1974, 1975). **Mutual Bowing** (Fig. 4): members of pair direct open bills into nest bowl and utter succession of deep pulsed phrases (Voice). Females start performance more often than males; occurs before and after laying and during moult. Often leads to Mutual Forward Trumpeting. Bowing also performed solitarily and may have territorial connotation in some circumstances. **Mutual Forward Trumpet** (Fig. 1): members of pair direct bills forward and extend flippers, while uttering series of long loud pulsed phrases (Voice). Occurs throughout breeding season. Occupant of nest normally exchanges Forward Trumpets when returning partner some distance from nest. Display may aid recognition. Males start performance more often than females; often performed solitarily; sometimes used in aggressive circumstances. Use as sexual behaviour often leads to Mutual Vertical Trumpeting. **Mutual Vertical Trumpet**: members of pair face each other, extend flippers and call skyward with loud pulsed phrases used in Forward Trumpet (Voice). Occurs throughout breeding season. Rarely performed by solitary birds, which instead use Vertical Head-swinging. **Mutual Display**: male performs Vertical Head-swinging as female reaches up to male's head, calling with slightly open bill. Calls similar to that used during Mutual Vertical Head-swinging (Voice). Performed throughout breeding season by mated pairs. **Quivering**: bird vibrates bill in very small arcs as it bows over nest-bowl to deposit nesting material. Most commonly performed silently, but series of low pulsed phrases similar to those produced during Bowing sometimes used (Voice). Most often performed solitarily. **MUTUAL ALLOPREENING**. Reciprocal or simultaneous;

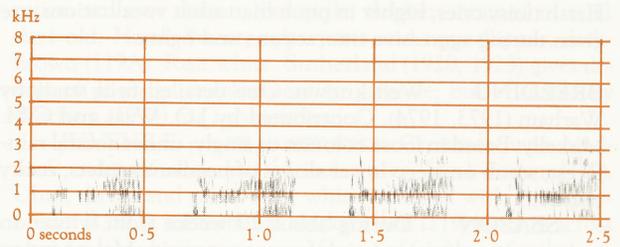
heads, napes, cheeks or throats; no vocal component. Common throughout breeding cycle. Suggested that allopreening is first sign that advertising male has accepted female (Warham 1975). Not obviously ritualized. Mock preens sometimes occur; performed near partner but no contact made with feathers. **COPULATION**. Male pats female's back and sides with flippers until she lies prone with flippers held to sides. Male then mounts, still patting sides and treads on female's back while gently billing her nape and head. Female raises tail to one side everting cloaca as male lowers tail to make cloacal contact. After coition, male dismounts and freezes for several seconds holding bill pressed to one side of upper breast (Warham 1973). Most common during week before laying and does not occur after clutch complete. Observed in non-breeders and occasionally between breeders during moult (Warham 1973).

RELATIONS WITHIN FAMILY GROUP Males start nest-building on arrival at sites. When females arrive, both collect material but females less often. Nest-bowl formed primarily by females using feet and breast in rotating hollowing motion (Warham 1973, 1974, 1975). Males are present during laying. After laying of second egg, both birds stay at nest for 5–10 days (Warham 1974). Males take first long incubation stint (c. 13 days but varies), females gradually leaving to feed at sea. Females take second incubation stint (c. 13 days) and males go to sea; during this time, breeding groups quiet with few social interactions. At hatching, either male or both parents present. Males stay with chicks throughout guard-stage; chicks rest on parents' feet, tucked into brood patch. Females return only for brief periods, usually towards dusk, to feed chicks. Only females feed young at guard-stage but chicks beg from both parents. Visits by females set off numerous Mutual Bowing, Trumpeting and Vertical Head-swinging displays, which appear infectious between pairs (Warham 1973). By 18 days old, chicks too large to brood; stand next to or lean against parent. By this stage, chicks and parents allopreen regularly. During threatening situations, chicks push heads beneath parent, often begging. By about 3 weeks, only one chick usually alive. Surviving chick begins to wander round breeding ground and eventually joins crèche. Aggressive behaviour, including adult-like Jabs, aggressive calls (Voice) and fights common between chicks in crèches; also perform mutual or non-reciprocal allopreening. Formation of crèche marks end of guard-stage; correlated with departure of males. Both parents return regularly to feed chick during post-guard

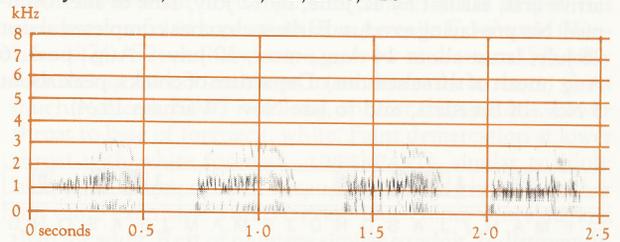
stage. On return to nest-site from sea, parent performs Bowing, Forward or Vertical Trumpets or both. Chick responds by leaving crèche, moving toward parent with flippers raised, and begging loudly. No quantitative information on parent-chick recognition but both possess individually distinct calls. Chick pecks toward adult's bill while begging, inducing regurgitation. Begging Cheeps (Voice) emphasized by sharp upward flicks of flippers. Adults may peck chicks begging in apparently too aggressive a manner. Adults regurgitate 6–8 times during course of feed (Warham 1974). Feeding occurs at or near (<10 m) nest. Toward end of post-guard stage, males feed young more often than females. Crèches break up in mid- to late Oct. (2–3 weeks before fledging) and chicks wait at nests for returning adults toward dusk or early evening. Crèches may re-form under threatening conditions. By c. 75 days of age, fully-feathered chick makes its way to sea. Adults depart shortly after.

VOICE Only quantitative studies of voice by Warham (1973, 1975). Calls generally persistent, loud, harsh and low-pitched. Most composed of loud discordant pulsed phrase labelled Throb by Warham (1973, 1974, 1975); used singly or repeatedly. Only calls that do not fall into this category are Hiss, Bark and perhaps Squeal. Call throughout day, peaking at dusk or early evening; less often during night. Call consistently throughout breeding season with peaks just after breeding-sites occupied and during the pair- and male-phase of egg-stage. Lower levels of calling during moult and at sea. Little quantitative data on sexual differences. Female calls higher in frequency but based on limited sample (Warham 1973). Variation may be simple consequence of size difference. Calls of individual stereotyped; less variation than between individuals. Most variation within individuals in overall length and completeness of calls (Warham 1973, 1975). General form and quality consistent among conspecifics. Calls similar in form and setting to other crested penguins. Especially resemble calls of Snares Penguin but slightly less harsh. Generally more lowly pitched with longer phrase-lengths than Rockhopper Penguin; more highly pitched with shorter phrase-lengths than Erect-crested Penguin. No data on regional variation.

ADULT SEXUAL. Calls associated with (1) **Vertical Head-swinging**: repeated Throbs (sonagram A), each composed of 20-ms pulses. Throb length 0.1 s at beginning of displays, increasing to 0.25–0.35 s midway and ending at 0.45 s; separated by 0.10–0.18 s intervals of silence, increasing in length toward end of display. Frequency spanned 0–4 kHz but main energy at 1.2–1.4 kHz and at 3.0–3.2 kHz. Total length 4.0–5.0 s. Based on sample of six males. Amplitude lower than Trumpets. Female displays may be more lowly pitched (Warham 1973, 1975). Not known whether differences occur between advertising, solo and mutual Vertical Head-swinging. (2) **Bowing**; details not known. Shorter in total length, and pitch lower, phrases shorter and silent intervals longer than Vertical Head-swinging vocalizations or Trumpets. Not known whether sexual differences occur. No data on variation between mutual and solo performances of Bowing. (3) **Trumpet**: repeated Throbs (sonagram B), each composed of 20-ms pulses; may have unpulsed, perhaps inspiratory, groan. Throb length 0.1–0.2 s at beginning of display, increasing to 0.30–0.35 s midway and ending at 0.45–0.50 s; separated by 0.12–0.18 s intervals of silence. Frequency spanned 0–4 kHz but main energy at 1.5 kHz. Total length 4.0–5.0 s. Based on sample of six males. Female call may be more lowly pitched



A J. Warham; Fiordland, NZ, 1968; P26



B J. Warham; Fiordland, NZ, 1967; P26

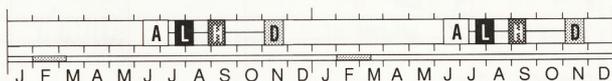
(Warham 1973, 1975). No data on variation between forward and vertical, solo and mutual Trumpet performances. No data on differences between sexual or agonistic Trumpets. (4) **Mutual Display**. One example (Warham 1973): repeated Throbs, each composed of 25-ms pulses. Duet had whirring or rollicking quality because phrases of two individuals overlapped by 80 ms; sound peaks during overlaps. Main energy at 1 kHz. Male and female components could not be distinguished. (5) **Quivering**; no details. Similar to vocal component of Bowing. **AGONISTIC.** Vocalizations associated with (1) **Jab-hiss**; details unknown. One example (Warham 1973, 1975): low-pitched hiss, c. 0.6 s in length, ending with sudden growl. Main energy at 1 kHz. Phrase unpulsed. No known sexual difference. (2) **Forward Gape**, **Bill-lock Twist** and **Bill-lock Fight**. Single Throb composed of 20-ms pulses overlaid by noise. Length varies much depending on stimulus. Typically 0.1–0.5 s during Forward Gape, longer in Bill-lock Twist and Fight. Frequency spans 0–4.0 kHz with main energy at 1–4 kHz, but varies. Based on sample of 10 males. Not known if sexual differences occur. (3) **Forward Trumpet**. See sexual Trumpet. (4) **Squeal**; details unknown. One example (Warham 1973, 1975) consisted of five harmonics spread over frequency range of 800 Hz followed by burst of unstructured noise concentrated between 1–3 kHz; not pulsed. Total length, 0.6 s. Main energy at 1.2–2 kHz. **OTHER CALLS.** **Contact Call**. One example (Warham 1973, 1975) lasted 0.3 s and consisted of simple pure note at about 1.5 kHz with one principle harmonic at 3.1 kHz. **NON-VOCAL SOUNDS.** During fights, sound of flippers bashing rapidly against opponent, loud and arresting. Flipper patting of females by males during copulation also obvious but not so loud. Various sneezing, coughing and snorting sounds associated with comfort. Snorts sometimes given during Forward Gape.

YOUNG Chick begs using simple *cheeps* lasting 0.14–0.30 s and repeated at 0.5–0.7 s intervals. Pitched at 4.0–5.0 kHz; much higher than adult calls. One example (Warham 1973, 1975): each *cheep* characterized by sharp rise in frequency followed by sharp decline. Call rate increases when parent sighted. Performed throughout development. Calls very constant in form and patterning. Greater variation between chicks in structure of calls. At later stages of development and in post-guard stage, calls become more varied.

Harsh noisy cries, higher in pitch than adult vocalizations, are given during aggressive interactions and fights.

BREEDING Well known. One detailed field study by Warham (1973, 1974). Contributed by J.O. Waas and C.M. Miskelly. Breed in loose colonies or singly; under coastal rain-forest, scrub on steep lower slopes of headlands, islets, rocky coasts.

SEASON During about 20 weeks from winter to early summer; little variation from year to year. Males tend to arrive first, earliest by 12 June; by 12 July, 70% of sites occupied. No pre-laying exodus. Earliest clutches completed about 26 July; latest about 14 Aug.; most, 30 July–9 Aug.; peak, 6 Aug. (mean of three seasons). Departure of chicks, peak about 3 Nov. of breeders, mid to late Nov. (Warham 1974).



SITE On ground under dense forest or scrub; typically (e.g. Jackson Head) on steep lower slopes of promontory, scattered with boulders of limestone, granite and conglomerate, but also in deep rock tumblers on shorelines of some islands, especially where access beyond shore limited. Sites sheltered from elements; inconspicuous (Warham 1974); in hollows at foot of trees, between and under boulders and in scree, in caves, sometimes under dense vegetation. From near sea-level to c. 60 m asl, rarely more than 800 m from sea. Dimensions of hollows, crevices vary; no detailed measurements. Same sites used by same pair year after year, moving slightly (mean 8 m; n=15) if original nest disturbed or destroyed. Males select sites and begin to build before females arrive (Warham 1974).

NEST, MATERIALS Shallow, cup-shaped, usually sparsely lined with fern fronds, leaves, sticks to 40 cm long; stones, if available. Made of fresh *Poa foliosa* leaves on Solander I. (Cooper *et al.* 1986). Cup typically 30 cm across. Males build more actively than females; collect material at considerable distances from nest, even out of sight; deposit it on nest with rapid quivering motion, shake head to clear it from bill, accompanied by low calls (Voice). Times of day for building not recorded. Males begin to build on arrival; nest complete before eggs laid but material added during nesting cycle. Pilfering from nearby nests common.

EGGS Short sub-elliptical to short oval, often pointed to nearly oval; mat, chalky with small irregular pimples; dull white with bluish or greenish cast, becoming stained after c. 2 days.

MEASUREMENTS:

A-egg: 68.0 (2.6; 59–75; 134) x 51.9 (1.9; 44–56);
B-egg: 71.2 (2.3; 65–78; 121) x 55.0 (1.8; 51–59) (Warham 1974).

Shell thickness: A-egg: 0.50 (0.07; 8); B-egg: 0.54 (0.04; 7) (Grau 1982).

WEIGHTS:

A-egg: 99.9 (7.8; 66);

B-egg: 120.3 (8.6; 52) (Warham 1974).

CLUTCH-SIZE Two. C/1 never recorded by Warham (1974); reports of single egg in 10–20% of nests suspect because second egg had probably already been lost; report of C/3 rarely (Oliver); not substantiated.

LAYING Synchronized, mostly from 30 July to 9 Aug.; peak (date on which 50% of nests had two eggs, 50% only one), 1 Aug. 1969, 6 Aug. in next three seasons (Warham 1974). Similar schedule throughout range (Henry 1903; Sutherland 1920; Falla 1948). Yolk formation begins second week July, requires 16 days (14–18) for both A- and B-eggs; higher proportion of albumen and lower proportion of yolk in B-eggs, shell proportion constant; average 7 days (4–9) between yolk completion and laying (Grau 1982). Interval between eggs 4.1 days (3–6; 10). No data on time of day of laying. Single-brooded. No replacement after loss; Sutherland's (1920) single exception, doubtful and not substantiated.

INCUBATION Begins at laying of B-egg. Addled eggs may be incubated for at least 3 weeks beyond period. Both parents incubate during first 5–10 days, relieving one another in short stints; females then leave males to incubate for about 13 days and themselves then sit for about another 13 days. Incubating birds lie prone on eggs, which are aligned with long axes parallel to length of body. **INCUBATION PERIOD:** 33.5 days (31–36; 13). Males return before hatching. Hatching simultaneous or two days apart, usually B-egg hatching first. Empty shells disintegrate in nest.

NESTLING Semi-altricial, semi-nidicolous. Sparse proptile, dark chocolate-brown on back, neck, throat; pale creamy white with silky lustre, below; bill, horn-coloured; feet and legs pale flesh-pink; claws horn-coloured, darker at sides; soles of feet, backs of tarsi, dull greyish flesh-pink; down on flippers, short, fine. Hatch blind; eyes open at 4–6 days old; iris, dull brown. Mesoptile appears about 12 days, soon becomes dense and furlike, blackish brown above, on head, throat; creamy white, below; flippers covered with brown down, soon develop irregular white centre on underside. Down lost from flippers, lower back and underparts in that order; last down remains on crown, nape, base of flippers. Hatching synchronized to 18-day period; half of fertile clutches hatched by 9 Sept., nearly all by 17 Sept. Earliest hatch 22–23 Aug. 1969; latest, 23 Sept. 1971 (Warham 1974). **NESTLING PERIOD.** About 75 days. Males brood chicks during guard-stage of 3 weeks, fasting; females may brood for short periods during feeding visits. After guard-stage, single surviving chick wanders and eventually joins crèche; male leaves soon after. Only female feeds chick (daily) during guard-stage; both adults do so after it ends, returning to nest-site, displaying (Bowling, Trumpeting; see Social Behaviour); chick at once leaves crèche or concealment, comes to adult, pecks its bill and is fed by incomplete regurgitation, 6–8 times in a bout, at or within 10 m of nest, most often at dusk or early evening.

GROWTH Only one chick survives, usually B-Chick. Weight at hatching: A-Chick: c. 66; B-Chick: c. 79 or 20% heavier than A-Chick. Nearly linear increase (c. 50 g/days at first, with decrease to fledging; maximum 2955 (601; 20) at c. 65 days old to 2307 (340; 17), or 65% of av. adult mass at fledging. Bill increases almost linearly but not to adult size at fledging; flippers and feet grow rapidly at first; feet 90% of av. adult size by end of guard-stage; flippers in initial growth when crèches form, level off in growth when chick weight 2000 and crèches disband (Warham 1974).

FLEDGING TO MATURITY Departure when c. 75 days old, from mid Nov. with peak departure about 23 Nov.; little annual variation. Departure not co-ordinated; chicks rarely seen at water's edge. No information on post-fledging associations at sea. First pairing perhaps when 3–4

years old, first mating at 5–6 years old but no adequate data (Warham 1974).

SUCCESS No detailed data. Of 83 pairs that laid, 63 (76%) retained both eggs throughout incubation, 20 lost one or both eggs; 67 (81%) hatched at least one chick, 16 failed to hatch any. Of the 63 that retained both eggs, 30 (48%) hatched both, 56 (67%) reared a chick to within 7 days of end of guard-stage. Of 32 chicks hatched, 26 (81%) survived to within 1–2 weeks of fledging. Estimated average hatching success of 79%; breeding success to within 1–2 weeks of fledging, 65%; assuming some losses in last week(s). Warham (1974) estimated that 50% of pairs that lay rear one swimming young. **PREDATORS.** Weka *Gallirallus australis* the only natural enemy on land; take unguarded eggs. Introduced stoats *Mustela erminea* take eggs, chicks and even adults (Warham 1974; Morrison 1980). Dogs may kill adults and be a menace near habitations. Heavy rain may chill eggs, wash them out of nests, drown chicks (Warham 1974). Most colonies inaccessible but in places humans disturb and destroy habitat. Black fly *Austrosimulium unguatum* carries protozoan blood-parasite *Leucocytosoon tawaki* and infects chicks in crèches (Fallis *et al.* 1976).

PLUMAGES

ADULT Age of first breeding unknown. **HEAD AND NECK.** In fresh plumage: crown, nape, side of neck and hindneck, black-brown (119). Sides of head, and chin to lower throat, darker black-brown (119); at lower throat, sharp convex demarcation with rest of white foreneck. On malar area, 5–6 horizontal, parallel short stripes; malar stripes formed from exposure of white bases of feathers, mainly during breeding; stripes may be entirely absent (Falla 1935; Warham 1974). Long broad straw-yellow (57) superciliary stripe, silky in texture, extends from base of culminicorn to hindcrown; supercilium narrow at bill gradually broadening posteriorly; supercilium narrower in females than males (Warham 1974). At hindcrown, feathers of superciliary stripe, loose; form crest, laterally splayed and drooping downwards; feathers intermixed with long black-brown (119) feathers at outer margin of crown, some tipped white imparting streaked effect. Crest tends to droop well below imaginary line drawn along tomia through eye. When wet, feathers flattened against head. **UPPERPARTS.** Feathers black-brown (119), tipped light blue-grey (88); tips more obvious on rump, where less exposed to wear. In worn plumage, during pre-moult, dorsum dark brown (119A); caused by discoloration of feather tips. **TAIL,** black-brown (119); stiff rectrices have light blue-grey (88) tips that are prone to wear. **UPPERFLIPPER.** Feathers, black-brown (119), tipped light blue-grey (88); tips more obvious towards base and posteriorly. One narrow posterior row of white feathers, extending from humeral joint to near tip. **UNDERPARTS,** white; junction of light underparts and dark upperparts curves towards upperparts below flipper, at middle of flanks. Feathers of underparts shorter than in *E. robustus* (Stonehouse 1971). **UNDERFLIPPER,** white; black-brown (119) patch near humeral joint, narrowly and faintly extending as trace along anterior margin to near tip. At tip, similar dark patch, though varying in size (see illustration in Warham 1974); concealed bases of feathers, white, merging through dark-brown (119A) to black-brown (119).

DOWNY YOUNG Protopile, silky. Dark-brown (221) on head, lower throat, hindneck, sides of neck, upperparts and upperflipper; dull-white on lower throat, foreneck, underparts and underflipper. Sharp square line of demar-

cation at lower throat. Mesoptile, thicker; attained at c. 12 days old. Head, throat, upperparts and upperflipper, dark-brown (119A). Rest white. Sutherland (1920, 1923) gives details of plumage development to juvenile; but criticized by Warham (1974) for inconsistencies.

JUVENILE HEAD AND NECK. Crown to nape, hindneck, sides of neck and auricular area, black-brown (119). Chin, throat and malar area, white, suffused with light grey-brown (119D); subterminal black-brown (119) patches across rami. In some birds, exposure of bases of feathers of malar area forms three small horizontal and parallel malar stripes; this character useful in separation from juvenile *E. robustus* (Warham 1974). Superciliary stripe, narrow and cream (54); silky texture not so noticeable as in adult; feathers short. Crest much reduced; 20–25 mm long; shorter than adult's. Lower throat to base of foreneck, white. Faint demarcation at lower throat with white foreneck. **UPPERPARTS,** similar to adult; blue colour more marked because light blue-grey (88) feather tips more extensive. **TAIL, FLIPPER:** blue colour more marked than for adult. Rest of plumage similar to adult. Indistinguishable from adult following post-juvenile moult.

ABERRANT PLUMAGES Melanistic birds recorded (Sutherland 1920).

BARE PARTS Based on photos in Lindsey (1986), NZ-DOC Library and Harrison (1987), except where stated.

ADULT Iris, rufous (41); varies from dull brownish grey, grading through dull claret to bright vermilion; dull claret usual. Vermilion retained from year to year; noted particularly in males (Warham 1974). Further study needed for evidence of seasonal change. Bill rufous (140); paler in females. Front of tarsus, toes and webs, dull pink (5) to pink-white. Distal edges of webs, hind tarsus and soles, dull dark-brown (219). Claws, grey-black (82). Brood patches, bluish-red (Warham 1974).

DOWNY YOUNG Iris, dark-brown (121). Eyes open at 4–6 days. Bill, black-brown (119) with cream tip (92). Egg-tooth, white; disappears when chick c. 40 days old (Warham 1974). Front of tarsus, toes and webs, pale pink-white. Rest like adult; dull dark-brown (219), on webs more extensive. Details in Sutherland (1920, 1923). In second down, flesh-pink stripes may be present along soles of innermost toes (Warham 1974). In old chicks, mouth lining near tomia, yellow-green (Warham 1974).

JUVENILE Similar to adult; iris appears lighter, dark-brown (c219A).

MOULTS Based on Warham (1974), except where stated.

ADULT POST-BREEDING Complete; adult breeders go to sea for 60–80 days for pre-moult fattening before returning to natal colony. Moult occurs at breeding site, Feb.–early Mar. Some birds still unmoulted as late as 21 Feb.; no birds seen ashore after 12 Mar.; duration from first shedding of feathers to replacement 20–30 days. For 5–7 days before feathers shed, plumage appears brown, crests faded. Rectrices shed first. Moult in failed and non-breeders, Jan.–early Feb.; occurs ashore, away from site of breeding colony.

POST-JUVENILE Complete; Jan.–Feb.; duration of moult unknown; occurs ashore, on edge of breeding colony. At Snares Is, most birds in faded pre-moult plumage by 21 Jan.; some moulted by 31 Jan., most complete by 5–10 Feb., sometimes as late as 20 Feb. (Warham 1967).

MEASUREMENTS (1) Jackson Head, NZ, adults (mostly breeders), live; FOOT = distance from tip of middle claw to back of heel; FLIPPER = extended flipper from axilla (Warham 1974). (2) Jackson Head, NZ, breeding pairs, live; BILL (G) = bill measurements at gonys (Warham 1974). (3) Locations unspecified, adults, skins; methods as in Warham (1974) (Stonehouse 1971).

		MALES	FEMALES	
FLIPPER	(1)	185.7 (5.2; 87)	178.5 (5.8; 55)	*
	(2)	185.0 (3.7; 20)	176.0 (5.5; 20)	*
TAIL	(1)	81.1 (6.9; 17)	83.1 (9.0; 17)	
BILL	(1)	51.1 (2.0; 94)	45.0 (1.7; 61)	*
	(2)	51.3 (1.7; 20)	44.0 (1.2; 20)	*
BILL D(G)	(1)	26.1 (1.7; 94)	21.8 (1.3; 61)	*
	(2)	25.8 (1.6; 20)	21.9 (1.0; 20)	*
BILL W(G)	(1)	12.6 (0.6; 94)	10.6 (0.6; 61)	*
	(2)	12.6 (0.4; 20)	10.6 (0.5; 20)	*
FOOT	(1)	124.0 (5.3; 32)	116.5 (4.5; 61)	*
TOE	(1)	82.9 (4.0; 44)	77.8 (3.9; 34)	*
UNSEXED				
FLIPPER	(3)	161.9 (7.1; 145-178; 31)		
BILL	(3)	50.4 (4.5; 44-60; 32)		
FOOT	(3)	106.6 (7.9; 90-125; 33)		

Details of growth rates of chicks in Warham (1974).

WEIGHTS Vary with sex, age and season. Based on Warham (1974), who gives full details. Adults lose weight during incubation. During guard-stage, from 36-57 days after laying of B-egg, males attend chicks more than females and lose more weight. At peak of egg-laying, c. 6 Aug., weight loss great; nine males and six females lost about 21% of initial weight between 11 July and 4 Aug. During moult, weight loss linear (Warham 1974). Pre-moult adults, Feb. (Warham 1974): males 4936 (350; 11); females 4820 (356; 5). Moulded adults (Warham 1974): males 3004 (289; 13); females 2521 (227; 14). Average weight loss in males during moult, c. 88 g/day; females, 105 g/day. At Snares Is, mean weight of yearlings at start of moult: 3766 (460; 5); mean weight of moulded yearlings: 2177 (534; 6) (Warham 1974). Details of weight changes in chicks in Warham (1974).

STRUCTURE Flightless. Flipper, hard and bony, long. Feathering of body dense, strongly lanceolate; rachis broad and flattened at tips; imparts glossy appearance. Tail, short and wedge-shaped; c. 14 rectrices, t1 longest, t7 c. 36 mm shorter; tips prone to wear. Ventral surface of rachis on rectrices concave. Bill robust, hooked at tip; fits into groove at tip of lower mandible. Culminicorn bi-convex; bowed in outline when viewed from above. Arcuate ridges (growth lines) present at base of culminicorn; visible, but fewer, in young and old chicks; also some short median striation from base of bill (Buller 1905; Warham 1974). In adults, median striations also present; in males, 15 parallelstriae extend forwards for about 8 mm; females have fewer and shorter striations (Warham 1974). Legs very short, feet webbed. Pads of soles thick. Claws long and curved; middle toe longest, outer toe 91%, inner toe 66%, hind toe 17%. Both sexes have brood patch; location not stated; retained longer in males (Warham 1974).

SEXING, AGEING Sexually dimorphic in bill; males larger. Bill-shape index (bill-length x bill-width x bill-depth [mm]/10, see Warham 1974 for details) has bimodal distribution: adults: males > 1300, 1667 (172; 10); females < 1300, 1022 (72; 10). Sexed also on behaviour; females have muddled breast and abdomens during early breeding season, through copulation. Age-classes distinguished on plumage (Warham 1974).

RECOGNITION In adult plumage, similar to congeners but distinguished by absence of fleshy skin round margins of bill. Juveniles separated by absence of fleshy skin round margins of bill and, in some birds, by presence of three white malar stripes. Distinguished from congeners on bill measurements and plumage e.g. extent of supercilary stripe. Details of distinguishing characters in Falla (1935), Oliver (1953), Stonehouse (1971) and Warham (1974, 1975).

GEOGRAPHICAL VARIATION None. Forms superspecies with *E. robustus* and *E. sclateri* (Peters). Warham (1974) considers *E. pachyrhynchus* to be separate species on basis of absence of interbreeding with *E. robustus* in areas of sympatry, though hybrids may be difficult to recognize by plumage. Variation in pattern of underflipper and presence of white cheek-stripes in some *E. robustus* suggests some gene-flow occurs (Warham 1974).

RMO

REFERENCES

- Adams, J. 1984. *Aust. Bird Watcher* 10: 144-5.
 Bailey, A.M., & J.H. Sorensen. 1962. *Denver Mus. nat. Hist. Proc.* 10.
 Blackburn, A. 1960. *Notornis* 8: 196-215.
 Booth, D.F. 1982. *Notornis* 29: 49-74.
 Brown, R.S., & A.H. Corrick. 1979. *Aust. Bird Watcher* 8: 61-4.
 Buller, W.L. 1905. *A Supplement to the Birds of New Zealand*. 1.
 Cooper, W.J., C.M. Miskelly, K. Morrison & R.J. Peacock. 1986. *Notornis* 33: 77-89.
 Falla, R.A. 1935. *Rec. Auck. Inst. Mus.* 1: 319-26.
 Falla, R.A. 1947. *NZ Bird Notes* 2: 37-55.
 Falla, R.A. 1948. *NZ Bird Notes* 3: 52-55.
 Falla, R.A. 1954. *Notornis* 5: 211-39.
 Falla, R.A., R.B. Sibson & E.G. Turbott. 1966. *A Field Guide to the Birds of New Zealand*.
 Fallis, A.M., S.A. Bisset & F.R. Allison. 1976. *NZ J. Zool.* 3: 11-16.
 Gaze, P.D. 1985. *Notornis* 32: 140-51.
 Gaze, P.D. 1986. *Notornis* 33: 120-37.
 Grau, C.R. 1982. *Condor* 84: 172-7.
 Harrison, P. 1987. *Seabirds of the World: Photographic Guide*.
 Henry, R. 1903. *The Habits of the Flightless Birds of New Zealand; With Notes on other New Zealand Birds*.
 Jouventin, P. 1982. *Visual and Vocal Signals in Penguins*.
 Kinsky, F.C. 1969. *Notornis* 16: 225-36.
 Learmonth, N. 1952. *Emu* 52: 199-201.
 Lindsey, T.R. 1986. *The Seabirds of Australia*.
 Morrison, K. 1980. *Notornis* 27: 324.
 Oliver, W.R.B. 1953. *Emu* 53: 185-7.
 Packer, T.J. 1953. *Notornis* 5: 85-105.
 Parker, S.A., & I.A. May. 1982. *S. Aust. Orn.* 28: 213-16.
 Powlesland, R.G. 1984. *Notornis* 31: 155-71.
 Powlesland, R.G. 1985. *Notornis* 32: 23-41.
 Powlesland, R.G. 1986. *Notornis* 33: 171-84.
 Reilly, P.N. 1974. *Emu* 74: 198-200.
 Reischek, A. 1884. *Trans. NZ Inst.* 17: 187-98.
 Richdale, L.E. 1945 *Emu* 44: 305-19.
 Robertson, C.J.R., & B.D. Bell. 1984. *ICBP Tech. Publ.* 2: 573-86.
 Serventy, D.L., & H.M. Whittell. 1976. *Birds of Western Australia*.

- Sibson, R.B. 1978. *Notornis* 25: 332-49.
- Stonehouse, B. 1971. *Ibis* 113: 1-7.
- Stonehouse, B. (Ed.) 1975. *The Biology of Penguins*.
- Sutherland, R.S. 1920. *Emu* 20: 24-30, 74-81.
- Sutherland, R.S. 1923. *Emu* 23: 34-42.
- van Heezik, Y. 1989. *Notornis* 36: 151-6.
- Veitch, C.R. 1980a. *Notornis* 27: 369-85.
- Veitch, C.R. 1980b. *Notornis* 27: 115-24.
- Veitch, C.R. 1982. *Notornis* 29: 41-7.
- Warham, J. 1967. *Notornis* 14: 122-39.
- Warham, J. 1973. Unpubl. Ph.D. thesis, Univ. Canterbury.
- Warham, J. 1974. *Ibis* 116: 1-27.
- Warham, J. 1975. Pp. 189-269. **In:** Stonehouse 1975.
- Wheeler, R.W. 1982. *Notornis* 29: 236.



Volume 1 (Part A), Plate 10

Snares Penguin *Eudyptes robustus*

- 1. Adult
- 2. Adult
- 3. Juvenile
- 8. Downy young, mesoptile

Fiordland Penguin *Eudyptes pachyrhynchus*

- 4. Adult
- 5. Juvenile

Erect-crested Penguin *Eudyptes sclateri*

- 6. Adult
- 7. Juvenile

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