

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

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Rijke, R.M. 1970. *J. Exp. Biol.* 52: 469–79.

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Aptenodytes chrysocome Forster, 1781, *Comment. Phys. Soc. r. Sci. Götting.* 3: 135, Pl. 1 — Tasmania and Falkland Islands = Falkland Islands; further restricted to Kidney Island, Berkeley Sound, East Falkland Islands (Carins 1974).

The generic name is combined of εὖ (good) and δυτής (a diver). The specific name is that of Apollo, the golden-haired, χρυσοκόμης and refers to the colour of the crest.

OTHER ENGLISH NAMES. Crested, Drooping-crested, Tufted, Victoria, Jackass, Rocky Penguin, Jumping-Jack, Sea-cat.

Crested-Penguin is often used as a good group-name for *Eudyptes* spp. If, however, this is adopted as part of the English name there are difficulties and absurdities; for example **Rockhopper Crested-Penguin** is never likely to displace the almost universal **Rockhopper** and *E. sclateri* would need to become the **Erect-crested Crested-Penguin**. It is better not to recognize **Crested-Penguin** as an official group-name.

POLYTYPIC. Nominate *chrysocome* breeds Falklands Is and islands off Cape Horn; *filholi* Hutton, 1879, breeds Marion, Crozet, Kerguelen, Heard, Macquarie, Campbell, Auckland and Antipodes Is; *moseleyi* Mathews & Iredale, 1921, breeds Tristan da Cunha, Gough, Iles Amsterdam and St Paul.

FIELD IDENTIFICATION Length 45–58 cm; flipper 15–19 cm; bill 38–53 mm; weight male 2.8–3.4 kg, female 2.3–2.7 kg. Medium-small stocky penguin with small bulbous orange-brown bill; bright-yellow superciliary stripe starts well back from base of bill and forms long drooping and laterally projecting crest behind eye. Smallest crested penguin but

larger than Little Penguin *Eudyptula minor*. Sexes similar but separable when together. No seasonal plumages. Immatures recognizable by smaller browner bills and shorter crests than adults.

DESCRIPTION ADULT. Head, black with narrow bright-yellow superciliary stripe starting 1–2 cm behind junc-

tion of culminicorn and latericorn, extending back horizontally above eyes. Behind eye, superciliary stripe develops into long drooping and laterally projecting fibrous yellow plumes. Pronounced black occipital crest across back of crown joins the two yellow superciliary crests, which also contain obvious black feathers. Crests especially long and luxuriant in *moselleyi*. Cheek feathers, black. Flippers, blue-black dorsally with thin white trailing-edge. Dorsal plumage and tail, dark slate with blue-grey sheen, especially in fresh plumage. Sharp demarcation across throat separates black face from silky-white breast and abdomen. Underflipper, whitish, usually marked with black. Dark orange-brown bill small for a *Eudyptes* penguin but strongly built and bulbous. Mandible separated from feathers by prominent strip of pink skin (*filholi*) or inconspicuous thin strip of black skin (*chrysocome* and *moseleyi*). Eye, usually bright red. Feet and legs, pink above with black soles. Claws, brown. Before moult (Feb.–Mar.) dorsal feathers become dull and brownish and superciliary stripe and crests fade to pale yellow. Pre-moult fattening conspicuous, giving birds dumpy, coarse-plumaged appearance. Immediately after moult (Apr.) body slim and dorsal feathers shiny dark-blue.

FLEDGELING. Smaller than adult. Superciliary stripe inconspicuous or absent. No projecting crest feathers. Chin and throat, grey. Dorsal plumage, dark blue. Bill smaller than adult and blackish brown with small horn-coloured tip to maxilla and mandible. Skin at gape bare but inconspicuous. Eye, dull brown. Feet and claws as adult. **ONE-YEAR-OLD.** Smaller than adult. Superciliary stripe, pale yellow; crest plumes poorly developed and much shorter than in adult. Occipital crest, short. Chin usually grey. Bill smaller and duller brown than adult. Fleishy margin at base of mandible inconspicuous during moult. Eye, dull red-brown. Before moult (Dec.–Jan.) yearlings appear dumpy with brown dorsal plumage and inconspicuous head markings; after moult, small and slim with short bright yellow crests, greyish chin and throat, and shiny blue-black dorsal plumage. **TWO-YEAR-OLD.** As adult but crests shorter.

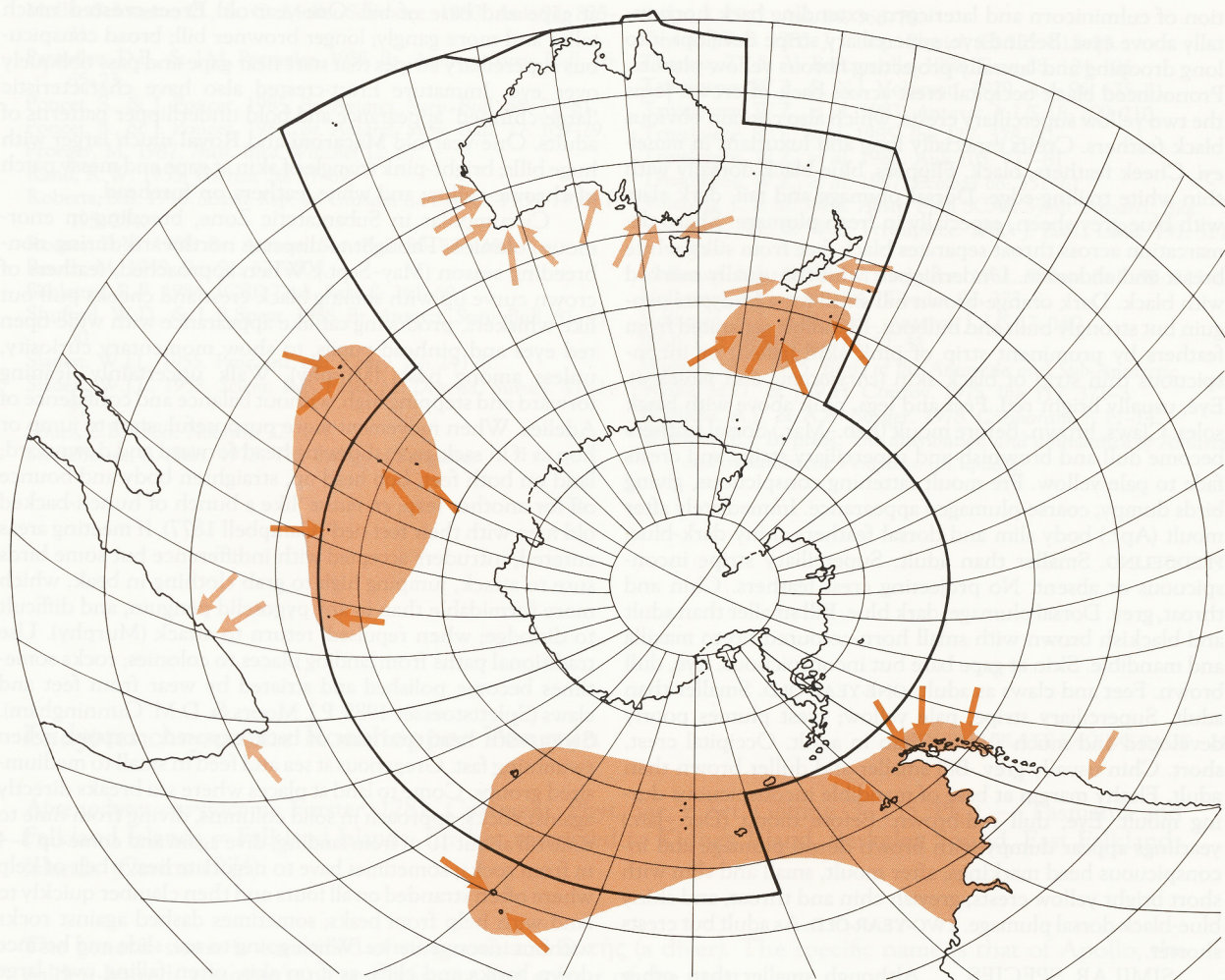
SIMILAR SPECIES Although smaller than other crested penguins, care must be taken in identifying isolated birds. Subspecies *filholi* most similar to immature **Snares Penguin** *E. robustus* but bill of Snares much longer and very robust; bare skin at gape and base of bill more prominent; superciliary stripe broader and starts at naricorn; crests shorter and less pendulous with fewer black feathers; black occipital crest poorly developed; eye, dull red-brown (cf bright-red in Rockhopper). Black skin at base of bill (in *moselleyi* and *chrysocome*) like that of **Fiordland Penguin** *E. pachyrhynchus*, which is larger; has longer, more robust bill; broader superciliary stripe that starts nearer naricorn; shorter and less drooping crest with fewer black feathers; dull brownish-red eye; no occipital crest. **Erect-crested Penguin** *E. sclateri* much larger with longer browner bill; broader superciliary stripe that starts near gape and rises obliquely over eye to form erectile brush-like crests, not joined by occipital crest; 'large-chinned' appearance; bold underflipper markings. **Macaroni** *E. chrysolophus* and **Royal** *E. schlegeli* **Penguins** much larger with massive bills and orange-yellow crest-plumes that rise from forehead with no clearly defined superciliary stripe. **FLEDGELING.** Rockhopper resembles adult **Little Penguin**, but much larger. **IMMATURE.** One-year-old **Snares** and **Fiordland** larger; much larger bills; broad conspicuous superciliary stripes that start at naricorn; no occipital crests; dull-brown eyes. **Fiordland** usually have white stripes on cheeks. **Snares** have more pronounced pink fleshy margin

at gape and base of bill. One-year-old **Erect-crested** much taller and more gangly; longer browner bill; broad conspicuous superciliary stripes that start near gape and pass obliquely over eye. Immature **Erect-crested** also have characteristic 'large-chinned' appearance and bold underflipper patterns of adults. One-year-old **Macaroni** and **Royal** much larger with huge bills; bright-pink triangle of skin at gape and messy patch of chrome-yellow and white feathers on forehead.

Circumpolar in Subantarctic Zone, breeding in enormous colonies. Thought to disperse northward during non-breeding season (May–Sept.). When approached, feathers of crown curve up with shining black crest and cheeks puff out like whiskers, producing cat-like appearance with wide-open red eyes and pinhead pupils, to show momentary curiosity, unless among nests (Murphy). Walk uncertainly, leaning forward and stepping high, without balance and confidence of Adelies. When movement more purposeful, start to jump or hop as if in sack-race, throwing head forward and downward; land on both feet, bob head up, straighten body and bounce off for another leap; *en masse* 'like a bunch of hunch-backed old men with their feet tied' (Campbell 1877). If meeting areas entered, intruders accepted with indifference but some birds sure to attack, jumping high to grab clothing in beak, which more formidable than in any pygosclid penguin, and difficult to dislodge; when repulsed, return to attack (Murphy). Use traditional paths from landing places to colonies; rocks sometimes become polished and striated by wear from feet and claws (Spletstoesser 1985; P.J. Moors & D.M. Cunningham). Swim with head and part of back exposed; porpoise when swimming fast. Gregarious at sea and feed in small to medium-sized groups. Come to land at places where sea breaks directly against rocks; approach in solid columns, diving from time to time till about 10 m from landing, dive again and come up 3–4 m from rocks; sometimes have to negotiate heavy belt of kelp where often stranded on all fours and then clamber quickly to land with help from beaks; sometimes dashed against rocks without inconvenience. When going to sea, slide and bounce down banks and cliffs, as if on skis, often falling over large drops without mishap. Jump feet first into sea, not diving like Adelies (Murphy). Vagrants usually solitary but may be found among other crested penguins. Extremely vocal on land with loud trumpets and harsh squawks similar to those of other crested penguins.

HABITAT Marine; circumpolar in subantarctic and antarctic waters, N of n. limit of pack-ice. Main species taken as prey indicate feeding in pelagic waters (Horne 1985; Hindell 1988), but birds spend some time foraging close to shore (Falla 1937; Hindell 1988).

Breeding range circumpolar, extending from S of Antarctic Convergence to on or N of Subtropical Convergence. Colonies often in rugged rocky terrain; rocky shores, promontories, steep slopes, lava flows, boulder and talus falls, cliffs (Falla 1937; Rand 1955; Downes *et al.* 1959; Warham 1975); excluded only from vertical rock faces (Rand 1955; Warham & Bell 1979); sometimes occupy low flat ground when breeding alone, but when with larger penguin species, forced onto steeper slopes (Downes *et al.* 1959; Warham 1963; Warham & Bell 1979). Vegetation in rocky sites sparse or absent, but slopes may be consolidated by tussock grass and other vegetation (Falla 1937; Warham & Bell 1979; P.J. Moors & D.M. Cunningham). Colonies on Marion I. from just above sea-level to 60 m asl (Rand 1954). Most colonies near shoreline



(Rand 1954; Warham 1963); but some on Campbell I. require walk of 1–1.5 km from landing place (P.J. Moors & D.M. Cunningham). Sites vary in exposure; sheltered in caverns, fissures and tunnels or under vegetation (Falla 1937; Downes *et al.* 1959; Warham & Bell 1979); or exposed to weather on cliffs and slopes (Rand 1955).

DISTRIBUTION AND POPULATION Circumpolar, breeding on subantarctic and south Temperate islands in Indian and Atlantic Oceans. Little known of non-breeding distribution but thought to move N in winter from breeding islands to coasts of South America (to 35°S off Argentina; Harrison 1983), South Africa (irregular summer visitor, mostly first year birds and usually *moseleyi*; Brooke & Sinclair 1978; Cooper *et al.* 1978), Aust. and NZ, especially during moult, Jan.–Mar. (Harrison 1983). However, rarely beach-washed in NZ, even in winter (Powlesland 1984).

AUST. Most WA birds of race *moseleyi*; in e. Aust., some nominate *chrysocome*, otherwise presumed race *filholi* (HASB). Qld, NSW, NT: no records. Vic.: Lorne, Feb. 1910 (Nicholls 1910); Portland, June 1933 (Learmonth 1966), 1936 (C.F. Kurtze, MV), 1956 (N. Learmonth, MV), July–Aug. 1959 (Learmonth 1966); Discovery Bay, 1954 (Hitchcock &

Gwynn 1955, MV), 1978 (Aust. Atlas), June 1986 (Mitchell 1986); Warrnambool, 1928 (Anon 1928), 1961 (R.J. Edge, MV); Port Fairy, 1957 (N. Learmonth, MV); Pt Lonsdale, July 1968 (F. Smith, MV); Portsea, 1970 (K. Simpson, MV); Cowes, 1970 (T. Osbourne, MV); Darby Beach, Wilson's Prom., 1968 (Cooper 1974). Race *moseleyi*, July 1970, one W of C. Schanck (Simpson 1972); one, Wonthaggi, June 1986 (MV, B15237). Tas.: at least six, Strahan, 1972–74 (N. Sheppard, QVM); King I., one each, July 1970, Aug. 1970 (Porky Beach; Simpson 1972), three, July 1972 (Half Moon Bay and Porky Beach; McGarvie & Templeton 1974, QVM); Turner's Beach, Sept. 1978 (D. Rounsevell, QVM); Bruny I., Feb. 1977, 1978 (Tas. Bird Rep. 1977; D. Rounsevell, QVM); joint type-specimen from Bruny I., 1773 (Forster 1781 in Carins 1974). SA: St Francis I., Apr. 1913 (Condon 1962), 1940 (SAM 002 8011), 1963 (Parker *et al.* 1979); near Millicent, Dec. 1940 (Condon 1962); two near Beachport, 1972 (Parker *et al.* 1979, SAM 002 31340); Cape Jaffa, Dec. 1978 (Aust. Atlas). WA: Rottneest I., July 1909, Jan. 1956 (Strickland Bay), July 1957 (Thompson Bay), Feb. 1960 (Thompson Bay) (Conigrave 1909; Ford 1957; Storr 1964); William Bay, 1931 (Serventy 1931); Pt d'Entrecasteaux, 1957 (Aust. Atlas); Garden I., 1967 (Aust. Atlas); Two People's Bay, Aug. 1977 (Aust. Atlas); Esperance, 1981 (Aust. Atlas); between Bussellton and Augusta, 1982, 1983

(Anon 1983).

NZ SI: Otago Pen., Mar. 1971, Feb. 1977; Otago, Oyster Bay, Feb. 1977; Dunedin, Feb. 1972, Jan.-Feb. 1977; Puddingstone Rock, Feb. 1971 (A.E. Wright). **NI:** Gisborne, Dec. 1976, probably *moseleyi* (A. Blackburn; P.J. Moors); Wellington coast, Jan. 1984, *moseleyi* (Moors & Merton 1984). **Snares I.:** regular summer vagrant, usually moulting *filholi*, but also two nominate *chrysocome* (Tennyson & Miskelly 1989). **Chatham Is.:** South East I., Aug. 1968, Nov. 1970, *moseleyi* (Moors & Merton 1984).

S. SHETLAND IS Vagrant. One, Nov. 1985; one, Dec. 1986; one, Jan.-Feb. 1987; King George I. (Trivelpiece *et al.* 1987).

S. ORKNEY IS One, Laurie I., Jan. 1947; one, Moe I., Feb. 1957 (Tickell 1960); one, Signy I., Feb. 1957 (Tickell 1960), Jan. 1977 (Rootes 1988).

CORMORANT I. One, Dec. 1980 (Trivelpiece *et al.* 1987).

BRABANT I. Vagrant (Furse 1987).

ELEPHANT I. GROUP: One, possibly two, Clarence I., Dec. 1976; one, Aspland I., Jan. 1977 (Furse 1978).

S. GEORGIA Regular visitor (Prince & Payne 1979).

BREEDING Breed subantarctic and temperate islands in Southern, s. Indian and South Atlantic Oceans. Summary of known breeding sites and population estimates from Woehler (in press) unless indicated.

Prince Edward Is.:

Marion I.: 137 652 pairs.

Prince Edward I.: 35 000 pairs.

Iles Crozet:

Ile de la Possession: eight colonies, 60 000 pairs (Despin *et al.* 1972).

Ile de l'Est: 11 colonies, 46 500 pairs (Despin *et al.* 1972).

Ile aux Cochons: 20+ colonies, 46 000 pairs.

Iles des Apôtres: not numerous.

Iles des Pingouins: 300 pairs (Jouventin *et al.* 1984).

Iles Kerguelen: 85 500 pairs (Weimerskirch *et al.* 1989).

Ile Amsterdam: 50 000 pairs (Jouventin *et al.* 1984)

Ile St Paul: 5000 pairs (Jouventin *et al.* 1984)

Auckland I.: 12 colonies, 5000-10,000 pairs (Bell 1975).

Antipodes Is.: 86 colonies, 50 000 pairs (R.H. Taylor).

Campbell I.: nine colonies, 51 500 pairs (P.J. Moors & D.M. Cunningham).

Heard I.: 12 colonies, 10 000+ pairs.

McDonald I.: four colonies, 10+ pairs.

Macquarie I.: 23 colonies, 300 000 pairs (D.E. Rounsevell). Bishop and Clerk Islets: two colonies, 20 pairs (Lugg *et al.* 1978).

Falkland Is.: 44 colonies, 2.5 million pairs (Croxall *et al.* 1984)

Also reported breeding occasionally at S. Georgia (Prince & Payne 1979; P.A. Prince) and once Clarence I. (Elephant I. Grp), Dec. 1976 (Furse 1978). Extraliminally breeds on Falkland Is (Croxall *et al.* 1984b), islands S of Chile (Schlatter 1984), Iles Amsterdam and St Paul (Jouventin *et al.* 1984), Tristan da Cunha (Richardson 1984; Fraser *et al.* 1988) and Gough I. (Williams 1980).

Status needs continued review but possibly stable. Eggs and birds taken for food and oil on Tristan da Cunha (Williams 1984), Falkland Is (Murphy) and Ile Amsterdam (Jouventin *et al.* 1984). Sensitive to human disturbance on Ile Amsterdam (Jouventin *et al.* 1984) and possibly to competition from commercial fishing (Croxall *et al.* 1984). Popula-

tions increasing on islands off Chile (Schlatter 1984) but has declined on Tristan da Cunha and Campbell Is (Williams 1984; Moors 1986) and locally on Falkland Is (Croxall *et al.* 1984). Populations unchanged on Macquarie I. (Rounsevell & Brothers 1984) and Iles Crozet (Jouventin *et al.* 1984).

MOVEMENTS Dispersive, possibly migratory. Annual cycle of arrival and departure from subantarctic islands strongly correlated with sea surface-temperature (Warham 1972) except for Marion I. (Rand 1955), which is 10 days later than would be expected.

DEPARTURE Adults leave colonies at New I., Falkland Is, mid-Apr. (Strange 1982), Heard I. by early May (Downes *et al.* 1959), Campbell I. Apr.-10 May (P.J. Moors & D.M. Cunningham); chicks leave Tristan da Cunha 17 Dec.-8 Jan. (Williams & Stone 1981), Campbell I. from 9 to last week Feb. (P.J. Moors; D.M. Cunningham), Antipodes Is (Warham 1972), Falkland Is (Strange 1982) mid-Feb., Macquarie I. late Feb.-early Mar. (Warham 1963), Heard I. mid-Mar. (Downes *et al.* 1959). Non-breeding immatures leave gradually from all breeding sites during Jan. and Feb. Numbers of adults appear to leave independently (Warham 1963).

NON-BREEDING Movements away from nesting islands largely unknown. The few sightings at sea (Bourne & Curtis 1985; Enticott 1986) suggest movement along Subtropical Convergence 49°S, 51°W on 26 Aug. 1983 and 43°S 44°W on 14 Sept. 1984 (Bourne & Curtis 1985). Of 28 aged and dated records of birds beachcast in South Africa, 70% were first-year birds in Jan. or Feb. (Cooper *et al.* 1978). Adult records showed no pattern. Strange (1982) has suggested from synchronic return of male cohorts that they remain together in non-breeding season. No winter records of beachcast birds NZ (Powlesland 1984) despite assumed N movement from breeding islands.

RETURN Males return to Antipodes Is about 3 Oct. (Warham 1972), Campbell I. about 7 Oct. (Warham 1972; P.J. Moors & D.M. Cunningham), Falkland Is 9-10 Oct. (Strange 1982), Macquarie I. 15-17 Oct. (Warham 1963; A. Gwynn), Heard I. 2-5 Nov. (Downes *et al.* 1959). Females arrive 6.5 days (0-14; n=23) after mates (Warham 1963). Non-breeding immatures arrive gradually from start of breeding season.

BREEDING Foraging range round Marion I., while rearing chicks <30 days old, 4-157 km, probably increasing later up to 300 km (Brown 1987) though average foraging distance estimated to be 95 km (Williams & Siegfried 1980). Characterized as offshore feeders on basis of diet (Croxall & Lishman 1987) but at least some food taken near shore (Hindell 1988). Most records of vagrants from southern sites have been Jan.-Feb. (Rootes 1988)

FOOD During breeding at some southern sites mostly euphausiids with small fish and cephalopods increasing in diet fed to older chicks; fish or cephalopods predominate at some northern breeding colonies. **BEHAVIOUR.** Food taken by pursuit-diving from depths of up to 100 m (Brown & Klages 1987) at speeds of at least 2.18 m/s (Clark & Bemis 1979). When taking fish in captivity appear to stun prey first with blow from bill before swallowing it beneath surface, always approaching prey from below (Nicholls 1910). For first 20 days food regurgitated for young in mucous coating, later feeds lack mucous (Strange 1982). When foraging, travel 7.4 km/h (0.5; 6.9-8.1;

Table 1. Diet of Rockhopper Penguin while feeding chicks.

	% wt.			% no.			% freq.	
	1	2	3	1	2	4	2	4
CRUSTACEANS	85.2	45.1	69.3	99.4	79	7.7	100	50
FISH	9.8	1.9	28.3	0.5	*	91.2	56	100
CEPHALOPODS	5.0	53.0	1.7	0.2	21	1.7	46	67

(1) Marion I. (Brown & Klages 1987). (2) Beauchêne I. (Croxall *et al.* 1985). (3) Macquarie I. (Hindell 1988). (4) Campbell I. (P.J. Moors & D.M. Cunningham). * fish not included.

7) with 30% of time spent travelling (18; 6.0–59.6; 7; Brown 1987).

BREEDING Summarized Table 1. At **Marion I.** (85 water-offloaded samples; Brown & Klages 1987), crustaceans 2.09 cm: euphausiids *Euphausia vallentini* 69.9% no. ident. crustaceans (1118), *E. sp.* 4.1, amphipods *Themisto gaudichaudii* 0.1, *Primno* sp. 0.1, *Vibilia* sp. 0.2, shrimps *Nautica marionis* 5.2; fish *Krefflichthys anderssoni* 31.4% no. of ident. fish (893), *Protomyctophum tenisoni* 44.6, 4.5 cm (1.9–6.3; 40), *P. normani* 13.0, 7.48 cm (4.5; 5.6–8.5; 116), unident. 0.1, *Paranotothenia magellanica* 3.2, 1.2–8.5 cm; cephalopods 45.5% <1.0 cm: *Kondakovia longimana* 11.2% of ident. cephalopods (484), unident. 8.1, unident. Teuthoidea 8.0, unident. Octopoda 72.7. Diet differed between years, reflecting changes in availability of food. At **Marion I.**, proportion of crustaceans high during early chick-rearing but proportion of fish and cephalopods increased gradually to peak of about 50% late Feb. when chicks 47 days old. Then declined sharply, last two weeks before fledging diet almost entirely crustaceans. Changes probably correlated with foraging range, crustaceans being taken close to shore during guard-stage, pelagic fish and cephalopods when adults freed to travel farther. Return to predominance of crustaceans at Marion I. thought to reflect absence of Macaroni Penguins *Eudyptes chrysolophus* in final 2 weeks of chick rearing. At **Beauchêne I., Falklands Is** (29 stomachs; Croxall *et al.* 1985), crustaceans euphausiids *Euphausia lucens* 66% no. euphausiids, 100% freq., 1.66 cm (0.37); *E. vallentini* ads. 12, 93, 19.9 cm (1.4), juvs. 7, 34; *Thysanoessa gregaria* 15, 83, 15.0 (1.4); amphipods *Themisto gaudichaudii* 55% freq., isopods 3, decapods 3; cephalopods probably *Teuthowenia* beak size 0.061 cm (0.013). At **Macquarie I.** (77 water-offloaded samples, 114195 items; Hindell 1988), crustaceans euphausiids *Euphausia vallentini* 62.3% wt., 86.5% no., 79% freq., 0.05 g (0.01; 631), 1.81 cm (5.0; 631), *Thysanoessa gregaria* 4.5, 7.9, 14, 0.05 g (0.01; 52), 1.35 cm (0.31; 52), unident. euphausiids 2.3, 4.2, 12, amphipods *Cylopus lucasii* 0.1, 0.1, 6, Gammaridea <0.1, 0.1, 6, unident. amphipods 0.1, 0.1, 10; fish *Zanclorhynchus spinifer* 3.0, <0.1, 6, *Electrona carlesbergi* 2.2, 0.1, 5, 2.2 g (0.8; 17), 5.30 cm (0.59; 17), *Gymnoscopelus* 4.6, <0.1, 5, *Krefflichthys anderssoni* 16.0, 0.4, 23, 3.4 g (3.0; 45), 5.45 cm (2.05; 45), *Protomyctophum* 0.3, <0.1, 4, *Paranotothenia magellanica* 1.8, 0.3, 21, *Harpagifer georgianus* 0.4, 0.3, 10; cephalopods *Moroteuthis* 0.1, <0.1, 6, 15.7 g (18.6; 45), *Martialia hyadesi* 1.6, <0.1, 1, 60.8 g (39.0; 13). Diet similar throughout breeding period with no evidence of variation in foraging range, possibly because deep water is nowhere far from shore (Hindell 1988). In earlier study at **Macquarie I.** (19 water-offloaded samples without repetition; Horne 1985), crustaceans 70.3%

wt.: euphausiids 70% wt., 84% freq. (*Euphausia vallentini* 79% freq., *Thysanoessa gregaria* 16), amphipods 0.3% wt., 26% freq. (*Themisto gaudichaudii* 26, *Primno macropa* 5); fish 17% wt., 42% freq.: *Zanclorhynchus spinifer* 1.9 g, 6.0 cm, Myctophidae 42% freq., Nototheniidae 5 (*Notothenia* 10.2 g, <10 cm), cephalopods 2.7%wt., 11% freq.; also arrow worm, spider and a tick. Data probably biased because stomachs flushed only once (Gales 1987) and no allowance made for different rates of digestion (Hindell 1988). At **Campbell I.** (58 water-offloaded samples, 17201 items; P.J. Moors & D.M. Cunningham) fish were *Austrophycis marginata* 58.7% no., 97% freq., *Halargyreus johnsonii* <0.1, 10, *Trypterophycis gilchristi* <0.1, 5, *Merluccius australis* 9.7, 91, *Micromesistius australis* 15.4, 90, Congiopodidae 7.3, 66, cephalopods *Moroteuthis ingens* 1.0, 57, *Alluroteuthis* <0.1, 3, *Octopus doffleini* 0.7, 37; crustaceans stomatopods *Heterosquilla tricarinata* pelagic larv. 0.5, 16, post-larv. 3.4, 33, amphipods 0.3, 21 incl. Hyperiidea 0.2, 5 (*Cylopus* 0.2, 2), Gammaridea <0.1, 2, euphausiids 2.9, 43 (incl. *Thysanoessa gregaria*), crabs 0.1, 7 (Majidae <0.1, 2). Samples from autopsied chicks (24) similar: fish 12.6% no., 67% freq.: *Electrona subaspera* 0.8, 4, *Austrophycis marginata* 1.6, 33, *Merluccius australis* 1.3, 25, *Micromesistius australis* 75.6, 88, Congiopodidae 1.5, 8; cephalopods 6.6, 83: *Moroteuthis ingens* 1.7, 71, *Kondakovia longimana* 0.3, 17, *Martialia hyadesi* 2.6, 75, *Octopus doffleini* 2.0, 38; crustaceans 12.6, 67: calanoid copepods 0.1, 4, stomatopods *Heterosquilla tricarinata* 2.9, 38 (pelagic larv. 0.6, 21, post-larv. 2.3, 29), amphipods <0.1, 4, euphausiids 9.5, 58, crabs Majidae <0.1, 4.

Other records: Heard I., large numbers amphipods *Hyperia galba*, *Themisto antarctica* (2–300 g/bird; 6 stomachs; Ealey 1954); at **Marion I.**, euphausiids *Euphausia lucens*, *Thysanoessa macrura*, fish *Protomyctophum bolini*, *Gymnoscopelus nicholsi* (Williams & Laycock 1981; Brown & Klages 1987) in addition to species listed above; at **Falkland Is**, euphausiids *Euphausia vallentini*, cephalopods <1.5 cm, fish fragments (seven samples) where change in colour of chick faeces from bright pink to grey-green at Falkland Is after 20 days may reflect change in diet from crustaceans to cephalopods (Strange 1982); at Iles Kerguelen, amphipods (Paulian 1953), Ile Amsterdam, cephalopods 50% no., crustaceans euphausiids 25, shrimps *Jasus paulensis* 10, fish 10 (100 stomachs; Duroselle & Tollu 1977); at **Gough I.**, euphausiids *Thysanoessa vicina* 39% vol. (five stomachs; Williams & Laycock 1981).

INTAKE Mean wt. chick stomach contents **Marion I.** 176 g (80–430; 85; Brown & Klages 1987); **Beauchêne I.** 219 g (45; 148–278; 29; Croxall *et al.* 1985). Adults bringing food ashore **Macquarie I.** contained 197.0 g (147.0; 77), increasing from 20.0 g mid-Oct. and nil Nov., to 47.0 g early Dec. and 319.3 g late Jan., varying but declining until late Feb. (Hindell 1988); at **Campbell I.** 261.8 g (107.4; 96–540; 58; P.J. Moors & D.M. Cunningham). Daily wt. gains **Marion I.** (Williams 1982) from 142 g (49; 33; 1–5 days old) to 456 g (238; 28; 51–55 days old) to 196 g (146; 18; 66–70 days old just before fledging). Max. daily wt. gain 650 g. Between hatching and fledging receives 14.7 kg in 30 meals to gain 4.8 kg (0.8; 18). Given 1 feed/day **Campbell I.** to ≤25 days old, after that feeding trips sometimes >1 day (P.J. Moors & D.M. Cunningham).

SOCIAL ORGANIZATION Information from Warham (Macquarie I.; 1963) and P.J. Moors and D.M. Cunningham (Campbell I.). Gregarious at sea, feeding in small to medium-sized flocks. Breed in scattered colonies, sometimes

vast; size may be determined by broken nature of terrain.

BONDS Some pair-bonds maintained in successive seasons, but substantial changes in pairs even if both members alive and present at colony. At Macquarie I., 13 pairs unchanged from 1960–61 to 1961–62 season; 11 birds with new mates. Of these 11, two birds mated in 1959–60, took new partners in 1960–61, and reverted to former mates in 1961–62. Warham (1963) suggests pair-bond maintained in successive seasons if both members of pair present at colony. But at Campbell I. between 1985–86 and 1986–87 breeding seasons, 53 (59%) of 90 banded pairs unchanged, 37 (41%) changed; in 14 of 37 changed pairs, mate from 1985–86 known to be alive and present at colony; in two, mate from 1985–86 known to be dead. At Macquarie I., some females formed temporary attachments to males whose mates delayed returning, but ousted when original mates arrived. No evidence of continuing association of mated pairs at sea.

BREEDING DISPERSION On Campbell I., 1986–87, av. density of three colonies, 2.2 nests/m² (1.6–2.7; 325 nests; P.J. Moors & D.M. Cunningham); in rugged terrain, density may be determined by number and spacing of suitable sites.

ROOSTING At Campbell I., non-breeders roost at margins of colonies; failed breeders at nest-sites, especially shortly after failure, and later usually at margins of colonies; breeders at nest-sites. Birds coming ashore often rest and preen for short period at traditional sites close to landing places. Moulting non-breeders roost at margins of colonies or in groups away from colonies, often near landing places.

SOCIAL BEHAVIOUR Described in detail by Warham (1963) and reviewed in Warham (1975) and Jouventin (1982). Warham's (1975) classification of displays followed here. Displays vary little between species of *Eudyptes* (Warham 1975). Roberts (1940) and Murphy states that Rockhopper Penguins can erect yellow superciliary plumes and do so during aggressive or submissive displays but Warham (1963) noted no muscular control of drooping yellow crest-feathers, although some voluntary movement of black occipital crests possible. Early observers may have misinterpreted passive waving of plumes during head-shaking.

AGONISTIC BEHAVIOUR **THREAT. Mild Threat:** bird reaches towards another, turning its head to one side and bobbing up and down; flippers often raised, ready for aggressive action; series of short cries given. Response to human or strange bird walking through rookery; if in range, intruder pecked fiercely or struck with flippers. **Severe Threat:** birds jab open bills towards each other, uttering harsh cries. Bills may become interlocked and one bird may be pulled off nest. **FIGHTING:** two birds grapple until one can grip the other by nape, belabouring it with flippers. Very aggressive male may cling to opponent as it flees and follow it through colony, disregarding pecks from other birds. Threatening actions of male more vigorous than female; threaten any moving object within reach. Mates exempt through individual recognition and greeting ceremonies. Much bickering between breeders when colony crowded, especially when both sexes present during pre-egg stage and shortly after laying. Later, when immatures and non-breeders present, hierarchical system established; breeding males dominate all others; non-breeding males dominate rest; short-crested birds (immatures) dominate yearlings; yearlings dominate chicks. **APPEASEMENT. Slender Walk:** bird walks through rookery with body erect, head bowed, bill pointed downwards at about

45°, feathers sleeked and flippers held forward as in Shoulders-hunched attitude; posture shields it from attack. Hurries wherever through is thick. Seldom retaliates to pecks received on way. When hemmed in, pushes through, stretching up, apparently to keep eyes out of pecking range. Attitude similar to Shoulders-hunched, into which it merges when nest reached. When bird reaches open space, adopts **Stare-around** posture of Warham (1975): lifts head and jerks it from side to side as if taking bearings. **Submissive Posture:** incubating female attacked by strange male flattens onto nest, draws in head and keeps still, while attacker pecks and beats it with flipper. Presentation of nape to aggressor may inhibit pecking (Warham 1963). Submission rather than retaliation protects eggs and chicks. Attack caused on one occasion by male misidentifying his nest-site; on another by female sitting on wrong nest. **Wing-shivering:** birds shiver flippers through small amplitude in response to human intruder in colony. **UNCLASSIFIED POSTURES. Head-shake:** rapid side-to-side shaking of head; used after any period of activity and appears to mark return to rest. **Squeal:** sudden and penetrating cry, sustained for some seconds, seems to be given through closed bill; throughout breeding season. No accompanying movement. Possibly an Alarm Call or call of excitement; once uttered by incubating bird as skua flew low overhead, and echoed by others; once, by one-year-old standing in unoccupied nest when rightful owner approached; once when party of adults hesitated on rocks before plunging into water; once when male on nest approached by mate, before usual Trumpeting of greeting.

SEXUAL BEHAVIOUR **Stone-carrying:** stones, tussock grass and earth collected and placed round nest. Mainly by male when mate on nest during laying period, particularly after male relieved; but may occur whenever both birds ashore, even during moult. Sitting female takes offerings from edge of nest and places them to one flank with Quivering motion. May prevent eggs rolling out of nest, but action probably mainly of ritual significance. **Quivering:** nesting bird bends down, bill slightly open, and shakes head rapidly from side to side, while pointing bill into nest or swinging head from flank to flank; flippers not lifted. Silent or accompanied by deep *kruk kruk* calls. Bill may be empty, but usually grass or other material placed to one flank during swinging action. Used by both sexes, sometimes in unison, but mostly started by males. Mainly at nest, but also used by birds temporarily shifting position during moult; one non-breeder observed Quivering. Display may follow Mutual or Trumpeting Displays. **Bowing:** with bill near feet, bird utters succession of deep throaty throbbing notes; body shakes in time with calls but head remains still. Used by both sexes; performance solo or mutual, in which both birds reach forward with bills together. Bowing infectious; may be stimulated in others by bird bending to feed chick and feeding bird's response may interfere with feeding. Display may fade out, or progress to Vertical Head Swinging or Mutual Display. **Shoulders-hunched:** body fairly upright, head tilted forwards with bill pointing down, and flippers held stiffly forward, downward and parallel at c. 30° to vertical. Used by bird returning to occupied or unoccupied nest; posture adopted a few paces from nest; at nest, bird pads round with mincing gait, pivoting on feet, before settling onto nest. Also used by relieved bird as it moves off nest and by male immediately after copulation. **Trumpeting:** as relieving bird approaches nest, incoming and sitting birds break into loud Trumpeting, reaching towards each other with open bills. Neighbours often join in, directing

cries towards newcomer. When incoming bird steps into nest, pair begin Vertical Trumpeting, or perhaps Mutual Display (see below). **Vertical Trumpeting:** birds point wide-open bills to sky, raise and lower flippers in time with braying; keep heads fairly still, male reaching a little higher than female; muscles of breast ripple and swell. Calls different from those of Mutual Display; louder and lack pulsating rhythm. Cries gradually die down, male generally changing to Vertical Head Swinging, and performance subsides to throbs and silence. If absence of relieving bird extended, ceremony commonly repeated several times. Display rarely seen away from nest; mainly during incubation and guard-stages. May indicate individual recognition between members of pair. When parent returns to nest during crèche-stage, Trumpeting used, but usually with bill forward rather than vertical; may signal chick to leave crèche to be fed. **Vertical Head Swinging:** (Male Display of Warham 1963) begins with Bowing, bill first directed at feet and then suddenly swung back so that crown vertical and bill pointed skywards; head then rapidly shaken from side to side through arc of c. 30°; flippers may be held against sides, but more often raised progressively as display proceeds; not moved in time with calls. As head wobbles, loud pulsating cries given though open bill. If female present, Mutual Display usually results. Display common from first arrival of breeding males until departure after first long fast; then again after males return for second incubation shift and during guard-stage. Males that occupy sites but fail to find mates use Display frequently. May demonstrate ownership of nest-site and act as male advertising display (Warham 1975). **Mutual Display:** male Bows and throbs, and then begins Vertical Head-swinging. Female may or may not respond; if she does, she Bows and perhaps Quivers. When male swings up his head she rises to face him, calling with open bill and reaches towards his head or neck. Her body heaves as she calls, but no violent muscle contractions as in Trumpeting; no wobbling of head as for male, and her bill kept more horizontal; flippers seldom raised. Incubating females take part in Display, but generally remain seated. Male always initiates and often performs alone; female performs only in response to Male Display or male's Vertical Trumpeting. **MUTUAL ALLO-PREENING:** birds turn heads to one side and nibble each other's throats and necks with tips of bills. Very common between members of mated pairs; essentially an act of sexual recognition. But also between non-breeders that have formed attachments; between birds when one first accepts close approach of another of opposite sex; and between parents and chicks. Preening of chicks may curb excessive begging. **COPULATION:** Either sex solicits, female by squatting, male by beating mate with flipper; after peak period, males most active; unsuccessful attempts frequent, when female solicited by male fails to respond. Male crowds up to mate, nibbles her nape with bill and flicks flippers against her back. She subsides and he mounts. Female lies quiet with head raised, sometimes stretching flippers out to touch ground; male treads her back, drums flippers on her flanks, moves tail from side to side, and edges backwards. Male depresses his tail and female tilts hers upwards to make cloacal contact. During consummation, male remains still, propped in place by flippers and with female's bill turned into his neck. Male then slides off and remains still, in Shoulders-hunched attitude; female also remains still except for pulsations around cloaca. Then both preen, Head Shake and relax. Reversed copulation observed in one pair after loss of eggs. Copulation concentrated into very short period, about a week before egg-laying; on

Macquarie I., mainly 2–5 Nov. Birds involved in late matings are failed breeders or non-breeders. Copulation occurs only at nest; not seen between birds with eggs or chicks.

RELATIONS WITHIN FAMILY GROUP Male and female co-operate in building nest; female forms scrape, male gathers material; male collects nest material at intervals during incubation; placed by sitting female. After laying of first egg, both parents stay at nest, alternating incubation frequently; first long stint by female while male at sea, second by male until c. two days before hatching when female returns. After hatching, both present for 2–3 days; change-overs frequent; female feeds chick. Thereafter, male attends nest constantly, brooding in morning; female returns each afternoon to feed chick and brood. Guard stage, c. 20–26 days. Chicks form crèches at about three weeks old; fed at nest-site; by female alone for c. 7 days while male at sea regaining condition, then shared after male's return, but little co-ordination between sexes in feeding at this stage. At 65–70 days after hatching, chicks go to sea. No period of desertion by adults before chicks leave. Chicks fed by incomplete regurgitation; several feeds given at each visit. At crèche stage, adult Bows and Trumpets on return to nest; perhaps signal to chick to leave crèche to be fed. Chick approaches, calling with *cheeps* and jerking flippers up and down. More than one chick may respond, but only one fed; calls of chicks show individual differences by which adult probably identifies its own. Chick begs by wobbling head and pecking adult's bill, belly and flanks; beg persistently and, at crèche stage, may chase adult until fed. Occasionally, adult does not recognize own chick and pecks it, but then responds to persistent begging. Parents and chicks allopreen. When alarmed, chick at guard-stage thrusts head and shoulders under body of adult.

VOICE No detailed studies; behaviour and calls described by Warham (1963, 1975) and reviewed by Jouventin (1982); sonagrams in Warham (1975) and Jouventin (1982). Noisy, aggressive and demonstrative at colonies; utter short barking contact calls at sea. Most calls single or repeated short phrases consisting of repeated 25-ms pulsed notes. Calls described as 'raucous braying sounds, often given with great force through a wide-opened mouth, and involving extensive contractions of pectoral muscles'; 'often loud, harsh and virtually impossible to convey adequately in writing' (Warham 1975). Most calling during day; little at night. Calling begins with arrival at colony, peaking when sites occupied; colonies quiet during incubation when mates at sea with peaks of calling at change-over during incubation, and after hatching. No information on sexual differences though Warham (1975), referring to *Eudyptes* spp, states that female seems to have higher-pitched calls. Calls of all *Eudyptes* penguins similar; those of Rockhopper Penguins generally harsher, more highly pitched, more strident pulsed squawks, with shorter phrases and few harmonics thus sounding shrill and unmusical. **Individual differences.** Little variation in calls of individual but calls of different individuals differ; variation of songs by individual is much less than variation in population; adults recognize mates by voice and visual cues; recognition of chicks appears to depend on voice (Jouventin 1982). **Non-vocal sounds:** during fights, flippers slapped loudly against opponent; males flick flippers at back of female before copulation and rapidly vibrate or drum flippers against flanks of female during copulation. **Geographical variation.** Detailed analysis of Trumpet calls at Iles Crozet and St Paul showed marked variation (Jouventin 1982): at Iles Crozet (calls of 23

individuals) main frequency 2054 Hz (1500–3000), maximum frequency 7104 (6000–8000), length of phrases 0.25 s (0.15–0.45), number of syllables 7.12 (4–11) with 0.34 s (0.25–0.40) between phrases; at Iles St Paul (28 songs), main frequency 1352 Hz (1100–1500), maximum frequency 2796 Hz (2000–3400), length of phrases 0.39 (0.2–0.52), number of syllables 7.73 (5–20) with 0.63 s (0.4–1.0) between phrases.

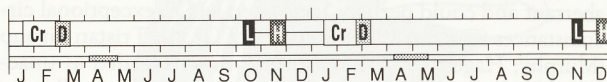
ADULT Trumpet (Ecstatic Display Song of Jouventin 1982). Examples in Warham (1975) and Jouventin (1982). Series of very loud braying yells with noticeable vibrato quality; calls usually with short preliminary phrase, which may be inspiratory, followed by series of repeated phrases, each consisting of 25-ms pulsed notes with low-frequency introductory and terminal notes to phrase; last phrases of call are of lower frequency and tend to lose vibrato quality (lacking pulsed notes). Phrases c. 0.2–0.4 s long with most energy concentrated between 3 and 4 kHz, though frequency distribution varies from note to note. Calls sometimes repeated several times, usually after long absence by one partner. Given during Forward Trumpeting and solo or Mutual Vertical Trumpeting and sometimes as threat during Forward Trumpeting; not known if calls differ between these displays. **Vertical Head-swinging Call**. Series of loud pulsating raucous or braying cries; similar to Trumpet; a series of repeated phrases, each consisting of pulsed notes of 25-ms duration; phrases tend to lengthen towards end of call and terminal phrases lose pulsed quality. Display and calls usually last 4–8 s. Warham (1975) shows two examples from different birds, differing in length of phrases and terminal syllables, one ending with slurred trill, the other more like a groan; in these examples, phrases of one bird 0.14–0.35 s duration, the other 0.13–0.22 s. Display and calls given by male only; not known if calls vary with circumstances. **Bowing Call**. Repeated deep throaty throbbing noises or cries; details not known. **Mutual Display Calls**. Male performs Vertical Head-swinging and gives associated calls (above); female also calls, resulting in duet but details not known. Calls generally similar to Trumpet. **Quivering Call**. Utter repeated deep *kruk kruk*. **Squeal**. Sudden penetrating cry of several seconds duration; given with bill closed. Rarely used; appears to be given when bird alarmed. **Threat Calls**. Warham (1975) gives examples of two types of Threat Calls: (1) Brief staccato pulsed cries or 'fussy yells' consisting of one or two 25-ms pulsed notes becoming harsher, more highly pitched and more sustained at higher intensities. Given when intruders (including humans) walk through colonies. (2) High-pitched, down-slurred note with harmonics with quiet pulsed notes before and after that sounded like brief grunts. **Contact Call**. Short high-pitched monosyllabic barking calls; given at sea, only rarely at colonies.

YOUNG Simple regularly repeated cheeping or peeping *see-up*, 0.14–0.30 s duration with 0.5–0.7 s between repeats. Calls of individual chicks tend to be constant in form and patterning; marked differences between individuals; Jouventin (1982) showed adults recognize chicks by voice. After guard-stage, calls begin to differentiate and chicks begin to utter a harsher cry, of similar form but becoming more complex (Warham 1975; Jouventin 1982; *contra* Warham 1963).

BREEDING Well known. Studies by Warham (1963) at Macquarie I., Williams (1980, 1981a,b,c, 1982) at Marion I., P.J. Moors and D.M. Cunningham (NZ islands) and A.M. Gwynn (Heard I.). Information supplied by A.M. Gwynn and P.J. Moors. Breed in simple pairs in colonies, often large. In

Falkland Is and Tristan group prone to tolerate other spp (penguins, albatrosses, shags) in colonies (Murphy).

SEASON Broadly Aug.–Mar., depending on locality and varying slightly from year to year. Peak of laying throughout range advances by about 10 days for each °C rise in mean sea temperature; thus generally later in higher latitudes, though in this respect discordant at Heard I. and Iles Kerguelen. At Macquarie I., first eggs 8 Nov., last 18 Nov., peak 11–16 Nov. (Warham 1963). At Campbell I. laying period 6–15 and 3–15 Nov. and mean date of laying 7–10 Nov. for different colonies during two seasons. At Antipodes I. about 7 days earlier than at Campbell I. (first chicks 2 Dec. for laying at end Oct.) but at Disappointment I., Auckland Is, recently hatched chicks 31 Dec. and probably laying about 10 days later than at Campbell I.



(Macquarie I.)

SITE Usually on ground on rocky scree; in natural tunnels in lava flows, even in almost total darkness (Heard I., Iles Kerguelen); in fissures, caves in collapsing cliffs (Macquarie I.); sometimes in areas of tussock grass and other dense vegetation (NZ islands). Where associated with colonies of other larger penguins (Antipodes I.) occupy more accessible sites on peripheries; where no competition (Campbell I.), occupy lower flatter areas near shore as well as steep scree slopes. At Campbell I. and elsewhere some colonies ≥ 400 m from shore and ≥ 50 m asl, connected to landing places by well-worn paths, along which passing birds said to keep to the left (Murphy). Older birds generally occupy same site year after year. At Campbell I. strong tendency for birds to return to exactly same site, whether or not successful breeders in previous season. Average density at three colonies on Campbell I. 2.2 nests/m² (1.6–2.7; 325 nests); over-estimate of population on Campbell I. in 1940s by Bailey & Sorensen (1962) based on 'seven birds to a square yard', which corrected from study of their photographs by P.J. Moors and D.M. Cunningham to c. 2 nests/m² and thus showing no difference from recent measurements.

NEST, MATERIALS Scrape in ground, lined with pebbles; less often with grass and other vegetable material. Unlined scrapes recorded in Falkland Is and in nests abandoned by Black-browed Albatrosses *Diomedea melanophrys* (Murphy). Nests more substantial than those of Macaroni Penguin *E. chrysolophus*. Before arrival of females, males spend more and more time at sites, gathering material; after arrival, females usually form scrape by squatting, rotating and raking backwards with feet; males then bring more material, collected nearby.

EGGS Varying; usually regularly ovate; often shortened to spheroidal or elongated to ovoid; smooth with shallow depressions and small pits; greenish blue, occasionally with thin whitish chalky coating (Murphy). First (A) egg invariably smaller than second (B).

MEASUREMENTS :

Marion I.:

A-egg 62.3 (2.6; 57.1–70.5; 122) x 46.8 (1.7; 43.6–50.5).

B-egg 70.2 (2.6; 64.4–78.6; 119) x 52.9 (1.7; 48.1–56.7).

Heard I.:

A-egg 63.9 (2.7; 59.0–68.0; 11) x 46.4 (2.9; 42.2–51.5).

B-egg 71.9 (2.0; 68.0–73.7; 11) x 52.9 (2.5; 49.0–56.7).

Campbell I.:

A-egg 63.5 (3.10; 57.3–72.8; 41) x 48.0 (1.55; 45.2–53.4).

B-egg 70.5 (2.65; 65.3–78.6; 39) x 53.7 (1.20; 51.0–56.3).

WEIGHTS.:

Heard I.: A-egg 76.1. B-egg 110.8.

Campbell I.: A-egg 79.6 (6.03; 64.5–91.0; 37). B-egg 112.0 (6.49; 92.0–125.0; 37).

Composition (% total weight: shell, albumen, yolk): Campbell I. A-egg 13.5, 60.7, 25.7 (n=5); B-egg 13.6, 60.3, 26.2 (n=5). Marion I. A-egg 15.8, 57.3, 27.0 (n=11); B-egg 13.7, 62.9, 23.5 (n=8).

CLUTCH-SIZE Two. Reports of C/1 (Duroselle & Tollu 1977) probably because observation incomplete. At Macquarie and Heard Is, three records of three eggs entirely aberrant and could perhaps have been laid in exceptional circumstances (Gwynn 1953). Reports of C/3 in Tristan Group (Murphy; Hagen 1952; Elliott 1957) now regarded as unacceptable. At Campbell I. three eggs in nest very rare; all to be explained by adoption of egg from neighbouring nest and two such adoptions definitely observed (P.J. Moors & D.M. Cunningham).

LAYING Highly synchronized; 4–5 days between A- and B-eggs (Williams 1981a). Replacements after loss of first clutches (Murphy) never confirmed and now regarded as erroneous.

INCUBATION At Macquarie I., after laying of A-egg both parents stay at nest and change over often, for protection of egg, but incubation usually starts before laying of B-egg. Throughout incubation, B-egg maintained at higher and steadier temperature than A-egg (av. 34.3 v. 29.9 °C) (Burger & Williams 1979). At first, incubation mostly by female, with male taking occasional spells before he goes to sea, having been ashore for average of 33 days (25–39; 19). Male then absent for 12 days (9–17; 25) until returning to take over. After spell ashore for 39 days (33–45; 20), of which 14 days (10–19) incubating, female leaves and stays away for 8.5 days (7–13). Some females reluctant to leave egg and stay for 2–3 days after males take over. Females usually return about 2 days before hatching and take over (Warham 1963). A-egg often fails during incubation. At Campbell I., A- and B-eggs both hatch in small proportion of nests; B-egg hatched first in 57/58 recorded nests; A-egg hatched 1.2 days (1.04; 18) and 1.1 days (1.15; 40) after B-egg in different seasons. If both eggs hatch, almost always one chick (usually from A-egg) dies or is discarded; but chick from A-egg may survive if B-egg has been lost. A-egg probably rarely, if ever, ejected deliberately, usually displaced during squabbles (Warham 1963; P.J. Moors; D.M. Cunningham). **INCUBATION PERIOD.** 33–34 days (n=3; Gwynn 1953; Warham 1963). At Marion I. for A-eggs, 39.1 and 38 days, for B-eggs, 34.2 and 35.9 days.

YOUNG Semi-altricial, nidicolous. Hatching (pipping to emergence) takes 24–48 h (Gwynn 1953); at Campbell I., A-egg took on average 1.5 days (0.63; 1–3; 31) and B-egg 1.2 days (0.46; 1–3; 86) (P=0.01). Both parents usually in attendance for first 2–3 days with frequent feeds by female. Feeding by incomplete regurgitation; when chick small, adult encloses chick's bill in its own and chick gets food from inside adult's bill; later, adult regurgitates in response to chick pecking at its bill. Guard-stage begins when female goes to sea again, leaving male in charge, 2–3 days after hatching. Chick brooded by male in morning till female arrives, usually in afternoon, which she does every afternoon at Campbell I.; male stays

nearby; may leave for short bathe but not to feed, as proved by white, not pink, excreta throughout period. Chick brooded by female in evening but time of departure for foraging not known (Warham 1963). Guard-stage at Macquarie I. lasts on average 26 days (21–30; 21) and length of male's second fast averages 36 days (31–40; 21); at Campbell I., guard-stage shorter, ending in first few days of Jan. when most chicks about 20 days old. When chicks too large to be brooded, stand in front of adult at nest. When alarmed, thrust head and shoulders under adult. Beginning of crèche-stage at about 3 weeks old heralded by chicks wandering from nest, even when male present, and joining into small groups with others. Eventually return to nest only for feeding; 1–3 days after this routine established, males go to sea. Thereafter, female continues to feed chick, and males share feeding once they have regained condition after guard-stage fasting; feeding always at nest-site. On arrival at site, adult adopts Shoulders-hunched posture, Bows and Trumpets loudly; one or more chicks, peeping loudly and waving flippers, approach but adult always feeds only own chick. Chick importunes by wobbling head and pecking adult's bill, belly and flanks; adult may respond readily and disgorge into chick's bill; sometimes needs persistent stimulation and then appears to provide only small meals. Parents may be chased for 20–30 m in colony before providing meal. Several meals provided in one feeding bout, e.g. 25 meals in 16 min (Warham 1963). At Campbell I. chicks, 30–50 days old, received meals of 255 g (106; 75–465; 19); at 50–65 days old, 291 g (121; 150–600; 23), measured by weighing before and after feeds. Chicks at first beg from any passing adult; adults usually peck chicks vigorously but may 'mock-feed' by bending down, throbbing and even opening bills as if to feed, but no food ever seen to be passed (Warham 1963). Chicks beg from strangers less as they grow, return to stand on their nests, fight one another mildly and sometimes help parents to evict intruders but quickly return to crèches if alarmed. Little co-operation of feeding by parents at this stage; both may feed chick on same day but on average chick fed probably twice every three days (Warham 1963). **FLEDGING PERIOD.** At Macquarie I., first chicks left 10 weeks after start of hatching, on about 24 Feb.; one marked chick left when 71 ± 1 day old. At this time, groups of newly moulted chicks gathered on rocks below moulting area and only strong healthy ones could reach sea through waves and beds of kelp (Warham 1963). At Campbell I., departure judged to be at c. 65 days old

GROWTH Chicks gain weight rapidly in first 6 weeks till weighing more than adults and then lose weight till departure; no period of desertion by parents before chicks leave; marked adults known to have returned to nest-site after chicks had left (Warham 1963). Weight at hatching on Campbell I.: A-chick 58.5 g (6.28; 49–70; 15) and 54.3 (6.69; 43–69; 12); B-chick 86.3 g (11.03; 63–110; 47) and 80.8 (7.49; 64–99; 37) in two successive seasons. Average weights: at 12 days old, 406 and 625 (A- (n=7) and B-chicks (n=10) respectively); at 24 days old, 894 (n=5) and 1170 (n=10); at 35 days old, 1315 (n=4) and 1583 (n=11); at 47 days old, 1783 (n=3) and 2211 (n=11). Peak weight reached at 50–55 days old and then declines by 10–15% to departure, when average weight immediately before going to sea (A- and B-chicks mixed) 1951 (163; 1675–2325; 29). No evidence for parental desertion; parents seen feeding chicks on day before departure. Chicks weighing less than 1600 g at 60–65 days old unlikely to fledge successfully (P.J. Moors & D.M. Cunningham).

SUCCESS At Macquarie I., 30 pairs laid 56 eggs;

assuming that all A-eggs failed or would have done so, out of 28 B-eggs, 23 hatched; of those, one died during guard-stage and 22 reached crèche-stage (79% or 0.37 chicks per pair) (Warham 1963). At Marion I., mortality for A-eggs was 88% and for B-eggs was 46%, which gave total success as 3.2% for A and 31.7% for B, or 0.35 chicks per pair (Williams 1980). At Campbell I., in one season, out of 175 nests, 113 (64.6%) hatched at least one egg and 83 (47.4%) fledged one chick; in next season, out of 309 nests, 193 (62.4%) hatched at least one egg and 156 (50.5%) fledged one chick. In latter season, two nests fledged two chicks each. PREDATORS. At Campbell I., eggs, chicks, fledgelings and diseased or injured adults killed and eaten by skuas *Catharacta* sp. Damaged or half-hatched eggs and moribund newly-hatched chicks (mostly A-eggs discarded or poorly guarded after B-egg has hatched) taken by Norway Rats *Rattus norvegicus*, which also scavenge all forms of penguin carrion and discarded eggs. NZ Fur Seals *Arctophthalmus forsteri* and Hooker's Sealions *Phocarctos hookeri* probably take adults at sea, especially near landing places. Northern Giant-Petrels *Macronectes halli* eat penguin carrion and sick or injured birds. Adults and chicks infected by *Pasteurella multocida* (avian cholera), which causes rapid death, especially in chicks. Moulting birds of all ages often heavily infested with ticks *Ixodes uriae* on head, chin, neck, round eyes and in gape (de Lisle *et al.* in press; P.J. Moors & D.M. Cunningham).

PLUMAGES *E.c. filholi*.

ADULT Definitive basic. Includes pre-breeders (Warham 1963, 1972). **HEAD AND NECK.** Pale yellow (light 57) superciliary stripe begins just behind mid-point of chord from base of rictus to base of culmen. Superciliary stripe narrow, pointed at anterior end, runs c. 5 mm above eye; curves slightly upwards to point above and behind eye. At this point about 15–20 long narrow plumes form ragged tufts, some feathers pendant; only extending below border of black throat and white foreneck if flattened. At Campbell I., length of plumes 66.2 (62–70.5; 8; Moors & Merton 1984). When wet, feathers flattened against head. Black (89) feathers of similar shape inserted just above yellow plumes also form part of ragged tufts (but never pendant). All elongate plumes have fibrous texture formed by stiff rami running parallel to rachis. Rest of head, upper throat, hindneck and sides of neck, black (89); feathers blackish (82) with glossy black (89) rachis, merging through brownish (c19) to concealed white bases. Feathers of nape concave and slightly longer than those of crown, forming short occipital crest, this flattened against head when wet. Cut-off between white foreneck and black throat square and sharp. **UPPERPARTS.**, blackish tinged blue-grey. Feathers, brown-black (c19) grading to concealed white bases, with black (89) rachis and narrow blue-grey (88) tips lost with wear. **TAIL.**, black (89); webs fade to greyish (c83) with wear. **UPPERFLIPPER**, blackish (c82) with narrow white trailing-edge from elbow to near tip. Leading-edge of flipper, white. **UNDERPARTS**, white; line separating black upperparts from white underparts runs just below flippers. **TAIL.**, black (89); webs fade to greyish (c83) with wear. **UNDERFLIPPER**, white, with blackish patches at elbow and tip. Line points towards centre of flipper from patch at tip. Leading-edge, black (82), in some birds not reaching tip.

DOWNY YOUNG Protoptile: head, brown-black (c119). Foreneck, flanks, upperparts and upperflipper, rich brown (c119A). Breast and central belly, white. Underflipper, white with broad greyish brown (119B) margins. Mesoptile:

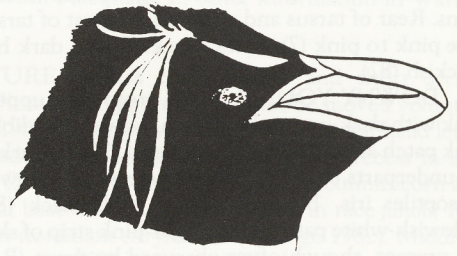


Fig. 1a Subspecies *filholi*

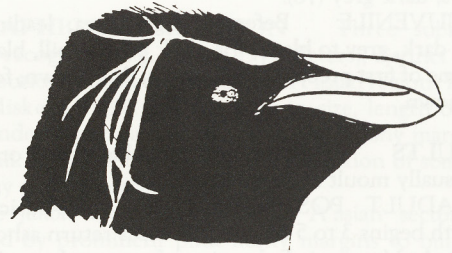


Fig. 1b Subspecies *chrysocome*

head, neck and upperparts, dark greyish brown (c119A). Underparts, including flanks, white.

JUVENILE Differences from adult. **HEAD AND NECK.** Narrow pale-yellow (light 157) superciliary stripe present at time of first prebasic moult. Sometimes not visible before juveniles first go to sea, but unknown if exposed by feather wear, or if some eyebrow moult occurs at sea. No superciliary plumes. Nape feathers, short, no occipital crest. Chin and central throat, white when fresh; mottled brown (121) and white when worn. Feathers, black-brown (121) with white tips. Sides of face appear greyish; feathers, dark brown (121) with narrow white tips. **UPPERPARTS**, when fresh, appear grey-blue, closely similar to adult *Eudyptes minor*. Feathers as adult, but with larger grey-blue (c88) tips; lost with wear. **UPPERFLIPPER**, in nominate *chrysocome*, darkens with age (Strange 1982); unknown if this occurs in *filholi*.

IMMATURE First and sometimes second basic. Similar to adults, but crest-tufts often shorter (Warham 1963); this character sometimes seen in birds in second basic (P.J. Moors & D.M. Cunningham). In first basic, chin and throat, black-brown with silvery tinge; feathers, brown (19) with silvery-white traces at tip.

ABERRANT PLUMAGES Isabelline individuals reported from Falkland Is (Strange 1982) and Iles Crozet (Murphy); albinos from Tristan da Cunha (Elliott 1957).

BARE PARTS Based on photos from Iles Crozet, Heard, Macquarie and Campbell Is (J-C. Stahl; P.J. Moors; Lindsey 1986; NZRD) and NMNZ labels.

ADULT Iris, crimson (c108) to scarlet (12). Fleishy strip of skin at base of bill 3–4 mm wide, slightly narrower above culminicorn, pink (c108) to light fleshy-pink (c7); rictus same colour. Bill, mostly dark orange to chestnut (32). Size of light-pink (pale 7) patch at base of bill varies; sometimes restricted to gony and narrow strip at base of lower mandible; sometimes wider, extending onto latericorn, and occupying up to one-third area of bill. On NZ offshore islands, size of pink patch increases with age, but varies between individuals of same age (P.J. Moors & D.M. Cunningham). Unknown if

variation in size of pink patch is age-related in other populations. Rear of tarsus and soles, black. Rest of tarsus and foot, pale pink to pink (7). Soles, black. Claws, dark horn (c91) to blackish (82).

DOWNY YOUNG In protoptile: upper mandible, pink with dark-grey culminicorn. Lower mandible, grey with pink patch at each side (Downes *et al.* 1959). Dark area of skin on underparts broadest at vent; peters out in lower breast. In mesoptile: iris, blackish brown; bill, black (82-89) with yellowish-white patch at tip. Light-pink strip of skin at base of bill present, though often obscured by down (P.J. Moors & D.M. Cunningham). Feet: distal half of webs, dark grey (78). Claws, dark grey (78).

JUVENILE Before going to sea, leading-edge of webs dark, grey to black; iris, dark brown; bill, blackish (82). At time of first prebasic, bill and iris, dull brown; foot colour, unknown.

MOULTS Complete; birds that have bred, or attempted to, usually moult at nest.

ADULT POST-BREEDING Pre-basic. Feather growth begins 3 to 5 days before birds return ashore (Brown 1986). At Macquarie I. duration of pre-moult exodus about 5 weeks (Warham 1963); at Falklands 20-25 days (Strange 1982); at Gough I., about 1 month (Swales 1965); at Tristan da Cunha, about 2 months (Elliott 1957). After return to Macquarie I., 7-10 days elapse before first feathers lost; 17 days (14-22; 28) elapse between shedding of first and last feathers. Birds depart 2-9 days after last feathers shed (Warham 1963). Richdale (1957) reported duration ashore 23 days in four birds, Otago Pen.; 25 days (20-30; 3) at Marion I. (Brown 1986); 24-26 days at Falklands (Strange 1982). At Macquarie I., first birds come ashore 25 Mar., latest recorded arrival 5 May. Usually first feathers shed 2-8 Apr., last feathers 19 Apr. to 5 May (Warham 1963); timing similar at Heard I. (Downes *et al.* 1959). At Marion I. first moulting adults recorded 12 Mar.; colonies most crowded mid-Apr.; numbers have decreased 28 Apr. (Rand 1954). At Falklands, females start moult before males; first birds arrive first half Mar., and last birds leave in third week Apr. (Strange 1982). At Tristan da Cunha, birds start to come ashore mid-Jan.; feather shedding complete end Mar.; last birds leave between 3 and 13 Apr. (Elliott 1957).

PRE-BASIC OF DEFINITIVE NON-BREEDERS At Macquarie I. moult begins in Feb.; most birds have returned to sea by end of month (Warham 1963). On Campbell I., failed breeders and pre-breeders moult mid-Jan. to first/second week Feb. (P.J. Moors & D.M. Cunningham). At Falklands, numbers of moulting birds peak third week Feb., moult completed about end of first week Mar. (Strange 1982).

COMPLETE MOULT OF IMMATURES Second and perhaps third pre-basic. At Macquarie I. mostly in Feb. (Warham 1963). On Campbell I., moult occurs mid-Jan. to first or second week of Feb. (P.J. Moors & D.M. Cunningham).

POST-JUVENILE. First pre-basic. At Macquarie I. earliest record of moulting 16 Jan.; some birds have completed moult 31 Jan.; most have left by end of Feb. (Warham 1963). Timing probably similar at Heard I. (Downes *et al.* 1959), but begins earlier at Campbell I., where moulting occurs between mid-Jan. to first or second week Feb. (P.J. Moors & D.M. Cunningham). At Tristan da Cunha, first birds come ashore end Nov.; birds leave mid-Jan. to early Feb.

MEASUREMENTS (1) Campbell I., breeding pairs, live; BILL = culmen length from tip to junction of culminicorn and skin at base, BILL W at widest point of culminicorn, BILL D at junction of gonyx and inter-ramal region. FLIPPER = extended flipper from axilla (P.J. Moors & D.M. Cunningham). (2) Campbell I., breeding pairs, live (Warham 1972). (3) Campbell I., live; sexed using point of inflection of bimodal distribution of bill shape index, length x width x height (Warham 1972). (4) Campbell I., immatures ashore for first pre-basic, live (Warham 1972). (5) Antipodes I., adults, live; sexed as source (3) (Warham 1972). (6) Antipodes I., immatures ashore for first pre-basic, live; methods as source 1, illustrated in Warham (1972, 1975) (Warham 1972). (7) Heard I., adults; methods as source 1 (E.J. Woehler). (8) Marion I.; methods unknown (Williams 1980). (9) Gough I., breeding pairs, live; BILL D as source 1, FOOT L = length of foot, other methods unknown (Williams 1980). (10) Amsterdam I.; methods unknown (Duroselle & Tollu 1977). (11) Falkland Is, adults, live; methods as source 1, but unclear if skin at base of culminicorn included in BILL measurement. (12) Falkland Is, juveniles before first departure, live; methods as source 1 (Strange 1982).

	MALES	FEMALES		
FLIPPER	(1) 167 (4.9; 158-176; 15)	161 (4.4; 152-167; 15)	**	
	(2) 167 (4.4; 10)	167 (3.4; 10)		
	(8) 165.3 (7.5; 5)	161.5 (5.6; 6)		
	(9) 185.0 (4.7; 176-190; 10)	179.4 (4.3; 174-186; 10)	**	
	(10) 189.2 (7.5)	183.3 (7.3)		
	(11) 175.9 (170-185; 10)	167.9 (165-175; 10)		
	BILL	(1) 46.5 (1.86; 43.4-49.6; 15)	41.1 (1.55; 36.7-43.3; 15)	**
		(2) 46.4 (1.37; 10)	41.1 (2.05; 10)	**
		(3) 46.3 (1.92; 20)	40.5 (1.91; 33)	**
		(5) 47.8 (2.32; 49)	41.8 (1.86; 34)	**
		(7) 44.8 (1.22; 10)	39.7 (2.53; 10)	**
(8) 45.7 (1.5; 5)		40.6 (1.7; 6)	**	
(9) 49.1 (3.8; 42.7-53.8; 10)		43.6 (1.6; 41.2-46.5; 10)	**	
(10) 49.1 (7.5)		43.8 (7.3)		
(11) 46.3 (10)		40.0 (10)		
BILL D		(1) 21.3 (1.20; 19.2-23.0; 15)	17.8 (0.83; 15.3-18.8; 15)	**
		(2) 20.7 (1.07; 10)	17.8 (0.67; 10)	**
	(3) 20.3 (0.8; 20)	18.0 (0.7; 33)	**	
	(5) 21.1 (1.6; 49)	18.8 (0.8; 34)	**	
	(7) 21.4 (0.79; 10)	17.9 (0.79; 10)	**	
	(9) 20.2 (0.9; 18.7-21.4; 10)	17.6 (0.8; 16.1-18.7; 10)	**	
	(11) 21.8 (10)	17.6 (10)		
	BILL W	(1) 9.23 (1.18; 7.9-11.4; 15)	8.68 (0.98; 7.4-10.6; 15)	**
		(2) 10.6 (0.23; 10)	9.2 (0.25; 10)	**
		(3) 10.4 (0.4; 20)	9.2 (0.4; 33)	**
		(7) 10.16 (0.470; 10)	8.81 (0.534; 10)	**
(5) 10.8 (0.5; 49)		9.7 (0.6; 34)	**	
(11) 10.35 (10)		9.35 (10)		
THL		(7) 114.1 (2.37; 10)	106.1 (2.62; 9)	**
FOOT L		(9) 115.9 (3.2; 112-122; 10)	110.1 (4.3; 101-116; 10)	**

Males larger. See Warham (1972) for discussion of sexing using bill measurements.

		UNSEXED
FLIPPER	(4)	165 (5.0; 24)
	(6)	163 (5.1; 32)
	(12)	173.6 (160-182; 15)
BILL	(4)	41.3 (2.3; 24)
	(6)	41.7 (2.5; 32)
	(12)	36.7 (15)

BILL D	(4)	18.5 (1.3; 24)
	(6)	18.5 (1.1; 32)
	(12)	15.4 (15)
BILL W	(4)	9.4 (0.5; 24)
	(6)	9.2 (0.5; 32)
	(12)	8.1 (15)

Older adults tend to have larger bills than younger adults (P.J. Moors & D.M. Cunningham); unknown when (or if) bill stops growing. Other measurements for race *moseleyi* in Hagen (1952), Jouanin (1953), Swales (1965) and Segonzac (1972).

WEIGHTS Weights in kg. (1) Campbell I., breeding adults, late Dec. to mid Jan. (P.J. Moors & D.M. Cunningham). (2) Campbell I., live, 17 Jan. (Warham 1972). (3) Campbell I., live, 13 and 17 Jan.; birds sexed on bill size (Warham 1972). (4) Antipodes I., 9 Feb.; birds sexed on bill size (Warham 1972). (5) Macquarie I., 30 Dec. (Warham 1963). (6) Macquarie I., pre-moult (Warham 1963). (7) Macquarie I., after moult (Warham 1963). (8) Heard I., adults when female has developed fat associated with egg deposition (E.J. Woehler). (9) Marion I., pre-moult (Brown 1986). (10) Marion I., post-moult (Brown 1986). (11) Falkland Is, birds arriving ashore to moult (Strange 1982). (12) Falkland Is, end of moult (Strange 1982).

	MALES	FEMALES
(1)	2.50 (0.26; 2.00–2.95; 14)	2.44 (0.16; 2.15–2.70; 15)
(2)	2.76 (0.27; 10)	2.40 (0.05; 10)
(3)	2.72 (0.25; 20)	2.37 (0.28; 35)
(4)	2.43 (0.23; 49)	2.23 (0.14; 33)
(5)	2.7 (2.1–3.2; 16)	2.5 (2.0–3.2; 16)
(8)	2.88 (0.29; 10)	3.08 (0.25; 10)
(11)	4.29	3.65
(12)	2.30	2.19

Males throughout range seem to be consistently heavier than females, except when males have lost weight after fasting periods ashore during breeding cycle.

	UNSEXED
(6)	3.5 (3.2–4.1; 7)
(7)	2.3 (5)
(9)	3.80 (0.20; 3.63–4.32; 8)
(10)	2.13 (0.11; 2.05–2.30; 8)

During period ashore on Marion I., 45% of weight lost at mean rate of 95 (13; 8) g per day, of which 7.6% consists of shed feathers (Brown 1986). On Campbell I., in pre-moult stage after coming ashore but before shedding feathers, failed breeders and pre-breeders of all ages: 3.45 (3.15–3.75; 10); same birds 10 days later: 2.51 (2.00–2.90; 9); same birds 20 days after first weighing: 1.95 (1.78–2.18; 5). One bird began at 3.75; declined to 1.83 25 days later when all old feathers shed (P.J. Moors & D.M. Cunningham). See Elliott (1957), Duroselle and Tollu (1977) and Moors and Merton (1984) for weights of moulting *moseleyi*. Warham (1972) presents measurements of immatures at Campbell I. taken at about time of first prebasal. Weights of chicks almost ready to depart from Antipodes Is 1.86 (0.27; 72; Warham 1972), and from Falklands 2.22 (Strange 1982). Warham (1963) presents average growth curve

of weights from Macquarie I.; other information in Warham (1972).

STRUCTURE Has crest plumes and short occipital crest (see Plumages); apparently cannot be moved voluntarily (Warham 1963). Bill heavy; culmen c. 37% total head length; upper mandible has hook at tip fitting into recess in lower mandible. Groove between latericorn and culminicorn deep, feathered at base. Tail short, 16 feathers in race *filholi*; 14–15 reported in nominate *chrysocome* (Strange 1982). Middle toe longest; outer c. 90%, inner c. 70%. Hind claw dangles on inner side of foot.

GEOGRAPHICAL VARIATION Three subspecies generally recognized (e.g. Carins 1974; Peters); distinct breeding distributions but all recorded from A'asian region (Tennyson & Miskelly 1989). Adults differ in size, length of crest tassles, underflipper pattern and colour of fleshy margins at base of bill. Confident subspecific identification of some juveniles may not be possible.

Race *filholi* most numerous in A'asian sector; distinguished by prominent pink fleshy margins to bill (most noticeable at gape) and very narrow superciliary stripe. Lower mandible often marked with pink blotches, varying in size and position. Crest plumes 6–7 cm long, reaching just past demarcation line of black and white on throat when flattened. Underflipper lightly patterned with small black area at tip and thin grey leading-edge (Tennyson & Miskelly 1989; HASB). Warham (1972) found bills were slightly heavier on Antipodes than on Campbell I.; no comparable biometrics from other parts of range. Also reported that at Macquarie I. pink at base of bill tended to be smaller than at Campbell I.; this character varies with age and difficult to assess. Measurements of crest-plumes from Marion I. of about 75 mm (Rand 1955) seem longer than those from Campbell I.

Nominate *chrysocome* rare straggler to A'asian waters; length of crest-plume and underflipper similar to *filholi* but nominate *chrysocome* has thin strip of black (89) skin 1–2 mm wide at base of bill (*cf* prominent pink skin of *filholi*) (Tennyson & Miskelly 1989). Superciliary stripe in front of eye varies but often broader and more triangular than in *filholi*. Rest of plumage as *filholi*. Length of crest and pattern of underflipper separate *chrysocome* and *moseleyi* (Strange 1982; Tennyson & Miskelly 1989). Plumage described in detail by Strange (1982).

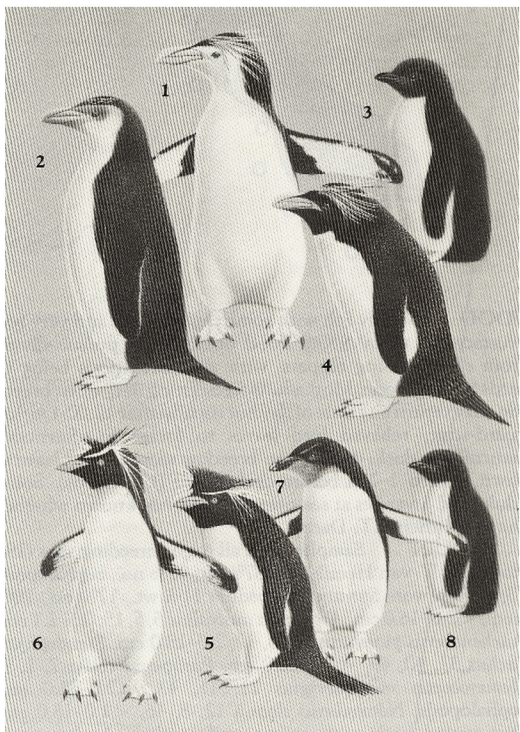
Race *moseleyi* frequent straggler to w. Aust., more rarely as far E as NZ and Chatham Is; claimed as separate species by some authorities on basis of northerly breeding distribution, size and voice (e.g. Jouventin 1982). Largest subspecies. Most obvious characteristic separating from other races, long yellow and black plumes forming luxuriant crest, without flattening reaching well past demarcation line of black and white on throat; some black and many yellow feathers pendant; longest crest feathers about 90 mm (Falla 1937; Hagen 1952; Elliott 1957; Duroselle & Tollu 1977; Clancey 1981; Moors & Merton 1984). Thin strip of black skin at base of mandible and comparatively broad superciliary stripe in front of eye. Face and neck said to be sooty brown (-) rather than black (Jouanin 1953; Elliott 1957). Flipper clearly larger than in other races (see Measurements) but published accounts do not specify measuring techniques. Underflipper boldly patterned with large black area distally and thick black leading-edge (Moors & Merton 1984; Tennyson & Miskelly 1989).

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Volume 1 (Part A), Plate 11 [caption errors corrected from original]

Royal Penguin *Eudyptes schlegeli*

- 1. Adult, light-faced morph
- 2. Juvenile
- 3. Downy young

Macaroni Penguin *Eudyptes chrysolophus*

- 4. Adult

Rockhopper Penguin *Eudyptes chrysochome*

- 5. Adult, subspecies *filholi*
- 6. Adult, subspecies *moseleyi*
- 7. Juvenile, subspecies *filholi*
- 8. Downy young, subspecies *filholi*

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