

Order **PODICIPEDIFORMES**

Family **PODICIPEDIDAE grebes**

Small to medium-large, foot-propelled diving birds. Single family in order. Morphology and egg-white protein suggest no close relationship with any other group of waterbirds (Sibley & Ahlquist 1972). Evidence from DNA hybridization (Sibley *et al.* 1988) implies that grebes diverged from a lineage that gave rise to penguins, petrels, pelicans and storks. Formerly considered closely related to Gaviidae (divers) but similarities due to convergence (Stolpe 1935; Storer 1960, 1971). Twenty species in six genera, worldwide; four species in three genera in our region.

Aquatic specialists, mostly in temperate climates. Main centre of adaptive radiation in New World, especially South America. Generally avoid ice, snow and cold waters. During breeding season, inhabit standing fresh water, particularly shallow eutrophic lakes with muddy, clayey or sandy bottoms and emergent, submerged or floating vegetation. Readily colonize newly flooded or excavated areas. Dispersive, capable of long-distance movements, probably normally at night. In winter, tend to form non-breeding flocks on permanent water, including sheltered bays and estuaries.

Body elongated (in larger fish-eating species) or rotund; feet placed far back, and high on sides of body. Neck rather long. Wings small and narrow; remiges curved; when folded, fitting closely to body, concealed by feathers of flanks and back; 12 primaries, p10 usually longest, p12 minute; 15-22 secondaries; usually diastataxic. Some species have never been seen to fly. Tail-tuft short, downy; lacks stiff rectrices. Shape of bill from long and pointed to short and stout; generally larger in males. Nostrils usually narrow slits. Feet large: used in propulsion and steering. Tarsi strongly laterally compressed. Toes broadly lobed, front three connected by small webs at base; hind toe raised, flattened, with small lobe. Nails broad and flat, those of middle toe pectinate. Joints of tibiotarsus and toe extremely flexible, conferring manoeuvrability while swimming. Clumsy on land but can run for short periods, often falling over. Oil-gland feathered.

Plumage dense and waterproof; looser on upperparts, more downy towards rump. Feathers of underparts directed perpendicularly from body and strongly curved towards tip (Chandler 1916), giving breasts distinctive satiny texture. Before diving, feathers pressed against body, decreasing buoyancy; assumed to be the way in which grebes adjust their level of swimming; often swim with only head and neck above water. Adults are generally dark brown above, white below. Most have a colourful or ornate breeding plumage, often with chestnut markings on neck or crests and head-plumes; also yellowish-green patch of swollen skin on gape and base of lower mandible. Chicks covered by short dense down, usually with longitudinal striping on upperparts and complex patterning on head. Strands of down attached to tips of individual barbs of emergent juvenile feathers and wear off gradually, especially on head. Juveniles, otherwise similar to non-breeding adults, can be recognized for some time, even months, on basis of remnant striped pattern on head.

Moult of remiges simultaneous; flightless period of about 3 weeks. Moult of wings usually follows breeding, but pre-breeding moult in some species, or wing-moult may be inserted between first and second broods. Body-moult (Storer & Nuechterlein 1985; Piersma 1988a,b,c, 1989) extremely complex; some tracts, especially flanks, in almost continuous moult, which may provide continuous source of ingestible feathers used in pellet formation.

Feathers usually found in stomachs of adults and young, especially in fish-eating species. Habitually eat own feathers, preferring those from flanks, while preening; given to young from day of hatching. Eating of feathers believed to assist in formation of pellets, reducing chances of gastric parasites building up (Piersma 1989). Breast-pelts ('grebe fur') were once used for making women's muffs, capes and hats, but now grebes are of no direct commercial use.

Usually monogamous, bonds probably lasting for only one season. Elaborate and complex displays when breeding. Territorial and usually well dispersed, but some species truly colonial nesters. Nest is usually a floating mass of sodden water-weed, attached to submerged or emergent vegetation. Both sexes build. Eggs, white, characteristically pointed at both ends; quickly become stained brown. Clutch-size of 2-6 eggs. Laying at intervals of about 48 h. Lost clutches and perhaps broods replaced. Two or three broods may be raised in one season. Both sexes incubate and rarely leave the nest but cover eggs when they do so. Incubation lasts for 3-4 weeks. Young precocial but depend on parents closely for about 3 weeks; when small often carried on backs of parents. Fledging period in some species 6-7 weeks, in others 10-12. Juveniles may help to feed and tend young of subsequent broods.

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*Podiceps cristatus* **Great Crested Grebe**

COLOUR PLATE FACING PAGE 113

*Colymbus cristatus* Linnaeus, 1758, *Syst. Nat.*, ed. 10, 1: 135 — Sweden.

The generic name is a contraction of the original *Podicipes* (Gloger, *J. Orn.* 1854), which is a combination of the Latin *podex* (*podicis*) or anus and *pes* or foot, i.e. the bumfoot birds. *Cristatus* means crested.

**OTHER ENGLISH NAMES** Crested, Southern Crested or Tippet Grebe, Topknot Shag, Gaunt, Loon, Carr Goose.

POLYTYPIC Nominate *cristatus* occurs in Palaearctic; *infuscatus* Salvadori, 1884, in Africa; *australis* Gould, 1844, in Aust. and NZ.

**FIELD IDENTIFICATION** Length 480–610 mm; weight 1100 g. Medium to large diving waterbird that sits low in water when swimming and dives to feed. Bill straight, compressed and pointed. Long neck and head with distinctive black double crest; crest held erect when displaying. Cheeks have chestnut frills or tippets, fringed black. Head held at right angles to long, thin neck. Upperparts dark brown; underparts satin white. Wings short and rounded, giving impression of weak flight. Prominent white patches on wings in flight. Many elaborate breeding displays. Dive frequently but, unlike cormorants and diving ducks, without splashing. Sexes similar but males slightly larger with much thicker neck, longer bill, larger crest and larger ruff and sometimes brighter plumage. Unlike birds in Europe, appear to retain full breeding plumage throughout year and do not have duller winter plumage. In Aust., crests apparently reduced and chestnut ruffs almost disappear in winter thus more like juveniles. Juveniles also look much whiter.

**DESCRIPTION** **ADULT MALE.** Upperparts, dark brown; black double crest. Face, white. Black line from base of bill to eye. Feathers on each side of head elongated to form rounded chestnut ruff merging into black edge. Wing, dark brown with white patch on upper wing-coverts along leading-edge of forearm and large white patch on secondaries. Underside, including front of long thin neck, satin white. Black plumage of crown may extend down to eye with buff feathers in front of eye, though some males light in same area (O'Donnell 1981). Eyes, red. Bill, thin, pointed, pinkish brown. Feet set far back on body, dark olive-green, with broadly lobed toes and flattened claws. **ADULT FEMALE.** As male but slightly smaller, neck thinner, bill shorter and crest and ruff smaller; usually white in front of eye, though some females dark in front of eye (O'Donnell 1981). **CHICK.** Downy: head and neck, white with black spots and longitudinal stripes. Naked wedge on top of head, usually pink but red when excited; smaller naked areas in front of eye and on cheek. Back, dark buff with brown-black longitudinal stripes. Underside white. Iris, orange and yellow. Bill, short blunt white-tipped with black stripe across upper mandible and pink base. Feet, yellow-green. Late-hatched birds show signs of head stripes into May. **JUVENILE.** As adult but tufts on crown poorly developed; no chestnut ruff. Crests, brown-black, only slightly erectile. Tippets with indistinct buff marking. Upperparts, more grey-brown and general appearance much paler with more white than adults. Bill, yellow-ivory. Adult plumage develops gradually during first winter. Black-brown stripes on cheeks and sides of head disappear after c. 3 months. Ruffs gradually appear by c. 6 months. Some early-hatched young may be developing chestnut colouring by autumn.

**SIMILAR SPECIES** Unlikely to be confused with any other species but at distance possibly with swimming Pied Cormorants *Phalacrocorax varius*. Whiter, larger, less dumpy than other A'sian grebes; usually found on larger water-bodies in open water often without emergent vegetation. Sharp pointed bill, erect swimming attitude and surreptitious diving habit without splash, different from those of ducks and other waterbirds.

When breeding, usually on large, open water-bodies; nests often built in or near dense vegetation; out of season may

be found on estuaries, large saline lakes and sea-coasts. May be shy but not skulking except when near nests; prominently visible on open water. Swim with body low, neck erect and head horizontal; may rest with neck sunk on shoulders and bill in feathers at side of neck. Dive when stationary by sinking in water and submerging, bill first, swinging neck forward and downward, followed by body; occasionally jump forward in diving. Not often seen flying; dive to escape danger but fly if harassed; no doubt move from one water-body to another mostly at night; in flight, neck extended and feet below line of body, giving hump-back appearance; wing-beats, rapid, looking laboured. Rarely on land, when gait awkward, body leaning forward, or flop along on breast. Generally singly, in pairs or in small parties.

**HABITAT** In Aust. inhabit rivers, swamps, lakes, lagoons, reservoirs, saltfields, estuaries, bays; favouring large deep open bodies of freshwater. Non-breeding concentrations form on large saline lakes, estuaries and bays, particularly in winter (Wheeler 1957; Corrick 1981, 1982; Burbidge 1982; Vic. Atlas; Jaensch *et al.* 1988). Regularly seen on some salt fields, on large low-salinity lagoons and near pumping sites for sea-water (Rix 1978). Occasionally on inshore waters along exposed coasts (Learmonth 1966; Pescott 1983; Martindale 1980). In aerial survey of e. Aust., 43% of estimated population on artificial impoundments; wetlands of > 1000 ha held 96% of estimated population (Braithwaite *et al.* 1985). In two Vic. surveys, 83% and 70% of counts on large wetlands of > 100 ha (Martindale 1988; Hewish 1988). On Southern Tablelands, found mostly in small numbers on large deep cold windswept lakes (Canberra lakes, L. Bathurst).

In Vic., during Feb. on only 33 of 472 wetlands surveyed; the five most important were: three large open lakes (fresh-brackish), one reservoir and one drainage basin for saline water; few birds on Pt Phillip Bay and Corner Inlet and so coastal concentrations probably form mainly in winter (Hewish 1988). In three other surveys more than 50% of records were on permanent saline wetlands: lakes, coastal lagoons and inlets with *Ruppia maritima*, *Zostera* algae, with sandy or rocky shoreline or with fringing *Juncus maritimus*, mangroves or saltmarsh. Also on open water in deep freshwater marshes without emergent vegetation and with sparse fringing vegetation of sedges, rushes, *Triglochin*, etc; on permanent open freshwater deeper than 1 m, including reservoirs and natural lakes with little fringing vegetation; on saltpans, with some aquatic plants in shallows (Corrick & Norman 1980; Corrick 1981, 1982). Perhaps restricted to salinities of < 30‰ (Corrick 1982).

In surveys in sw. WA, waterbodies with highest numbers were fresh to saline lakes and swamps with large areas of open water, and fringing rushes (*Typha*, *Baumea*), shrubs or trees (Jaensch *et al.* 1988; R.P. Jaensch; E. McCrum); in ne. WA, L. Gregory, an open saline lake, held high numbers after floods inundated surrounding shrubland and woodland (Jaensch 1989; Jaensch & Vervest 1989).

In NZ, E of Southern Alps of SI, where 70% of population occur, inhabit alpine and subalpine lakes in main mountain ranges, at 494–1066 m asl (average 652). In Canterbury (1964–70) five lakes at 690–790 m asl held 46% of

breeding population; 16 lakes at 580–670 m asl held 38%; and lakes at 490–580 m asl held 16% (Westerskov 1971). Most lakes large (average 7.7 km<sup>2</sup>); 16–20 ha estimated as minimum area needed to sustain pair of breeding Grebes (Westerskov 1971); but 25% of lakes on which breeding currently recorded <15 ha (C.F.J. O'Donnell). Lakes, of glacial origin, oligotrophic, with stagnant or slow-moving water, surrounded by *Festuca*-dominated tussock grassland, overhanging willows (*Salix* spp), reed beds (*Typha orientalis*), sedges (*Carex*, *Schoenus*), shrubs and open rocky shoreline; dense aquatic vegetation of *Elodea*, *Myriophyllum*, *Potamogeton* and *Isoetes*. Most of rest of population, W of Southern Alps, on lowland coastal lakes and lagoons that are infertile, surrounded by tall beech (*Nothofagus*) or podocarp-hardwood forests, rushes and sedges, flax or shrubs. A few visit brackish coastal lagoons on e. coast in winter; eutrophic, surrounded by extensive salt-marsh and supporting submerged aquatic vegetation (*Ruppia*, *Potamogeton*).

On alpine and subalpine lakes, climatic conditions often harsh (strong NW winds, rain, electrical storms and unseasonal snowfalls). Grebes tolerate rough water (waves up to 0.7 m high), strong turbulence and poor underwater visibility (as low as 0.2 m) when feeding (O'Donnell 1982). During intense storms, shelter under dense willows (O'Donnell 1982). Water levels on lakes vary; may rise up to 250 mm after heavy rain; in late summer and autumn, lake levels usually fall. In winter, snow lies on ground for long periods and lakes often partly or fully frozen. Some Grebes may remain on small areas of open water on frozen lakes (Geddes 1983) but others move to ice-free lakes (Sagar & O'Donnell 1982).

Breed on freshwater wetlands with some aquatic vegetation (for building and anchoring nest) and open water (for feeding).

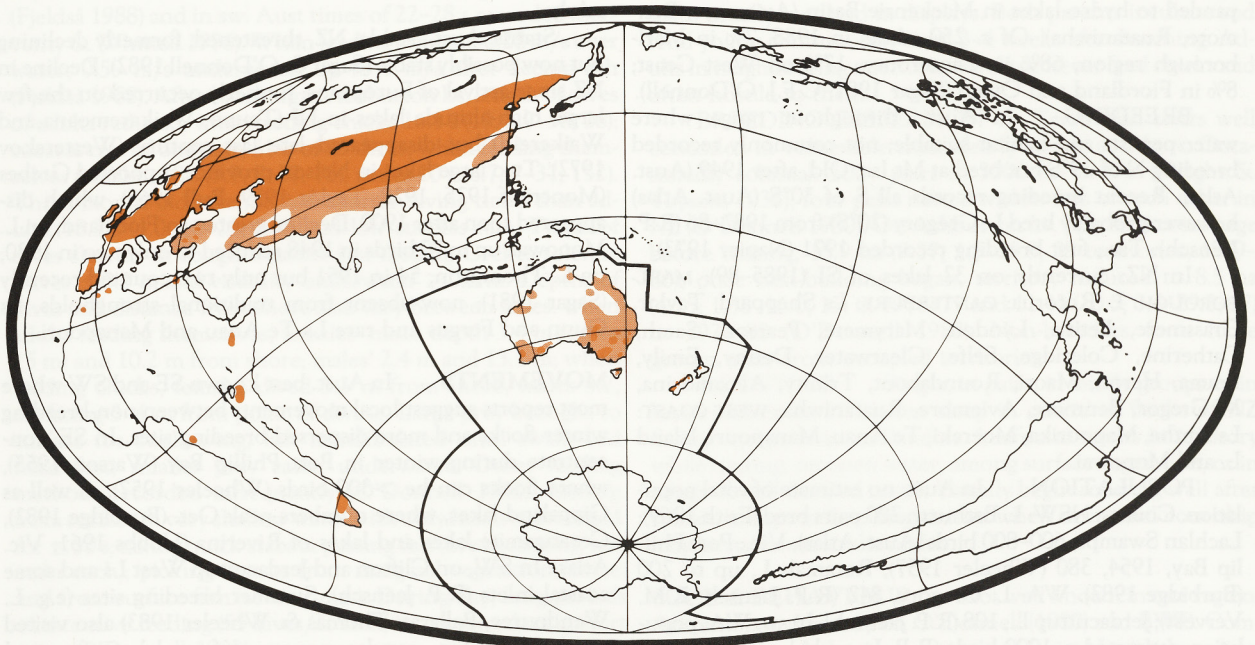
In Aust., has expanded non-breeding and breeding range since European settlement (Aust. Atlas); favoured non-breeding habitat of permanent saline wetlands have suffered less from destruction and modification than most other wetland

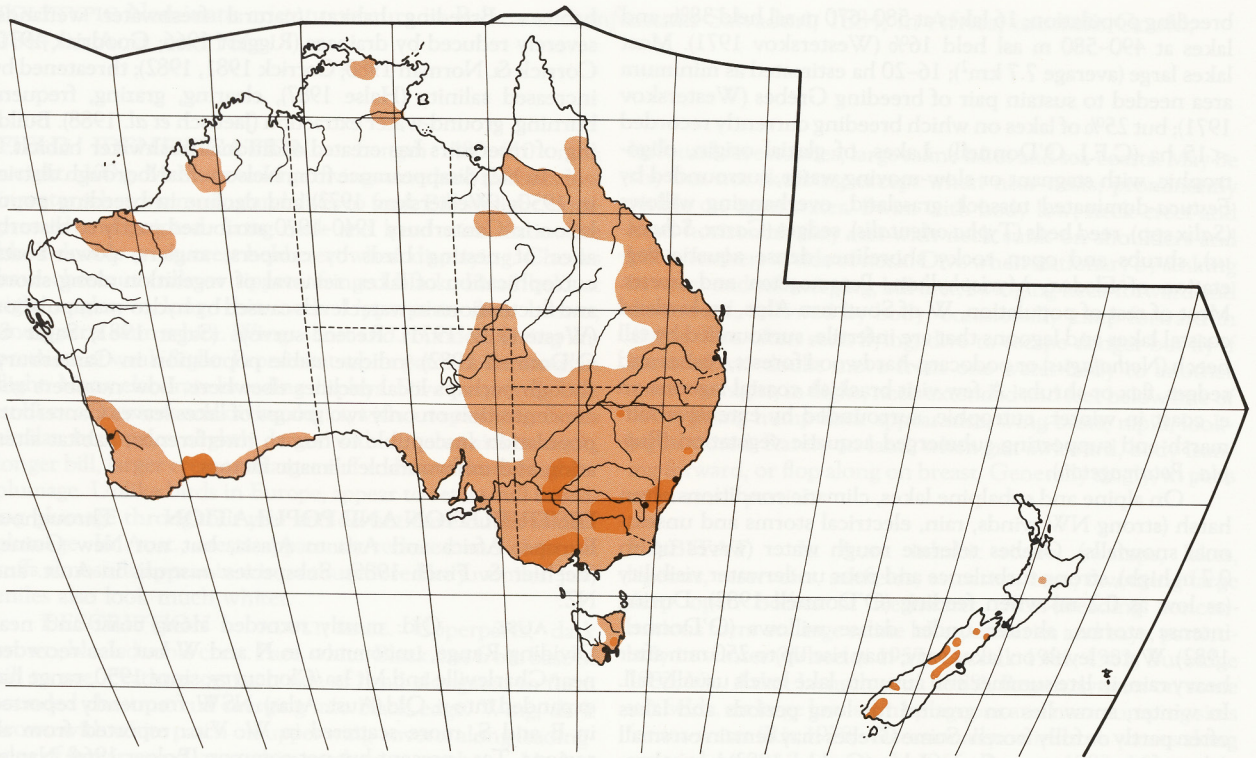
habitats. Breeding habitat (natural freshwater wetlands) severely reduced by drainage (Riggert 1966; Goodrick 1970; Corrick & Norman 1980; Corrick 1981, 1982); threatened by increased salinity (Halse 1987), clearing, grazing, frequent burning, ground-water extraction (Jaensch *et al.* 1988). Building of reservoirs has created additional freshwater habitat.

In NZ, disappearance from Nelson–Marlborough district in 1950s (Westerskov 1972) and decline in breeding population in Canterbury 1940–1970 attributed partly to disturbance of nesting birds by campers, anglers, power-boats; eutrophication of lakes; removal of vegetation along shore; and fluctuations in water levels caused by hydro-manipulation (Westerskov 1971). Recent surveys (Sagar 1981; Sagar & O'Donnell 1982) indicate stable population in Canterbury, though perhaps local declines elsewhere. Low numbers and concentration on only two groups of lakes leaves Canterbury population susceptible to human interference, habitat alteration and unfavourable climatic factors.

**DISTRIBUTION AND POPULATION** Throughout Europe, Africa and Asia to A'asia, but not New Guinea (Beehler & Finch 1985). Subspecies *australis* in Aust. and NZ.

**AUST.** Qld: mostly recorded along coast and near Dividing Range, uncommon in N and W but also recorded near Charleville and Mt Isa/Cloncurry; since 1950, range has expanded into n. Qld (Aust. Atlas). NSW: frequently reported in E and S, more scattered in W. Vic.: reported from all regions. Tas.: present but not common (Bolger 1964; Napier 1973). SA: most records coastal or near coastal from Vic. border to near Ceduna, also n. Flinders Ras and Coopers Creek. WA: scattered, mostly coastal and SW of a line from Cape Arid to Jurien Bay; recent regular reports from Pilbara (Aust. Atlas) and L. Gregory in NE (Jaensch & Vervest 1989). NT: isolated and irregular reports. Most records in n. WA and NT from influx in 1978 (Aust. Atlas); lack of records probably reflects distribution of observers.





NZ. NI: before European settlement more common (Westerskov 1972, 1977), now very rare. L. Rotorua, one bird, Dec. 1975–June 1976; two birds, 19 Sept and 13 Oct. 1979 (Palliser 1976; CSN 24, 28); Waikato R., near Taupiri Mt, one bird, 15 May 1977 (CSN 24); on farm pond near Te Awamutu, two birds (CSN 28). Subfossil bones from Taupo in cave middens (NZCL). SI: recorded on 89 lakes; currently known to breed on 32 of them. About 50% of grebes occur on two lake systems, the Alexandrina and Ashburton Ls; recently expanded to hydro-lakes in Mackenzie Basin (Aviemore, Benmore, Ruataniwha). Of c. 250 adults in 1988, 7% in Marlborough region; 68% in Canterbury; 17% on West Coast; 8% in Fiordland and Otago (Sagar 1981; C.F.J. O'Donnell).

**BREEDING** In Aust.: throughout range where water persists and habitat suitable; not commonly recorded breeding N of 29°S but bred at Mt Isa, Qld, after 1949 (Aust. Atlas). Recent breeding records all S of 30°S (Aust. Atlas) however probably bred *L. Gregory* (20°S) from 1982–86 (R.P. Jaensch). Tas., first breeding recorded 1971 (Napier 1973).

In NZ: currently on 32 lakes of SI (1985–89): **MARLBOROUGH:** L. Rotorua; **CANTERBURY:** Ls Sheppard, Taylor, Grassmere, Letitia, Lyndon, Marymere, Pearson, Sarah, Catherine, Coleridge, Selfe, Clearwater, Denny, Emily, Emma, Heron, Maori, Roundabout, Trinity, Alexandrina, McGregor, Benmore, Aviemore, Ruataniwha; **WEST COAST:** Ls Ianthe, Mapourika, Moeraki, Te Anau, Manapouri, Island L. and Monowai.

**POPULATION** In Aust. no estimate of total population. Counts: NSW: L. Bathurst: 200 pairs bred (Frith 1969); Lachlan Swamps, 600–800 birds (Aust. Atlas); Vic.: Port Phillip Bay, 1954, 380 (Wheeler 1957); Rotamah I., up to 200 (Burbidge 1982). WA: L. Gregory, 842 (R.P. Jaensch; R.M. Vervest); Jerdacuttup L., 108 (R.P. Jaensch). In sw. WA, population estimated c. 1000 birds (R.P. Jaensch).

In NZ: SI in 1980, breeding population estimated at 240–250 birds on 28 lakes, about 55% in Canterbury. In 1988, total estimated population c. 250 adults on 32 lakes (C.F.J. O'Donnell); similar numbers to 1980 estimate but with more birds in Canterbury (68%) and fewer on West Coast. On most lakes, numbers very low, often only a pair, and there may be considerable distance between lakes with Grebes (Sagar 1981; Sagar & O'Donnell 1982); L. Alexandrina has largest population with up to 110 adults, Ashburton Ls hold 50–60 adults.

Status. Aust., stable; NZ, threatened, formerly declining but now possibly stable (Sagar & O'Donnell 1982). Decline in NZ since arrival of Europeans; formerly occurred on the few large, high-altitude lakes in NI (Taupo, Waikaremoana and Waikereiti) but disappeared late last century (Westerskov 1972). Two large lakes in Nelson province supported Grebes (Moncrieff 1925, 1928; Taylor 1959; Bull 1965), which disappeared soon after 1900. Decline greatest in Fiordland; on L. Monowai, up to 70 birds in 1948 reduced to only two in 1980; on L. Thompson, 54 in 1951 but only two counted recently (Sagar 1981); now absent from traditional strongholds, Ls Gunn and Fergus and rare Ls Te Anau and Manapouri.

**MOVEMENTS** In Aust. best known SE and SW where most reports suggest local movements between non-breeding winter flocks and more dispersed breeding sites. In SE, concentrate during winter in Port Phillip Bay (Watson 1955), where flocks can be >300 birds (Wheeler 1957), as well as Gippsland lakes, where numbers peak Oct. (Burbidge 1982), Corangamite lakes and lakes of Riverina (Hobbs 1961; Vic. Atlas). In SW, on Clifton and Jerdacuttup West Ls and some coastal inlets (R.P. Jaensch). Summer breeding sites (e.g. L. Wendouree, Ballarat; Thomas & Wheeler 1983) also visited regularly. In Tas., regular movement from lakes of central

highlands to coast suggested by Sharland (1958). Numbers involved in winter movements fluctuate erratically. In s. Tas. very high numbers present Apr. to Oct.–Nov. 1959–60, peak July (Bolger 1964); L. George, ACT, numbers low 1961–62, increased suddenly July–Dec. 1963 (Lamm 1965). Elsewhere movements virtually unknown. Absent from Atherton Tableland, Dec.–Mar. (Bravery 1970) but most movement in n. Aust. may be governed by availability of water inland. An influx to n. NT, June–Dec. 1978, and one record from central Aust., Sept. 1977 (Aust. Atlas) occurred when waterbirds left w. NSW. In ne. WA, >800 present L. Gregory, Aug. 1986 after flooding 4 months previously and 77 remained 20 months later (R.P. Jaensch). In se. Qld, present during annual Oct. counts 1972–83 only when other waterbirds in abundance, usually in years when rainfall in sw. Qld below average (Woodall 1985).

In NZ, locally dispersive but capable of longer movements. Best known in Canterbury district (Sagar & O'Donnell 1982). In summer, movements between alpine and subalpine lakes usually within a lake system; during winter, concentrate on fewer ice-free lakes with some movement between systems. In severe winters individuals or pairs occasionally move to coastal lakes or estuaries (Guy 1948; Westerskov 1971; O'Donnell 1988), with 20 on coastal L. Forsyth winter 1987 considered unusual large-scale movement from high country (O'Donnell 1988); most stay on high country lakes even though freezing conditions may kill some adults (e.g. Geddes 1983). Two recent records from NI (CSN 24, 28) show occasional longer movement. Can fly up to 65 km/h (C.F.J. O'Donnell).

**FOOD** Mostly fish, taken mainly by diving in clear water. **BEHAVIOUR.** Submerges smoothly from stationary position with forward and downward swing of neck and minimal leap; feet alone used for propulsion underwater, wings kept folded. Dives recorded in NZ (O'Donnell 1982) usually lasted 20–30 s, females diving for 34.4 s (14.8; 5–85; 119); males 26.7 (13.8; 5–65; 87) although 12 dives timed by Edgar (1962) 52.6 s (45–62). In NSW, dives lasted 21.3 s (1–50; 51), pauses 35.2 s (Fjeldså 1988) and in sw. Aust times of 22–28 s recorded (Serventy & Whittell 1976). When feeding swims at 0.28 m/s over water, 0.59 m/s underwater, up to 3 m/s after fleeing fish (Fjeldså 1988). After hatching at Ashburton Ls, length of dives of adults reduced; when feeding chicks 16.1 s (13.4; 7–56; 26); success rate of one pair, 61% of 23 dives; when feeding themselves females: 28 s (9.7; 7–57; 72), males 20 s (6.7; 7–37; 152). Three-month-old juvenile had shorter diving times than adults, 18.3 s (4.0; 12–25; 320) and low success rate. Times of dives shorter in rough weather but feeding Grebes tolerate waves  $\leq 0.7$  m and visibility underwater  $\geq 0.2$  m. Depths of dives and distance from shore also vary between sexes: when adults feeding themselves, females' mean depth 3.4 m (up to 15 m) and 10.2 m from shore; males' 2.4 m and 13.1 m; when feeding chicks, females dived 5.3 m from shore, males 5.2, surfacing 3–4 m from point of diving. Large prey brought to surface for swallowing, fish mandibulated until swallowed head first; smaller prey eaten underwater. Other feeding methods recorded infrequently (O'Donnell 1982): feeding from surface in very shallow water with only heads submerged for  $\leq 30$  s; taking quick stabs at passing fish (five occasions, ten stabs each); picking insects from marginal vegetation (twice) and from surface film (seven times). During day, long periods of intensive feeding (55 dives/25 min) interspersed with short rests (O'Donnell 1982).

**ADULTS** At Ashburton Ls (47 items bought to surface; % frequency; O'Donnell 1982) fish 55.5%, 9.6 cm (6.0; 3.0–19.0; 18) (*Onchorynchus mykiss* 6.4, *O. tschawytscha* 12.8, *Salmo trutta* 21.4, Retropinnidae 2.1, Eleotrididae 12.8), insects 31.9% (midge pupae 8.4, waterboatmen 2.1, unidentified 21.4) and plants 12.6% (algae 8.4, *Myriophyllum* sp. 4.2). Most food probably swallowed underwater so analysis may be biased against smaller items. Chironomid larvae thought to be important. Regurgitated pellet contained feathers 40% vol., fish bones 15, fish scales 5, insect cuticle 5, bird eggshell 5, plants 10, unidentified 20. In Aust., shrimps 33% freq., short-horned grasshoppers 33, water beetles ads 67, larv. 33, water boatmen 33, fish *Philypnodon grandiceps* 33 (three stomachs; L. Cowal, NSW; Vestjens 1977); seeds of Polygonaceae (one stomach; SA; Lea & Gray 1935); crustaceans, grasshoppers, beetles Hydrophilidae, Dynastinae (Barker & Vestjens 1989); freshwater molluscs, crustaceans, small fish, stalks of freshwater plants (North); one seen surfacing with a fish (nw. NSW; P.J. Higgins).

**YOUNG** Fish (2.86 cm [1.55; 1.0–5.5; 33]) also main food fed to chicks (O'Donnell 1982), making up 85.9% of 43 items fed to chicks in first week with midge larvae, waterweed and unidentified insects 4.7%. Fish >6.0 cm refused. Chicks also fed feathers, often plucked from adult's breast, dipped in water and pulverised before presented to chick, from hatching onwards. Chicks fed individual fish, usually after moistening, at mean interval 31.6 min (17.1; 5–65; 60). At 3 months old, juvenile seen to catch two trout about 6 cm long.

**SOCIAL ORGANIZATION** Not highly gregarious. For most of year, pairs seem sedentary on breeding lakes, but may form loose flocks of up to c. 100 birds or temporary feeding assemblages in autumn and winter (R. Nelson). Though most not territorial when not nesting, some defend feeding territories in winter, and all hold feeding territories early in breeding season.

**BONDS** Monogamous. Pair-bonds maintained throughout year and nest-site tenacity strong. Many social interactions in form of ritualized displays between pairs. Both sexes usually involved in displays. Both parents incubate and tend young continuously until 3–4 weeks after hatching. Adults in neighbouring territories rarely or never feed chicks and often hostile to them.

**BREEDING DISPERSION** Territorial; nests well concealed in vulnerable sites, clearly visible at others. Occasionally colonial: 100+ pairs in 3000 m<sup>2</sup> in Vic. (Bright & Taysom 1932); four pairs nested within 3 m of each other in NZ (O'Donnell 1980). On Ashburton Ls, NZ, territories large before nesting, 15.9 ha (9.37; 1.5–29.8; 29 territories, 1979–80); once nest-building began, territory reduced to 8.3 ha (4.15; 1.38–16.0; 15) in 1978–79 and 11.43 (10.5; 0.4–29.3; 17) in 1979–80 (O'Donnell 1980). Non-breeders form loose groups away from occupied territories.

**ROOSTING** Singly, in pairs, in family groups or in loose parties. In NZ, often sleep in centre of flocks of NZ Scaup *Aythya novaeseelandiae*. Loafs and roosts in territory while nesting, on open water, among surface vegetation, or in edges of well-flooded cover. Usually begin roosting well after sunset, except in breeding season when nocturnal courtship may occur on moonlit nights.

**SOCIAL BEHAVIOUR** Not well known in our region. Account based mainly on O'Donnell (1980) and BWP. Complex ritualized behaviour patterns associated with breeding,

territorialism and aggression. Displays similar to those of European birds. In NZ, several displays not recorded: Ripple Approach, Cat Display, Ghostly Penguin Display, Discovery Ceremony. Loss of displays, particularly those of pair-formation, may be related to long breeding cycle, maintenance of pair-bond throughout year, and geographical isolation of population (O'Donnell 1980).

**AGONISTIC BEHAVIOUR** Displayed by sexual and territorial rivals, especially during initial pairing, establishment of territory and in defence of young. Both sexes aggressive, but males more so than females. **FORWARD-DISPLAY**: main threat posture; neck stretched and inclined forward at angle, tippets and crest held erect. At higher intensity, neck in water, back feathers ruffled. Display often accompanied by barking or growling call. In response to intruders in territory or along territorial boundaries; most common towards end of incubation period and usually performed by males. If intruder does not retreat, defending bird engages in **Skirmish-Display**: bird flies at intruder, rapidly pattering across water; usually one or two patter-flights enough to chase intruders away. **Sinister-dives**: ritualized display in which bird submerges after Forward-display and swims rapidly below surface. Used to stalk and chase intruders; may be used to escape aggressor, and sometimes interspersed with patter-flights on surface. **FIGHTS**: rare; bill-grappling with birds flapping wings and rising out of water breast-to-breast. Apparent **APPEASEMENT** displays, though more typical of courtship are Habit-preening and Head-dipping. **Habit-preening**: birds flick feathers of mantle during Head-shaking (see below). **Head-dipping**: bird turns and dips or bobs its head without touching feathers.

**SEXUAL BEHAVIOUR** Engage in **WATER-COURTSHIP** but, unlike European birds, platform-courtship rarely reported and only brief observations recorded by O'Donnell (1980). Pair-formation and maintenance include: Attraction Posture, Head-shaking, Head-dipping, Weed-dancing and Penguin-dancing. Characteristic of pre-laying stage; no displays, except Head-shaking, performed later in cycle as often claimed. **Attraction Posture**. Mutual display adopted after pair has been separated; seeking or advertising display in which female usually swims towards male with head stretched out in forward position, nearly touching water. **Head-shaking**. During courtship occurs spontaneously as greeting when pair joins after separation, or periodically when pair together; birds approach each other with necks fully stretched and inclined slightly forward, crests and ruff erect, heads shaken several times, head arched back. During intense Head-shaking, birds slowly withdraw from each other while Habit-preening, moving apart with erect neck, tippets spread in full circle with marked forward slant, crest depressed, and emitting twanging call. **Weed-dance**. Lead-up to copulation; follows Head-shaking: male dives then surfaces with weed in bill, swims towards female Head-shaking; female then approaches male in same way; finally both swim away from each other while Head-shaking, then dive, emerge face to face holding weed, and begin Head-shaking. **Penguin-dance**. Performed after Weed-dance; both birds assume Attraction posture and, still holding weed, suddenly rise up with feet paddling water vigorously and their breasts touching. **COPULATION** occurs soon after Penguin-dance on flimsy platform made of twigs. Both sexes may mount each other and interchange positions several times. Male copulates quickly, dismounts over female's head, re-enters water in upright position while vigorously stamping feet, and starts Head-dipping

with back to mate.

**RELATIONS WITHIN FAMILY GROUP** No details from Aust. or NZ; descriptions based on European studies and should be examined for A'asian populations. Young carried on parent's back for c. first 3-4 weeks. Chicks climb aboard unaided, but encouraged by adult raising wings and back-feathers. At moments of potential danger, adults invite chicks to board by growling and croaking, and assist them by lifting both feet sideways along water surface. Young dislodged from back by body-shaking and wing-flapping; sometimes when overdue for change-over, parents dive to dislodge chicks. Do not recognize parents for first 5 weeks, though parents recognize own young from early stage, probably through voice. Adults antagonistic towards young from other broods; swim or plough after them, sometimes seizing chick by head and ducking it. Young flee or remain and display appeasement behaviour. Interactions between adult and chick complex and association may continue well beyond fledging. Chick shows appeasement behaviour when begging for food. Fighting between siblings not uncommon; mostly head-pecking by larger; smaller young moving away or Bill-hiding. Disputes between older chicks rare, but can take form of persistent pursuits. Adult-like water-courtship displays between chicks evident after third week. Older chicks seen soliciting on raised sites, but no copulations observed. May build platforms, even depositing material on back of sibling or parent. Head-shaking and soliciting not uncommon in independent juveniles.

**VOICE** No detailed studies in Aust. or NZ; information supplied by C.F.J. O'Donnell. Apparently generally silent; most calling associated with breeding activities; call when nests threatened by humans (R.P. Jaensch). Vocalizations consist of a range of harsh guttural calls associated with displays. Calls probably similar to Great Crested Grebes elsewhere (BWP); studies of differences, if any, between A'asian and European birds needed. No information on sexual differences or individual differences in calls; in Europe, calls of males and females identical. Geographical variation and mimicry not reported but study warranted. In NZ, Barking, Growling, Crooning, Grunting and Twanging have been reported but not described (C.F.J. O'Donnell); descriptions below are based on European birds (BWP) and may not be accurate for Aust. and NZ. The circumstances in which calls are used are given for NZ only and other circumstances when calls are used in Europe are not described.

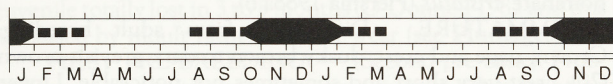
**ADULT** **Barking**. Guttural barking during Threat Display; loud, repeated *rah-rah-rah-*, 1-12 notes per call (BWP). **Growling**. Guttural growls associated with Attraction Posture; loud, drawn out *g(h)ar* or *gorr*, given singly or slowly repeated (BWP). **Twanging**. Reported during Head-shaking; quiet, metallic *gung*, repeated phrases of 2-3 notes (BWP). **Crooning**. Soft crooning heard during courtship displays; no obvious equivalent for European birds (BWP). **Grunting**. Harsh grunts heard during Head-shaking; possibly equivalent to Croaking of European birds (BWP). No further information for Aust. and NZ. Ten calls reported for European birds; other calls include Snarling, Clicking, Clucking, Ticking, Mooing and Rattling (BWP).

**YOUNG** In NZ, give high-pitched begging calls. Three main calls described for European birds: Squeaking, Wheedling and Peeping (BWP). In Europe, juveniles have specific Chattering Call after c. 14 weeks; after c. 17 weeks juvenile versions of adult calls begin to appear.



**BREEDING** Poorly known. Aust., no field studies. NZ, field studies by C.F.J. O'Donnell (1980, 1982 and in prep.), who supplied NZ information. Breed in simple pairs on inland lakes and larger waters; usually well dispersed but sometimes concentrated into loose colonies (Campbell) or small groups (R.P. Jaensch).

**SEASON** Aust.: in SE, generally said to be Nov. to end Feb. (North; Campbell) but few nests accurately recorded: NSW, Nov.–Feb. (Hobbs 1961; Frith 1969); Vic., Nov. (Bright & Taysom 1932); Tas., Dec.–Mar. (Napier 1973); SA, Jan.–Feb. (Beruldsen 1968); s. WA, Buller (1942) found a nest on 8 Aug.; laying indefinitely recorded as Aug.–Feb. with most clutches started Nov. (Halse & Jaensch 1989). NZ: whole nesting cycle between Sept. and May; active nests Sept.–Mar.; peak laying late Dec. and Jan. (C.F.J. O'Donnell).



**SITE** Normally on or near vegetated margins of large or fairly large open waters, 2–10 m from shore in water-depths of 1–2 m; among reeds, water ribbons *Triglochin*, tussocks of *Gahnia*, drooping branches of trees (Beruldsen 1968; Napier 1973), in flooded *Melaleuca* thickets (R.P. Jaensch); also on floating weed in open deep water and up to 50 m from shore (Beruldsen 1968; Buller 1942). In NZ almost always in or under vegetation, most importantly among willows *Salix*, averaging 3 m from shore and from open water in centre of marginal vegetation and in water over 1 m deep; a few reports of nests floating on beds of weeds in the middle of small lakes (C.F.J. O'Donnell); formerly nested off unvegetated shorelines (Henry 1903; Falla 1975). Density of nests in groups: 100+ nests in 3000 m<sup>2</sup> in Vic. (Bright & Taysom 1932) (misquoted as 300 m<sup>2</sup> in Aust. Atlas); 5–10 nests in c. 300 m<sup>2</sup> in WA (R.P. Jaensch); 23 active nests in c. 500–600 m<sup>2</sup> in SA with most nests within 3 m of another (R.P. Jaensch).

**NEST, MATERIALS** A saturated mound or platform of dead water-plants and weeds; usually not floating free but attached to some reeds, fallen or drooping branches or submerged stump (North; Beruldsen 1968). In NZ, most nests have a base of twigs (reeds rarely) covered with decomposing vegetation, mud and weeds; average diameter 40 cm, height 22 cm with 14 cm above water-level and poorly formed cup, most nests attached to submerged vegetation, particularly branches of willows (C.F.J. O'Donnell). Both sexes build, taking 2–10 days for completion of nest. Platforms, on which copulation takes place, generally built nearby (2–3 m) and nests may be built on them (C.F.J. O'Donnell). Once, when nest became stranded on stump as water-level fell, new nest was built alongside and three of four eggs transferred to new structure and successfully hatched; fourth egg found submerged on bottom (Beruldsen 1968); similar circumstances recorded in NZ (C.F.J. O'Donnell).

**EGGS** Elongate oval, pointed at both ends; fine-textured, with fairly even chalky white coating on pale bluish or greenish white shell, becoming stained to pale brown and even to deep reddish brown by end of incubation (North; Campbell; C.F.J. O'Donnell). **MEASUREMENTS:** Aust.: 55.4 (52.1–56.6; 8) x 33.9 (33.5–34.3) (North); 51.7 (51.1–52.3; 4) x 35.5 (34.5–37.1) (Campbell); NZ: 57.5 x 37, 56.5 x 35.5 2 eggs; Oliver).

**CLUTCH-SIZE** No quantified data for Aust., generally said to be 5–7, usually 5 (Bright & Taysom 1932); one clutch of 10 attributed to two females (North; Campbell) as also probably for 9 eggs reported by Bright & Taysom (1932). At Ashburton Ls, NZ, average 2.6 (1–4; 16) and generally in NZ average 3.1 (1–7; 32). Replacement clutches have two eggs (n=5; C.F.J. O'Donnell). Replacement layings by some pairs but not all; started 8–36 days after loss (n=7 nests) and usually within 2 m of original site (C.F.J. O'Donnell).

**LAYING** At intervals of 48 h (n=21; C.F.J. O'Donnell).

**INCUBATION** Starts with laying of first egg; by both sexes. Stints of incubation gradually increase: 30–45 min (first 3 days), 1 h (D4–5), 1.5 h (D6–7), 2.5 h (D8–9) and c. 4 h thereafter. **INCUBATION PERIOD:** at Ashburton Ls, average 26 days (25–31; 8) (C.F.J. O'Donnell) but 23 days recorded by Soper (1965). Hatching asynchronous at 1–2-day intervals. In NZ, eggs rarely covered when bird leaves nest (C.F.J. O'Donnell). In Aust. covering of eggs (even of incubating bird covering itself) implied to be usual (North); witnessed by Beruldsen (1968) and Tarr (1959); Campbell says eggs covered during laying period but nest rarely unattended after incubation starts. When leaving nest, adult immediately dives and surfaces 10–60 m away (North; Beruldsen 1968). Eggs withstand wetting and immersion (Campbell). Incubating adults may be easily visible or even conspicuous, though nests well hidden in *Triglochin*, by reason of their pale erect necks (Napier 1973).

**YOUNG** Precocial, semi-nidicolous. Downy when hatched and characteristically striped with black and buff or creamy white on head, neck and upperparts. Active as soon as hatched but usually stay at or near nest until all clutch hatched, swimming short distances till then. Both parents tend chicks, often carrying them on their backs under wings slightly raised into a protecting tent, through which heads of young may protrude. Chicks swim after two days, dive at about one week. Brood is apparently divided between parents (C.F.J. O'Donnell; NZ NRS). Size of broods averaged 1.8 (1–4; 23) (Westerskov 1971; Sagar 1981; C.F.J. O'Donnell; NZ NRS). No information on rate of growth.

**SUCCESS** At Ashburton Ls in one season only 17 of 28 pairs tried to breed, laying 37 eggs; only eight hatched and seven chicks died in first week (C.F.J. O'Donnell). At Canterbury Ls, NZ, during four seasons productivity 0.01–0.08 young/adult/year; however, in three recent summers with apparently better conditions success was higher: 0.3, 0.36 and 0.4 young/adult/year. Lack of success caused by natural and artificial fluctuation of water level, bad weather in high country and predation by introduced mustelids; late nests abandoned in autumn; also illegal shooting and disturbance by man. Chicks taken by eels, probably by large fish (C.F.J. O'Donnell); also by Swamp Harriers *Circus approximans* and Kelp Gulls *Larus dominicanus* (D.H. Ackerley).

**PLUMAGES** Described for subspecies *australis*.

**ADULT BREEDING MALE** Definitive; alternate. This plumage is found on at least some adults throughout year; see non-breeding plumage. Attained at about time of first wing-moult; a subadult plumage may differ (see Ageing and Sexing). Difficulties in applying Humphrey and Parkes' (1959) plumage nomenclature to grebes discussed by Piersma (1988b). **HEAD AND NECK.** Forehead and crown, grey-black (c82), with short transverse crest ending in two erectile tufts that lie along sides of head when lowered. Black crown ex-

tends down to eye in most birds but some have a narrow white stripe above eye (O'Donnell 1981). Upper hindneck, dark brown (20) merging to grey-brown in lower hindneck of some birds. Face, lores, chin and lower throat, white. Upper throat obscured by tippets (frill of elongate ear-coverts and upper-neck feathers). Tippets, orange-rufous at base and black (89) at tips. Some, but not all, tippet-feathers are bicoloured. **UPPERPARTS.** Mantle, dark grey-brown (119B). Back appears dark brown; feathers, dark brown with narrow light-brown tips. Scapulars mostly obscured by back feathers; most dark brown; longest, white with dark-brown fringes. Rump, dark brown (19). Tail-tuft, grey-brown above and white below. **UPPERWING.** Marginal and humeral coverts, white. Secondary coverts, grey-brown (119A, 119B), often with white inner webs, at least to some outer feathers. Tertiary coverts, and sometimes some (especially inner) lesser coverts, black-brown (c119). Other upper wing-coverts, grey-brown (119A and 119B). Humeral white, with brown tips to inner webs. Tertiaries, black-brown (119). Other secondaries, white; outermost has dark-brown outer web (119A). Primaries, dark brown (119A) with white bases and patchy white on inner webs. **UNDERPARTS.** Predominantly white, although some specimens have orange-rufous tinge to the upper breast probably caused by iron staining; incubating birds often have brown tinge caused by staining from vegetation. Sides of upper breast, pale rufous; feathers on flanks, pale rufous with blackish-brown (19) tips, giving mottled appearance. Axillaries, white. **UNDERWING.** White, save for brown-grey (brownish 86) tinge to primary tips.

**ADULT FEMALE** Definitive; alternate. Similar to male. O'Donnell (1981) noted in the field that females more often had white stripe over eye than males. Difference cannot be seen on skins (O'Donnell 1981; D. I. Rogers). White eye-stripe can be obscured by preening the crown-feathers of freshly dead specimens, which suggests that width of eye-stripe under voluntary control.

**ADULT NON-BREEDING** Basic? A female specimen (CSIRO 6064), aged as an adult on convoluted oviduct, is in this condition. Similar to immature save for secondary coverts, which have white tips (J. Wombey). No other evidence for non-breeding plumage in Aust.; birds with tippets have been collected at all times of year (n=17) and all birds without tippets examined (n=7) have immature characters. Non-breeding plumage does not occur in NZ, where all birds without tippets seen in winter are probably immatures; their numbers correlate with those of juveniles earlier in the year (based on monthly counts throughout year over 10 years; C.F.J. O'Donnell). Fjeldså (1988) suggested non-breeding plumage held for a short period, but could not show that all birds went into it. Limited data suggest that tippets of *australis* in Aust. are longest in spring and summer, and shorter in autumn.

**DOWNY YOUNG** **HEAD AND NECK** Bald areas on lores and top of crown. Most of crown, blackish-brown (19), with white downy circular spot on nape. Forehead and lateral crown-stripe, white. Supercilium, blackish-brown (19), narrow above eye, and separated from dark stripe on side of neck by white post-orbital stripe running into lateral crown-stripe. Rest of head, predominantly white, with line of blackish-brown (19) spots running from below eye to auricular region, and blackish-brown (19) blotch near base of lower mandible merging into narrow malar streak. Neck, white, with longitudinal dark-brown (119A) stripes: one mid-dorsal, one running along side of neck and another between these;

white stripes slightly narrower than dark brown stripes. Throat, white; brown (119A) mid-ventral stripe on upper throat divides into two parallel stripes on foreneck. **UPPERPARTS.** Alternating longitudinal stripes of dark brown (119A-21) and light drab (119C); mid-dorsal stripe, dark brown; two other pairs of dark-brown stripes on upperparts. **UPPERWING.** Dark-brown leading-edge, grey-brown trailing-edge. **UNDERPARTS.** Light-drab (119C) flanks, sides of breast, and under tail-coverts separated from white breast and belly by dark-brown (21) line.

**JUVENILE** Similar to immature (described below) but crown- and nape-feathers have narrow white tips. Head and neck have striped pattern identical to that of downy young; this has been attributed to down feathers adhering (Kop 1971), but feathers forming the pattern are pennaceous and have been shown to be an independent generation in nominate *cristatus* (Piersma 1988a,b).

**IMMATURE** Differences from adult breeding: Crown, nape and crest, dusky brown to dark greyish-brown (20); crest very short and sometimes not noticeable. Upper hindneck, dark greyish-brown (20) merging to grey-brown on lower hindneck. Chin, ear-coverts, throat and foreneck, white. Tippets absent, but during prolonged first prebasic, growing tippet feathers impart orange-buff (124) wash to ear-coverts, and sometimes a dusky wash below these. Flanks dusky; pale-buff traces begin to appear during first prebasic. Lesser coverts and secondary coverts, grey-brown in seven birds examined; one other bird had white inner webs to some secondary coverts.

**BARE PARTS** Based on two freshly dead specimens, Hall (1974), Gould (1865), and MV and NMNZ labels.

**ADULT** Iris, crimson (c108), at least sometimes with orange-brown inner ring. Hazel eye recorded on female from Westland (NMNZ). Bare skin on lores, olive-blackish (c82) to dark olive-brown-grey (c83). Reddish black reported for nominate *cristatus* (BWP). Bill, pink-red (10) to dirty pink (4) with brown-black culmen and red (13) underside. Soles, outer side of tarsus and hind-toe, dark grey (83) to blackish (82). Outer side of outer toe, olive-black; inner side, yellow (57-157). Other toes, yellow (57-157) with narrow darker strips above bones. Oliver and one label (MV) describe outer side as olive-green. Piersma (1988a) found that in nominate *cristatus* outer edge of tarsus always blackish, but that ground colour of inner tarsus very variable and often barred black. This possibly applies in Aust., where few data available.

**DOWNY YOUNG** Naked crown spot and lores, pink, flushing to red when excited (Aust. RD; NZRD); iris, orange-yellow; feet, green-yellow, bill, short and black, white-tipped and red at base (NZRD).

**JUVENILE** Only data available from 1 MV label, in which bill and legs as above. In nominate *cristatus*: iris, orange with narrow yellow inner ring; bill paler on sides than in adults (BWP). Tarsi of juvenile *cristatus* similar to adults but with significantly less barring on inner side (Piersma 1988a).

## MOULTS

**ADULT POST-BREEDING** (Pre-basic). Primaries and secondaries simultaneous. Primary wear of non-moulting birds in Aust. suggests primary moult generally occurs in autumn but timing varies much. In NZ, primary moult probably Jan.-Mar. No other data available for A'asia; see Piersma (1988b,c) for detailed account of moult of nominate *cristatus*,

where estimated duration of primary moult 17 days and body moult almost continuous in some tracts, perhaps partly because birds habitually eat feathers. Because eating feathers is also habitual in *australis*, continuous body-moult may be expected. Piersma described an autumnal plumage of *cristatus* as similar to breeding plumage but with shorter tippets. Because tippets of *australis* are apparently shorter in autumn and winter than at other times, this may occur in Aust.

**ADULT PRE-BREEDING** (Pre-alternate.) Extent unknown, but does not include remiges. Unknown if all adults have pre-breeding moult (see non-breeding plumage).

**POST-JUVENILE MOULT** (First pre-basic). Treated here as partial moult, because it produces distinctive immature plumage; however, unknown if feather-growth stops between post-juvenile moult and first pre-breeding. Begins soon after fledging, because striped head-pattern of juvenile totally lost in 3 to 5 months (O'Donnell 1982 and this is caused by moult rather than by wear (see Plumages).

**FIRST PRE-BREEDING** (Second pre-basic). Probably early in second year, from immature to adult breeding plumage. Complete, and probably gradual, with much body-moult occurring before primary moult. One specimen (MV) in simultaneous primary moult and heavy body-moult collected in Apr. had tippets, but secondary coverts grey-brown and tarsus-shape as immature, which suggests that tippets grow before first wing-moult.

**MEASUREMENTS** (1) Aust. adult breeding skins (MV). (2) NZ adult breeding skins (NMNZ).

	MALES	FEMALES
WING	(1) 185.3 (7.74; 174-197; 7) (2) 184, 194	176.5 (5.36; 170-183; 6) 182.6 (3.54; 175-188; 9)
8TH P	(1) 103.0 (7.96; 95-114; 4)	97.8 (6.79; 90-106; 6)
BILL	(1) 52.8 (2.49; 50.0-56.0; 7) (2) 53.7, 47.7	48.3 (5.67; 42.6-53.0; 6) 44.7 (2.40; 41.2-47.3; 9)
TARSUS	(1) 60.7 (2.35; 56.6-62.8; 7) (2) 61.6, 70.1	56.7 (1.12; 53.9-56.8; 6) ** 65.7 (3.13; 61.4-72.0; 9)
TOE	(1) 69.0 (4.22; 61.4-73.7; 7) (2) 73.8, 76	63.1 (1.93; 60.6-65.7; 5) * 70.5 (1.64; 68.7-72.7; 9)

(3) Unsexed adults (CM; C.F.J. O'Donnell).

	UNSEXED
WING	(3) 184, 190, 190, 190
BILL	(3) 53.4, 52.6, 53.4, 53.0
TARSUS	(3) 65.9, 70.0, 65.0, 60.0
TOE	(3) 71.2, 67.7, 68, 66.7

**WEIGHTS** Aust.: 440-1219 (juveniles and adults; sexes combined, n=7; fat status unknown (MV). NZ: adult females 1075-1218 (n=5, all with fat, in summer). Two emaciated females weighed 466 and 592. No data for males (NMNZ).

**STRUCTURE** Wing, short and narrow. Twelve primaries, p10 usually longest, p11 0-5 shorter, p9 0-5, p8 8-15, p7 17-25, p6 25-36, p5 33-45, p4 39-53, p3 50-61, p2 56-69, p1 63-67; p12 minute. Small emarginations on outer web of p9 and p10, larger emarginations on inner web of p9, p10, p11. Eighteen secondaries and four tertials, about six humerals. Bill, straight and stout; nostrils, narrow and oblong, in shallow

groove near edge of culmen. Strip of bare skin between upper mandible and eye. Toes lobed, claws flattened, not protruding past skin. Outer toe c. 120% of middle, inner c. 92%, hind toe c. 33%.

**SEXING** Males tend to differ from females in having longer heavier bill, longer crest and tippets, and shorter thicker neck. These characters of use in sexing breeding pairs (O'Donnell 1981; BWP).

**AGEING** Once striped head-pattern of juveniles lost, no single plumage character separates immatures from adults. In nominate *cristatus*, secondary coverts with white inner edges, and black-brown lesser coverts, are usually found only in birds that have completed first wing-moult; in juveniles all these coverts usually grey brown. At least 2% of *cristatus* cannot be aged correctly on these characters (Piersma 1988a). Skins suggest these characters useful in *australis* (Kop 1971; D.I. Rogers). Downy young *australis* have bare patch on crown; traces remain in at least some birds in immature plumage. Scales on hind edge of tarsus form two strongly notched ridges. In juveniles, ridges relatively smooth and almost fused. In *cristatus* a gradual transition from smooth to serrated ridges occurs in second summer (Kop 1971). Further information on ageing *cristatus* in Piersma (1988a).

**GEOGRAPHICAL VARIATION** None known in Aust. Mathews (1910-27) recognized *P.c. christiani* in Aust. and *P.c. australis* in NZ, on the grounds that *australis* was larger and darker, with larger and darker tippets. Plumage differences, if they occur, slight and inadequately described; Vaurie (1965) and Aust. CL considered NZ and Aust. birds inseparable. Subspecies *australis* differs from nominate *cristatus* of Palaearctic by lack of non-breeding plumage and darker upperparts (BWP). Subspecies *infuscatus* of Africa has no white superciliary stripe (Benson & Irwin 1964). Note it has been incorrectly asserted that *australis* lacks rufous tinge to flanks and white stripe over eye (BWP); eye-stripe is usually present, especially in females.

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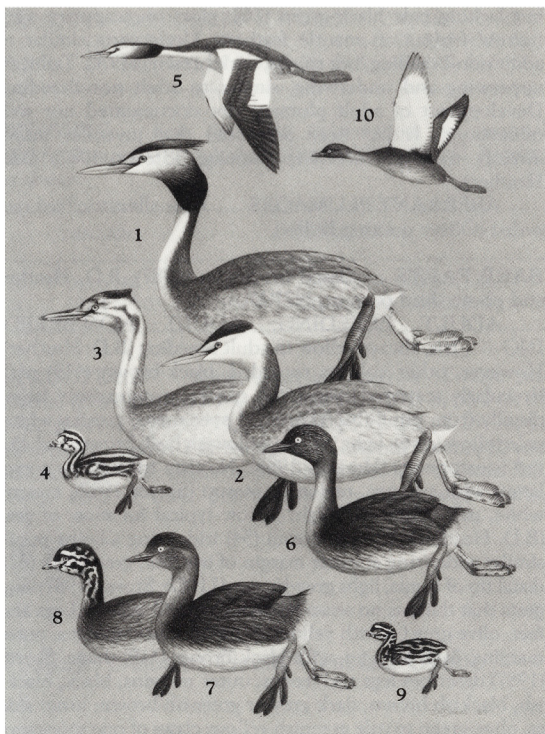
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Great Crested Grebe  
*Podiceps cristatus*

1. Adult
2. Immature
3. Juvenile entering post-juvenile moult
4. Downy young
5. Adult

New Zealand Dabchick  
*Poliiocephalus rufopectus*

6. Adult breeding
7. Adult non-breeding
8. Juvenile
9. Downy young
10. Adult breeding

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