Order ANSERIFORMES

Medium-sized to large aquatic, marine and terrestrial birds. Three families: (1) Anhimidae (screamers), (2) Anseranatidae (Magpie Goose) and (3) Anatidae (true wildfowl); Screamers confined to South America, Magpie Goose confined to Aust. and New Guinea, and rest cosmopolitan. Suggestion that the order is distantly related to Phoenicopteriformes and Ciconiiformes (see Sibley & Ahlquist 1972) now seems unlikely. Claims for some anatomical similarities with gamebirds such as Cracidae, suggesting distant affinity with Galliformes via Anhimidae and Anseranatidae (Simonetta 1963; Johnsgard 1968; Bock 1969), strongly rejected by Olson & Feduccia (1980).

All members of the Anseriformes are web-footed (in some semi-palmate) swimming (some now almost terrestrial) and diving birds that are filter-feeders or are derived from aquatic filter-feeders. They differ from Galliformes in almost every anatomical feature (see Olson & Feduccia 1980). The unique filter-feeding mechanism is diagnostic of the order. Two groups of filter-feeding birds probably evolved from some charadriiform origin; in one, the specialized mechanisms for filtering evolved in the lower mandible (flamingoes); in the other, the upper mandible housed the specialized tongue used to provide the pump-action for filtering. The complex structure of the bill and its operation during filter-feeding in a typical duck has been investigated recently (Zweers 1974; Zweers *et al.* 1977; Kooloos 1986; Kooloos & Zweers 1989; Kooloos *et al.* 1989). Sensory apparatus of the bill associated with this filtering function is likewise complex (Berkhoudt 1980). The typical bill, representing the fundamental apparatus unique to the order, acts as a double-action suction-pump in which fluid is drawn in at the tip and expelled past filter plates at the sides and rear. The tongue and internal shape of the bill provide the elaborate piston effects and the lamellae or fine plates, common to all members of the order, act as the sieves. Lamellae trap the food, which is then brushed free and swallowed by the combined actions of tongue and lamellae. Vestigial lamellae occur in screamers (Olson & Feduccia 1980). Filtering is the original feeding method and departures from it towards adaptations for grazing in geese, serrated edges for catching fish in 'saw-billed' ducks (mergansers and allies) or superficially fowl-like bill of screamers, are all derived features (Olson & Feduccia 1980). Anhimidae, however, being extralimital, are not considered further.

The innovative modern classification of the ducks, geese and swans, and the systematic order proposed by Delacour & Mayr (1945, 1946) and Delacour (1954–64), was modified by Johnsgard (e.g. 1965a, 1968) in the light of further studies, particularly on behaviour and social signals, and new information on little known species. Woolfenden (1961) and Livezey (1986) have prepared phylogenetic analyses of the order based on morphological characters, and the classification by Livezey has been followed by some recent works (e.g. Madge & Burn 1988). Madsen *et al.* (1988) provide important additional information from DNA studies and give a partial classification of the order. We have adopted the classification of Johnsgard in Peters with some modification concerning only those species within our area. Our reasons for these changes are as follows but the arrangement of species fits closely the proposed classification of the order given by Sibley *et al.* (1988) and Madsen *et al.* (1988). The arrangement is consistent with the persuasive argument presented by Olson & Feduccia (1980) concerning the origin and evolution of the order. The fossil *Presbyornis* (Eocene; North America) and the endemic *Stictonetta* (Freckled Duck) and *Malacorhynchus* (Pink-eared Duck) of Aust. have special significance in this respect (see Olson & Feduccia 1980).

Special features of *Stictonetta* are: reticulated anterior face of tarsus; lack of a syringeal bulla; no speculum; unpatterned downy young (see Frith 1964a,b). Structure of the trachea and syrinx described by Ramsey (1878) and in more detail by Campbell (1889) and in Campbell demonstrate the lack of any development of a swollen bulla in drake. Claim by Frith (1964a, 1965, 1967, 1982) that tracheal loop occurs in mature drake is unconfirmed in many hundreds of birds examined (G.F. van Tets). Long neck. Uropygeal wax esters like those of some swans (Edkins & Hansen 1972) but chemotaxonomy difficult to interpret because similarities also shown with *Cereopsis*, *Branta*, *Cairina*, *Tadorna*, *Mergus* and *Melanitta* (Jacob & Glaser 1975). Brush (1976) has shown that the feather-proteins are unique. Verheyen (1953) on skeletal characters (cranial & post-cranial) concluded that it was sufficiently distinct to be separated from other waterfowl. Clearly it shows a large number of 'primitive' characters. Olson & Feduccia (1980) emphasize several feature of the cranium that are unique in living ducks: the markedly recurved rostrum and mandible and the expanded lachrymal. Livezey (1986), largely from osteological characters, supports traditional conclusions that it is the last branch of the waterfowl with reticulate tarsi and places it after the geese and swans. Faith (1989) has shown that many of these skeletal characters might be explained on divergence between diving, dabbling and grazing adaptations. Recent DNA studies (Madsen *et al.* 1988) lend some support to an earlier suggestion, based on behaviour and some morphological features, of possible similarity with Oxyurinae (Johnsgard 1965b). Fullagar *et al.* (in press) add support to idea that *Stictonetta* has several behavioural similarities with stiff-tails. The uniqueness of this species has been widely supported, but in the past the absence of information about its behaviour and ecology ensured that it remained doubtful to which other group of

wildfowl it was most closely related. Many of these deficiencies have now been resolved (see text elsewhere) and the argument for a link with stiff-tails has become more compelling. Plumages, social signals and vocalizations are all in some way most readily comparable to *Oxyura* and *Biziura* but specially to *Heteronetta*. A seasonally colourful bill in the male most closely matches the condition found in *Heteronetta* but also in most stiff-tails; sequence of moults follow unusual pattern found in at least some, if not all, stiff-tails but not known in other wildfowl, notably the presence of a post-juvenile moult including wings. Many characteristics of breeding biology (nest-construction and choice of site; small clutch-size; predisposition to dump laying; appearance and quantity of down used in lining nest; unpatterned ducklings) are features shared with most stiff-tails. In particular the unusual copulation involving greatly elongated pseudopenis is most closely comparable with features shown only by stiff-tails.

Major recommended works of reference are: **Comprehensive accounts**: Delacour (1954–64); Todd (1979); Phillips (1922–26) [ducks]; Scott (1972) [swans]; Owen (1980) [geese]. **Regional accounts**: Palmer (1976) [Nearctic]; BWP [w. Palaearctic]; Bauer & Glutz von Blotzheim (1968–69) [Europe]; Frith (1982) [Aust.]. **Field guides**: Scott (1988); Madge & Burn (1988). **Special studies**: Hochbaum (1955, 1973) and Sowls (1955) [migration and habits]; Johnsgard (1965a) [complete review of behaviour]; Hochbaum (1944); Driver (1974) and Kear & Berger (1980) [species monographs].

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Family ANATIDAE wildfowl

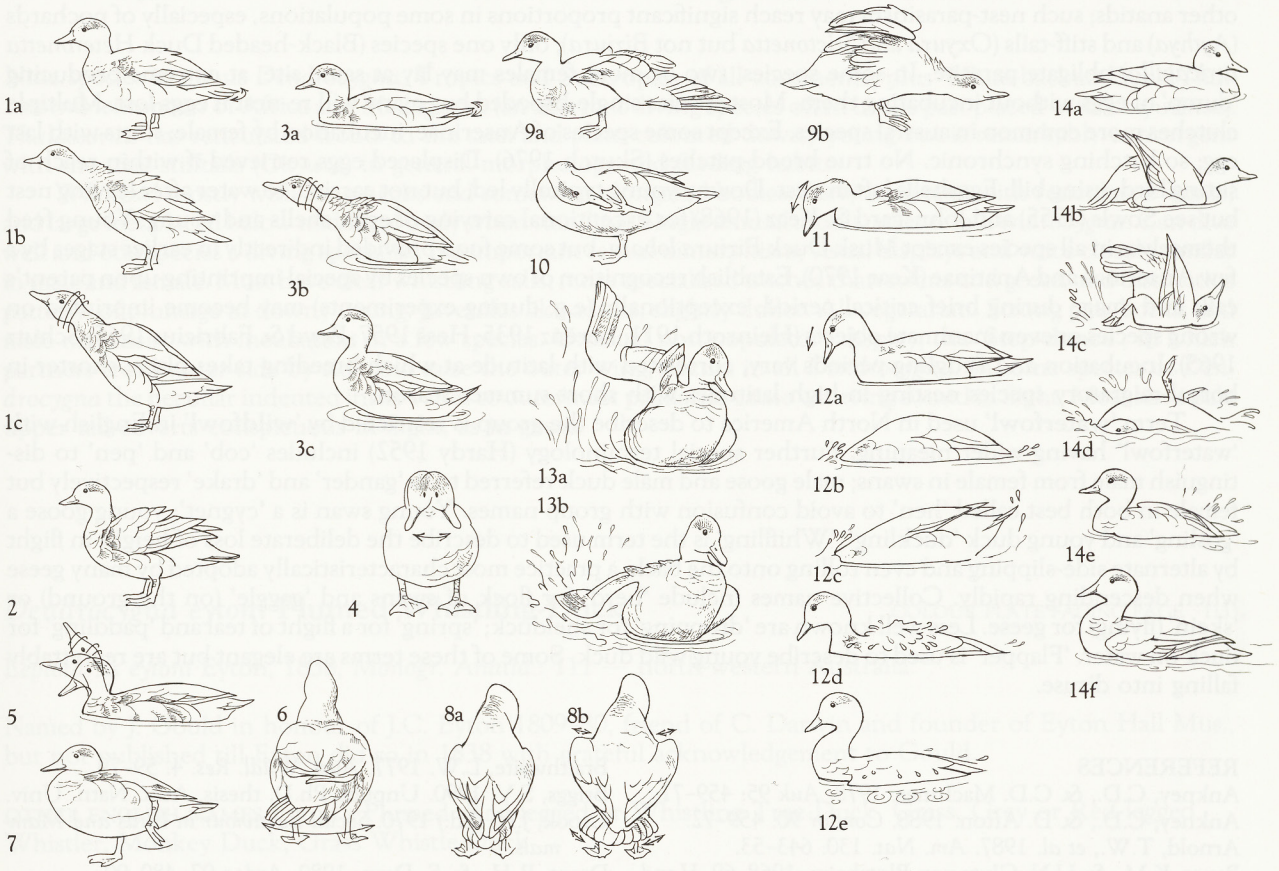
Waterbirds (some more or less terrestrial) with rather short legs and front toes connected by webs; hallux elevated and reduced. Though considerable adaptive diversity in outward appearance, size, colours of plumage, behaviour, and ecology, homogeneous in many characters, as attested by numerous, often fertile, interspecific hybrids reported, chiefly in captivity (see Gray 1958). About 160 species in six sub-families: (1) Dendrocygninae (whistling-ducks); (2) Oxyurinae (stiff-tails and Freckled Duck); (3) Anserinae (swans and geese); (4) Tadorninae (shelducks, sheldgeese and steamer-ducks); (5) Anatinae (dabbling ducks and allies); (6) Merginae (eiders, scoters, mergansers and allies).

Body, broad and rather elongated in many, though more rotund in some, especially diving species. Plumage, thick and waterproof; contour-feathers distributed over distinct feather-tracts with underlying coat of down. Neck, medium to long. Wings generally rather small; mostly pointed, fairly broad in many, but narrower in some highly migratory species. Small claws on first and second digits occur in most. Spurs–horny sheathed bones–occur in several species as projections near carpal joint; attached either to radial carpal or the metacarpal. Wing-spurs are found in the Tadorninae and *Sarkidiornis, Plectopterus* and *Merganetta* in the Anatinae. Eleven primaries; p9 nearly always longest, p11 minute. Wide range in number of secondaries, from 12 to 24, innermost (tertials) often long and brightly coloured; diastataxic. Many species, particularly in Tadorninae, Anatinae and Merginae have a specialized, contrastingly coloured patch (speculum) on upper surface of inner wing, important for sexual and social signalling. Most fly fast and have large, high-keeled sternum. Tail, short and square or slightly rounded in most; long in some diving species (serving as rudder), pointed or with elongated central feathers in some others. Tail-feathers, 14–24 but varying even in single species. Bills show much adaptive variation but typically of medium length, broad, often flattened centrally and distally but high at base, and rounded at tip with horny nail at tip, producing slight terminal hook; covered with soft skin. Edges of mandibles with rows of lamellae, showing different development in various ecological types and taxonomic groups; most highly specialized in surface plankton-feeders, least so in species (such as scoters *Melanitta*) that swallow molluscs whole. Tongue, thick and fleshy; epithelium covered with papillae and horny spines. Lower part of tibia and tarsus bare; front toes connected by webs (reduced in a few species), hind toe elevated. Gait, striding or waddling. Oil gland, feathered. Aftershaft, reduced or absent. Special intromittent copulatory organ present in males; vascularized sac everted from wall of cloaca, protruded by muscular action; facilitates sexing by examination (Hochbaum 1942), even of small young. Salt-secreting nasal glands subject to adaptive variation in size, even in same species; enlarged in forms inhabiting saltwater or brackish habitats, modifying profile of head considerably. In many species, males have remarkably lengthened, bent, or locally widened trachea forming resonating tubes; also syringo-bronchial sound-boxes (bullae), either fully ossified or with membranous fenestrae. These vocal structures highly characteristic of species or larger taxonomic units (see Eyton 1838 and, especially, Johnsgard 1961, 1971). Considerable diversity in types of plumage: male and female similar, nearly similar, or show extreme sexual dimorphism. In all species, except some sheldgeese, flight-feathers moulted simultaneously, producing period of flightlessness lasting 3–4 weeks. Two body-moults per cycle. Young precocial and nidifugous, covered with thick down; pattern often cryptic and characteristic of taxonomic groups within sub-families. Able to swim soon after hatching.

Cosmopolitan, but absent from continental Antarctica and some islands. Usually on or close to water. Highly vulnerable to human pressures on habitats. Labrador duck *Camptorhynchus labradorius* extinct during last century, and three more (Crested Shelduck *Tadorna cristata*, Pink-headed Duck *Rhodonessa caryophyllacea*, Auckland Merganser *Mergus australis)* probably so this century. A few species domesticated: Swan Goose *Anser cygnoides*, Greylag Goose *A. anser*, Muscovy Duck *Cairina moschata*, and Mallard *Anas platyrhynchos* (Goodwin 1965); some populations of a few more (Mute Swan *Cygnus olor*, Canada Goose *Branta canadensis*, Egyptian Goose *Alopochen aegyptiacus*) kept in semi-domesticated or feral conditions.

N. forms often highly migratory and tied to Arctic or high latitudes for breeding, exploiting brief but productive period each year to raise young; for many of these species autumn movements preceded by marked moult-migrations by males to special areas for period of flightlessness. More sedentary in warmer latitudes, specially in equatorial regions. The term 'boreal' for these n. wildfowl is useful to draw attention to the marked differences between the breeding ecology of n. high-latitude wildfowl compared with many s. hemisphere species for which the term 'austral' has been used (Fullagar *et al.* 1988). In general, most austral species are more sedentary and certainly lack spectacular migrations. Regular movements in most s. hemisphere species are at best only local. Occasional much wider dispersal is often initiated by factors such as flooding rains and drought (specially in Aust.). Many austral ducks exploit seasonally persistent or occasional, extremely propitious conditions by responding with an extended breeding season. In reality, most are seasonal breeders but productivity of some will vary greatly according to rainfall and flooding; most notable with many species in Aust. For further details see Fullagar *et al.* (1988).

Wide range in diet, from totally vegetable to totally animal, and in feeding habits, from terrestrial grazing to bottom diving; correlated with conspicuous adaptations in structure of bill, musculature of head, length of neck, and in general proportions of body. Terminology of feeding methods in species accounts mainly after Szijj (1965) and Bauer & Glutz (1968, 1969); see also Olney (1963). Typical filtering action of most members of the order, described earlier, best termed 'suzzling'. Most species gregarious, feeding, loafing, roosting, and travelling in cohesive flocks, integrated by calls and special pre-flight signals. Generally solitary breeders nesting in concealed sites, though some species colonial, either habitually or, more often, as alternative to dispersed nesting, usually in protected areas such as islands. Degree of territorialism when breeding and relation between territory and nest-site vary between species and larger taxa; some strictly territorial; others occupy wholly or largely undefended home-ranges. Monogamous pair-bond in most species but much variation between taxonomic groups in duration of bond and degree of male promiscuity (if any). Social systems and displays correlated with formation and maintenance of pairs; complex (see classic work of Lorenz 1951–53) and largely dissimilar in six sub-families (see below). Copulation on water in all species (except some Anserinae and Tadorninae), typically with male grasping female's nape in bill. Vocalizations varied but generally simple (mainly honks, grunts, quacks, coos, and whistles); often different between sexes when linked with anatomical differences in vocal apparatuses (syringeal bullae). Non-vocal sound-signals produced in some species. Calls of downy young are: (1) Contact or Greeting Call (also termed Pleasure and Contentment Call) and (2) Distress Call (see Kear 1968). Comfort-behaviour well known. Bathing frequent and elaborate. Typically performed while swimming in water too deep for standing; involves head-dipping, wing-thrashing, somersaulting, and diving. Followed by oiling (with use of bill and head) and preening. Full description of comfort movements, the behaviour patterns of shaking, stretching, preening, bathing and related activities given by McKinney (1965). The diagrams (Figs 1 to 14) based on those from McKinney illustrate most of these actions, all of which are common to all wildfowl. Some essentially aquatic species (genera *Thalassornis, Oxyura* and *Biziura*) have other, slightly specialized, preening and shaking actions peculiar to them because they are performed on water. No elaborate thermoregulatory responses except erection of feathers. Other behavioural characters are: (1) direct head-scratching; (2) resting, often on one leg, with head



Figs 1–14. Comfort movements of Anatidae (based on Grey Teal): (1a-c) Body-shake; (2) Wing-shake; (3a-c) Swimming-shake; (4) Head-shake; (5) Head-flick; (6) Tail-wag; (7) Foot-shake; (8a,b) Wing-shuffle and tail-fan; (9a) Wing-and-leg Stretch; (9b) Both-wing Stretch; (10) Foot-pecking; (11) Bill-cleaning; (12a-e) Head-dipping; (13a,b) Wing-thrashing (14a-f) Somersaulting.

turned back and bill inserted in scapulars on same side as lifted leg (Heinroth & Heinroth 1954), latter being characteristically stowed away in waterproof flank 'pocket'.

Breeding strictly seasonal in boreal, migratory species and populations; less so or opportunistic at warmer latitudes. For most wildfowl, censuses of breeding numbers extremely difficult. Although breeding habitat and nest-sites show considerable diversity, nests usually placed over water or on or near ground. Well hidden in vegetation or sometimes concealed in other dark places such as burrows and tree holes (or nest-boxes); some species also use old nests of other birds or cliff ledges. Often near water but some species may at times nest far away from it. Nests made only of vegetation, or other materials, within reach of sitting bird, using side-building method (see Harrison 1967). In spite of limited scope of this method materials are often collected from large area by repeated movements of this form. Nest usually lined with down plucked from female's belly (often cryptic and grown specially for this purpose). Value of down for insulation and for concealing nest examined for arctic geese by Thompson & Raveling (1988). Eggs, large, immaculate; surfaces greasy. Clutches often large. Regulation of clutch-size in Anatidae has been the subject of much investigation in n. hemisphere (Rohwer 1984, 1988), but has received little attention in s. Proximate (physiological and psychological [Lack 1974]) factors that may regulate clutch-size include availability of food, condition of birds, weather, age or experience of the breeding birds, ability to incubate, and, of the female, to acquire resources for production of eggs, time of breeding, hormonal levels and interactions between two or more of these (Bengston 1971; Johnsgard 1973; Braithwaite 1977; Ankney & MacInnes 1978; Drent & Daan 1980; Duncan 1987; Ankney & Afton 1988; Kingsford 1989; Briggs 1990). Ultimate (evolutionary [Lack 1974]) factors that may regulate clutch-size are availability of food, condition of birds, length of breeding season, weather, predation and viability of eggs, ability to incubate and rear brood, time of breeding, trade-offs between annual reproductive effort and residual reproductive value, and interactions between two or more of these (Williams 1966; Lack 1967; Ryder 1970; Johnsgard 1973; Braithwaite 1977; Pellis & Pellis 1982; Toft *et al.* 1984; Lessells 1986; Arnold *et al.* 1987; Briggs 1990). Both proximate and ultimate factors can act together to influence clutch-size. Eggs laid at intervals of 24 h in most species but longer in some. Clutch covered by down in most species during recess of adult. Some species may lay some or all of their eggs in nests of other anatids; such nest-parasitism may reach significant proportions in some populations, especially of pochards (*Aythya*) and stiff-tails (*Oxyura* and *Stictonetta* but not *Biziura*); only one species (Black-headed Duck *Heteronetta atricapilla*) obligate parasite. In some species, two or more females may lay at same site, at extreme producing 'dump' of eggs without incubating them. Most species single-brooded but many will re-nest if eggs lost. Multiple clutches more common in austral species. Except some species of Anserinae, incubation by female; starts with last egg; so hatching synchronic. No true brood-patches (Skutch 1976). Displaced eggs retrieved if within reach of sitting bird, using bill. Eggshells left in nest. Downy young typically led, but not carried, to water after leaving nest but see Sowls (1955) and Johnsgard & Kear (1968) for exceptional carrying of eggs, shells and young. Young feed themselves in all species except Musk Duck *Biziura lobata*, but some food provided indirectly in earlier stages by a few Anserinae and Anatinae (Kear 1970). Establish recognition of own species by special imprinting upon parent's calls and image during brief critical period; exceptionally (e.g. during experiments) may become imprinted on wrong species or even inanimate objects (Heinroth 1911; Lorenz 1935; Hess 1957; Boyd & Fabricius 1965; Schutz 1965). Incubation and fledgling periods vary, correlated with latitude at which breeding takes place; shorter in boreal migratory species nesting in high latitudes with short summer season.

Term '**waterfowl**' used in North America to describe the group is restricted by '**wildfowl**' in English with 'waterfowl' having wider meaning. Further special terminology (Hardy 1952) includes 'cob' and 'pen' to distinguish male from female in swans; male goose and male duck referred to as 'gander' and 'drake' respectively but female in both best called 'hen' to avoid confusion with group names. Young swan is a 'cygnet'; young goose a 'gosling' and young duck 'duckling'. 'Whiffling' is the term used to describe the deliberate loss of height in flight by alternate side-slipping and even rolling onto the back; a practice most characteristically adopted by many geese when descending rapidly. Collective names include 'herd' for flock of swans and 'gaggle' (on the ground) or 'skein' (flying) for geese. Less well known are 'dropping' for shelduck; 'spring' for a flight of teal and 'paddling' for duck on water. 'Flapper' is used to describe young wild duck. Some of these terms are elegant but are regrettably falling into disuse.

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Sub-family TADORNINAE sheldgeese, shelducks and steamer ducks

Fairly large, often semi-terrestrial, mostly goose-like wildfowl; most are moderately long-necked grazing birds with short toes and rather long tarsi inserted well forward. Tarsi scutellated in front. Intermediate in many characters between Anserinae and Anatinae. One aberrant group of solidly built, diving ducks, most flightless, considered allied to these birds rather than other ducks. Nineteen living species, predominantly in s. hemisphere, in six genera; two typical sheldgeese (*Cyanochen* from Abyssinia, *Chloephaga*; five species South America); two intermediate (*Neochen* from South America, *Alopochen* from Africa); shelducks (*Tadorna*) and Steamer ducks (*Tachyeres*; four species from South America). *Tadorna* consists of seven species in two groups (1) typical *Tadorna* (*T. tadorna* Palaearctic and *T. radjah* tropical se. Asia and Aust.); (2) *Casarca* (remaining five species from Africa, Palaearctic and A'asia).

Wings with bony, spur-like knob on metacarpal joint. Tails fairly long. Bills comparatively short and thick (sheldgeese), or depressed (*Alopochen*, shelducks) with distinct lamellae (shelducks generally) and turned slightly upwards (typical *Tadorna*). Steamer ducks have massive bills. Sexes differ in tracheal structure: that of females simple and goose-like, male with enlarged bullae; usually on left of trachea but in Shelduck *T. tadorna* enlarged on both sides; bullae much reduced in *Casarca* group. Calls differ between sexes. Sexes dimorphic in some *Chloephaga* and *Tadorna*; similar or nearly so in rest. Plumages of both male and female usually bright except *Tachyeres*; no discernible non-breeding plumage in most species. True eclipse plumages rare. Large metallic green speculum except in *Tachyeres* where secondaries white; lesser and median wing-coverts usually plain (often white). Juveniles like adults but colours duller. Downy young boldly patterned black-and-white but *Tachyeres* dull.

Largely cosmopolitan but most species subtropical and temperate s. hemisphere, and all absent from North America. Essentially birds of low or lower middle latitudes, or (as *Cyanochen* and some *Chloephaga*) of mountains in tropical zone. As a group, best characterized by continental warm or mild climatic requirements, acceptance of high altitudes; prefer inland waters or, at most, sheltered coastal waters, except for maritime Kelp Goose *Chloephaga hybrida* and Steamer ducks. *Cyanochen* and *Chloephaga* typically use grassland for terrestrial grazing; *Alopochen* and *Tadorna*, nest in holes and like unvegetated sand, silt, or mud margins, and are adaptable to semi-domestication. Orinoco Goose *Neochen jubatus*, atypically, a bird of dense tropical forests where (like *Alopochen*) it perches freely. In w. Palaearctic, *Alopochen* contrasts with *Tadorna* in being a partly tropical breeding species much more tolerant of forest country. When flightless during post-breeding moult, often frequent areas of open land or water where can observe and avoid terrestrial predators. Little detailed information of movements of sheldgeese and most other s. Tadorninae but many populations resident to greater or lesser extent. In *T. tadorna*, major moult-migration at end of breeding season to traditional moulting areas in w. Europe involves immatures and most adults, except those attending crèches of young, which moult *in situ*. Similar pattern known from *T. variegata*. Movements in most species mainly nocturnal and in flocks; do not hesitate to cross land-masses. Three species of *Tachyeres* flightless and fourth periodically so (Humphrey & Livezey 1982; Humphrey & Thompson 1981; Livezey & Humphrey 1986).

Some (e.g. *Chloephaga, Alopochen*) chiefly plant feeders, mainly by terrestrial grazing; some shelducks (e.g. *T. ferruginea, T. variegata* and *T. tadornoides*) omnivorous, feeding by grazing, dabbling and up-ending; others (e.g. *T. tadorna*) primarily animal feeders, mainly by dabbling in mud or shallow water, swimming with head submerged, and up-ending (cf. *Stictonetta* from our region). Steamer ducks dive using wings underwater and feed on marine animals. Often feed and otherwise associate in pairs and family parties or in flocks. **Pre-flight** signals consist mostly of lateral **Head-shaking** and repeated **Chin-lifting**. None in steamer ducks. Most species highly aggressive, specially steamer ducks. Maintain nesting territories at least while breeding, but territories of some *Tadorna* (e.g. *T. tadornoides*) mainly for feeding and meeting of pairs with nest-sites elsewhere, sometimes in groups. Long-term monogamous pair-bonds much as in Anserinae, though thought by Johnsgard (1965) to be less strong in shelducks than in sheldgeese. In some species, pair occupy territory together throughout year. Courtship often terrestrial; more elaborate than in Anserinae but less so than in Anatinae, with no true communal displays. Not fully studied in most species, especially in wild. Pair-formation in steamer ducks involves few rather hostile actions with loud vocalizations. In all other species, females play important or major role in pair-formation; mainly by use of characteristic aggressive **Inciting** display typical of most Anatidae but finding most complete expression in Tadorninae, where often directly functional in causing chosen male to attack others. Male pairing and other sexual displays include **Puffing**, **Bowing**, and **High-and-Erect**, often with wing-raising and strutting gait (Johnsgard 1965), but often difficult to distinguish from antagonistic behaviour; displays of different genera or even of different species-groups within *Tadorna* often divergent. In some sheldgeese (including intermediate *Alopochen*) and some *Tadorna*, mutual **Triumph Ceremony** much as in Anserinae. Displays more typical of Anatinae found in some species, mainly *Tadorna*; include unilateral and mutual **Bill-dip**, **Ceremonial-drinking**,

Mock-preening in form of **Preen-behind-Wing** display, and, in *T. tadorna*, vocal version of **Upward-shake** (male only). **Pursuit-flights** (see Anatinae) also reported from at least one species (*T. tadorna*). Copulation typically on water, sometimes in shallows or on land. Pre-copulatory behaviour resembles Anserinae with mutual **Head-dipping**. Post-copulatory behaviour distinctive; includes **High-and-erect** display by male, usually with wing lifted on side farthest from female. Voices often loud and sexually well differentiated. Females of all species with low-pitched rasping calls like those of some Anatinae (Johnsgard 1968). Males of most sheldgeese have whistling calls as also those of *T. tadorna* and *T. radjah*; in *Casarca* group of shelducks, however, voice of males loud and honking, while that of male *Alopochen* different again. Often call in flight and on water, land, or perch. In most species, male's vocal response to **Inciting** call of female of two types: aggressive (to other males), friendly (to female); see Johnsgard (1965).

Seasonal breeders. Nests on ground in open (*Chloephaga* and *Tachyeres*); in burrows and holes in ground, trees, or buildings (*Tadorna*); on ground in thick cover, cliff ledges, or in holes (*Alopochen*). Old nests of other species also sometimes used (*Alopochen*, *T. ferruginea*). Sites sometimes far from water. Usually solitary nesters but sometimes close in hole-nesting *T. tadorna*. Amount of nesting material varies, from mound of vegetation on ground to little or nothing in holes; lined with down. Building by female only. Eggs rounded, creamy-white and smooth. Clutches 3–12, averaging larger (8.4) in hole-nesting species than in open nesters (6.1) (Lack 1968). Multiple laying by females in one nest common in some species (e.g. *T. tadorna*). Replacement clutches produced after early loss of eggs. Eggs laid at intervals of 24 h. Incubated by female only, leaves nest once or more often each day when usually joins male; latter may stand guard in many species. Incubation periods 28–30 days (Kear 1970), with no significant difference between hole-nesters and others (Lack 1968). Young attended by both parents but brooded by female only. Both parents aggressively defend young at times in most or all species. **Distraction** display by female or both sexes, in form of 'injury-feigning', reported in *Chloephaga* and *Tadorna*, but evidently lacking in *Neochen* and *Alopochen* (Hebard 1960). Other anti-predator reactions by parents include 'tolling' (Sowls 1955 for dabbling ducks) i.e. moving or flying conspicuously, often while calling, away from or near predator. In most species, young not independent until fledging or after, remaining with parents for up to 6 months. In *T. tadorna*, broods may amalgamate into crèches, some parents then deserting own young. Mature usually at 2 years.

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Tadorna tadornoides Australian Shelduck

COLOUR PLATE FACING PAGE 1228

Anas tadornoides Jardine and Selby, 1828, *Ills Orn.* 4: Pl. 62 and text — New South Wales.

The scientific names are modern Latinizations of the French *tadorne*, first published by Belon (1555) (Newton & Gadow, *Dict. Birds*, 1896).

OTHER ENGLISH NAMES Chestnut-breasted, Chestnut-coloured, Chestnut or Mountain Shelduck or Sheldrake, Mountain Duck, Grunter.

Shelduck is claimed to be derived from 'sheld' (parti-coloured) or the old Norsk word 'skjoldi' (patch, piebald, with a secondary meaning of 'shield'); if derived from the last, then referring to the shield-like band across the breast of these birds. The traditional term **Mountain** was originally applied by Reichenbach (*Bergente* aus New Holland), *bergente* being the German name for the European Shelduck *T. tadorna*, which commonly nests in sand-dunes, and the meaning of 'berg' (mountain) being extended colloquially to 'dunes'. The retention of **Mountain Duck** for the Australian species is inappropriate, especially if **Shelduck** is not used. Variations based on **Chestnut** are not definitive (cf. *T. tadorna*). **Australian** is best for this endemic species.

MONOTYPIC

FIELD IDENTIFICATION Length male 59–72 cm, female 56–58 cm; wingspan male 96–132 cm, female 94–116 cm; weight 1.3–1.6 kg. Large-bodied, boldly coloured shelduck with small black head, black bill and conspicuous orange breast and white forewing. Sexes similar but females have white ring round eye and base of bill. Immatures duller, flecked white between bill and eye. Eclipse plumage appears identical in field.

DESCRIPTION ADULT MALE Head and upper neck, black or black-brown, tinged iridescent green or blue; occasionally, white ring round base of bill; white collar round lower neck; mantle and breast, cinnamon-brown forming broad band round upper body; scapulars and back, black with fine buff vermiculations; rump to upper tail, black. Upper wing-coverts (except primary coverts), white, boldly contrasting with black primaries and primary coverts and dark-brown secondaries with large glossy green speculum; tertials, rich chestnut; when standing or on water, white upper wing-coverts visible against black of back and lower breast. Lower breast and abdomen, dusky brown with fine light-brown vermiculations; undertail, black. All under wing-coverts, white, contrasting with black remiges forming broad dark trailing-edge to predominantly white underwing. Bill, black. Iris, dark brown. Legs and feet, dark grey. ADULT MALE ECLIPSE. Not recognizable in field. Similar to adult female but breast, yellow-brown, neck-ring less defined. ADULT FEMALE. Similar pattern to male but breast and mantle, more chestnut and with obvious white ring round eye and base of bill; these white patches meeting in some individuals. Female noticeably smaller than male when pair together. DUCKLING. Forehead and sides of head, white contrasting with brown crown and hindneck. Upperparts, dark brown, with boldly defined white stripes from wing-pads to sides of tail; wing-pad, dark brown with broad white band. Underparts, white. Bill, legs and feet, blue-grey. Iris, brown. IMMATURE. Like adult, but duller; flecked white between bill and eye; back of head and neck, flecked brown; lacks white collar at base of neck; mantle and breast, light brown. White wing-coverts flecked or margined with grey or black; underside of secondaries may be tipped white. Iris, brown. Legs and feet, blue-grey.

SIMILAR SPECIES In Aust., generally unmistakeable on ground or on water: large stocky small-headed duck with erect stance and legs set well forward; white collar and chestnut breast contrast with dark body and head, pattern found in no other Aust. waterfowl and visible in most conditions. White eye-ring and bill-base of female can usually be seen even at longe range and are distinctive. **Maned Duck** *Chenonetta jubata* is much smaller, with even more erect stance and relatively longer neck; plumage very different and should not be confused unless viewing conditions poor. **Radjah Shelduck** *T. radjah* also considerably smaller, though with similar stance; white head and underparts distinctive and

can be seen at great distances. On water, Australian Shelduck floats very high and with large size and plumage should not be confused; Maned Duck and Radjah Shelduck also float high but distinguished by above characters. In flight, pattern of upperwing of large white shoulder patch (formed by white upper wing-coverts, except primary coverts) boldly contrasting with dark remiges with glossy green speculum, unmistakeable; pattern shared only with Magpie Goose *Anseranas semipalmata* (which is larger with distinctive pied plumage) and Radjah Shelduck (which has white head and underparts and is much smaller). From below, white under wing-coverts contrast strongly with dark remiges and body; pattern also found in Freckled Duck *Stictonetta naevosa* (which has long neck, peaked head and less obvious contrast of colour) and Pacific Black Duck (which is pale throated with obvious contrasting facial pattern). In NZ, vagrant Australian Shelduck has similar size, shape and posture with endemic **Paradise Shelduck** *T. variegata* (*q.v.*) and with which could be confused. DUCKLINGS. Most other ducklings in Aust. with bold brown and white markings have large white supercilium (whistling-ducks, pygmy-geese, Cape Barren Goose *Cereopsis novaehollandiae*) except Radjah Shelduck, which has white spot on rump rather than white stripe.

Seen in pairs, family groups or, out of breeding season, flocks of 1000 or more on deep fresh-waters or large saline lakes, billabongs, lagoons, estuaries, sandspits, islands; also farm dams, short grasslands, pastures, crops, irrigation areas, open woodlands. Occasionally on sea. By day rest in loose groups on muddy margins or far out on water. Alert, difficult to approach. Feed in evening and early mornings by grazing at water margins or by up-ending in water. Walk fast and strongly; stand with erect posture; rarely perch in trees. On water, swim buoyantly and well, only diving to escape predators during moult when flightless. Flocks rise very quickly and noisily when disturbed. Flight strong, direct; flocks often form Vs or long skeins, unlike all other Aust. waterfowl. Vocal in flight; male deep loud honking; female higher-pitched *ang-gankr*, strident *ow ow ow*.

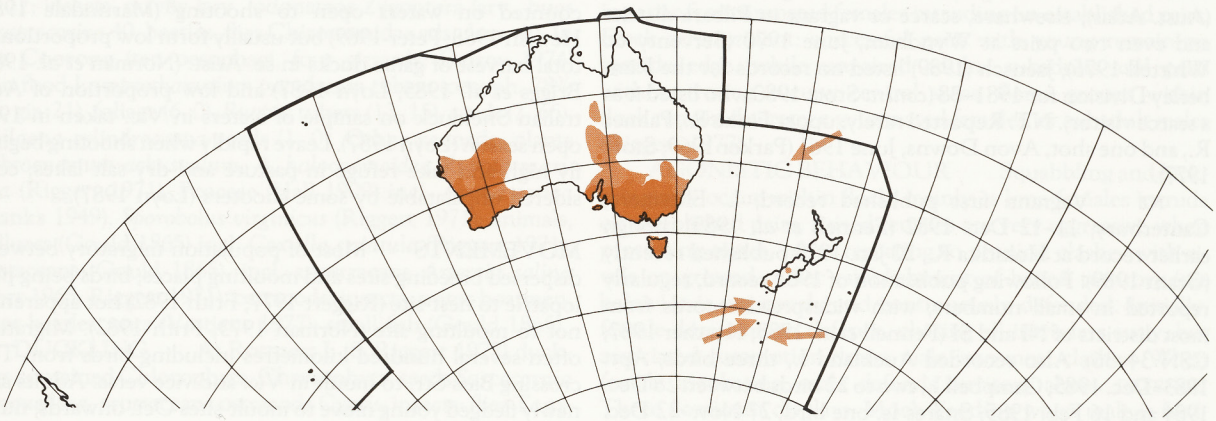
HABITAT In temperate zone, mostly S of 30°S in e. Aust. but to 25°S in WA. Found on grasslands and croplands, terrestrial wetlands, estuarine waters, and occasionally wooded grasslands. Equally at home in terrestrial and aquatic habitats, grazing on dry-land plants or aquatic plants in shallow water or on mudflats or shores. Seek open aspect: flat or undulating terrain, at most lightly-timbered; large wetlands with expanses of open water, mudflats or wide beaches; or small wetlands where emergent vegetation short and sparse. Particularly favour large lakes, large shallow swamps on alluvial plains, and open parts of deep freshwater swamps (Corrick & Norman 1980; Fjeldså 1985); greatest densities on waters near rich dry-land feeding grounds with short grass, pasture, grain or seed crops (Vic. Atlas). Tolerate high salinity (Delroy 1974; Crawford 1975; Corrick 1982), but need freshwater seepages or wetlands for drinking (Riggert 1977); common on estuarine mudflats, salt lakes, coastal lagoons, saltworks, saltpans (Morgan 1954; Delroy 1974; Corrick & Norman 1980; Jaensch *et al.* 1988). Other wetlands used include tidal and inland rivers, river pools, billabongs, fresh meadows, shallow swamps, saltmarsh or rush-dominated swamps, sewage ponds, sheltered inshore waters, and large dams (Corrick & Norman 1980; Corrick 1982; Frith 1982; Fjeldså 1985; Congreve & Congreve 1985; Hewish 1988). In arid zone, move onto salt lakes or claypans after rain and floods (Ridpath *et al.* 1979; Frith 1982).

Breed throughout range; usually nest in hollow trees, but in places, in limestone crevices on island shores and beneath shrubs in saltmarsh (R.J. Loyn). Brood territory may be several kilometres from nest-site; contains small wetland or part of lakeshore, either freshwater or saline with fresh seepage, providing fresh water for ducklings (Riggert 1977). Gather for moult in summer on large permanent waterbodies with open aspect, feeding grounds close to water for safety, and to islands, sandbars or wide beaches for loafing. Moulting flocks noted on fresh and saline lakes, reservoirs, sewage ponds, estuaries (Jenkins 1976; Riggert 1977; Hewish 1988; Jaensch *et al.* 1988). Unlike other Aust. ducks, fly in formation at great heights. Swim well, but rarely dive; on water, feeding only where bottom can be reached from surface.

Population increases in some areas attributed to clearing and conversion to pasture and cropland (Masters & Milhinch 1974). Prefer saline swamps and lakes little affected by drainage (Riggert 1966; Corrick & Norman 1980; Corrick 1981, 1982); unlike many other species of waterbird, use and perhaps prefer salt-affected wetlands (Masters & Milhinch 1974). Construction of freshwater impoundments may have removed limitations on breeding in some places; breeding territories often established round farm dams (Riggert 1977).

DISTRIBUTION AND POPULATION Endemic to Aust., vagrant to Norfolk I. and NZ.

AUST. SE and SW, spreading N in WA, vagrant or casual breeder elsewhere. **Qld**. Scattered records; pair, L. Moondarra, 12–20 Mar. 1966 (Carruthers 1966); one,



L. Machaltie (Storr 1973); in far W, recorded several times between Glenormiston and Birdsville (Aust. Atlas) and near Bedourie, counts of 20, 243, 224, 15 obtained during aerial surveys, Oct. 1984 and 1986–88 respectively, with smaller numbers just N of NSW border in 1984 (E and W of Goondiwindi) and 1988 (SW of Eulo) (Braithwaite *et al.* 1985b, 1987; Kingsford *et al.* 1988, 1989). **NSW**. Scarce or vagrant N of line roughly from L. Bathurst, upper Lachlan R., Ivanhoe and Broken Hill; recorded near Grafton, Newcastle, on central coast, and Macquarie Marshes (Morris *et al.* 1981; Aust. Atlas). Widespread in s. parts of State. **Vic**. Widespread throughout except in forested and upland areas in E and cleared mallee country in W (Vic. Atlas). **Tas**. Widespread, mostly in E. **SA**. Widespread in se. areas, S of Murray R. and westward to Spencer Gulf; less common or vagrant in e. and ne. areas round L. Eyre and Cooper Ck (Parker *et al.* 1985; Aust. Atlas). **WA**. Widespread in sw. corner, S of Gascoyne R. and W of line roughly from L. Carnegie to Israelite Bay (Aust. Atlas); elsewhere, scarce or vagrant in Pilbara district and even two pairs at Wyndham, June 1970 (Serventy & Whittell 1976); Jaensch (1989) listed no records for the Kimberley Division for 1981–88 (*contra* Storr 1980 who listed it as a scarce visitor). **NT**. Reported rarely: upper Finke R., Palmer R., and one shot, Avon Downs, June 1961 (Parker 1969; Storr 1977).

NZ Vagrant: first published record, L. Ellesmere, Canterbury, 11–12 Dec. 1982 (Fennell *et al.* 1983) though earlier record at Hokitika R., 20 Jan. 1973 published recently (Grant 1989). Following publication of 1982 record, regularly reported in small numbers, with widespread records from most districts of NI and SI (Fennell *et al.* 1983; Heather 1987; CSN 34–36). Also recorded Auckland I., three birds, Apr. 1983–Dec. 1985; Campbell I., two to 22 birds between 28 Dec. 1984 and 16 Feb. 1985; Snares Is, one bird, 27 Nov.–22 Dec. 1984 (Heather 1987).

NORFOLK I. Vagrant: 1, 29 Nov. 1984 to 12 Dec. 1985 (Moore 1985; Hermes *et al.* 1986).

POPULATION Annual indices of abundance from aerial survey of wetlands in *c.* 12% of land area of e. Aust., 1983–88 were 34,600; 108,507; 16,721; 4664; 4599; 4145 respectively (Braithwaite *et al.* 1985a,b, 1986, 1987; Kingsford *et al.* 1988, 1989). Counts in Vic. in summer surveys, 1987–89, were respectively: 63,223 on 332 wetlands; 91,558 on 472 wetlands; 87,905 on 626 wetlands; making up *c.* 30% of all ducks counted in the State (Martindale 1988; Hewish 1988; Peter 1989). Counts in sw. Aust., 1986–88, respectively: 19,395 on 872 wetlands; 65 552 on 1201 wetlands; 48 802 on 1398 wetlands (Jaensch & Vervest 1988a,b). At Narrung, se. SA, *c.* 15,000, Mar. 1983 (Parker *et al.* 1985).

Southern distribution exposes Australian Shelduck to main concentration of shooters. Pre-season surveys in Vic. indicate that exposure to shooting high; 74–78% of birds counted on waters open to shooting (Martindale 1988; Hewish 1988; Peter 1989) but usually form low proportion of total harvest of game ducks in se. Aust. (Norman *et al.* 1984; Briggs *et al.* 1985; Loyn 1987) and low proportion of Australian Shelduck on sample of waters in Vic. taken in 1987 open season (Loyn 1987). Leave rapidly when shooting begins, fly high and take refuge in pasture and dry salt lakes; considered unpalatable by some shooters (Loyn 1987).

MOVEMENTS Most of population migratory between dispersed breeding sites and moulting places; birds being philopatric to nest-site (Riggert 1977; Frith 1982) but apparently not to moulting site (Norman 1973; Frith 1982). Migration often several hundred kilometres including birds from Tas. crossing Bass Str. to moult in Vic. and vice versa. Adults and newly fledged young move to moult-sites Oct. onwards, num-

bers building up continually until Feb. at some sites, at others reaching a peak early summer then declining as habitat becomes unsuitable. After Feb., number at all sites usually declines, returning to breeding season levels by May (Lamm 1965; Frith 1982). In dry years movement may be more extensive; during drought in 1982–83 exceptional numbers reached NZ (Heather 1987). First recorded NZ, 11 Dec. 1982 (Fennell *et al.* 1983) with numbers increasing through early 1983 with records from Auckland Is. Birds appeared to wander through NZ, settling on ponds briefly before disappearing. Few seen late 1983 and throughout 1984 but 22 arrived Campbell I., Jan. 1985 with some staying on main islands and one breeding record, which suggests successful colonization, at least temporarily (see Distribution).

BANDING Of birds banded L. George, se. NSW, where moulting flocks gather Oct.–May, 99% recovered outside State with 78% of 131 recoveries 300–700 km away, possibly because, shooting being prohibited near banding area, local recoveries few. Distances of >400 km were sometimes covered in 3 days after banding, some birds apparently travelling together in pairs (McKean & Braithwaite 1976). Movement within Vic. also extensive with 47.7% birds banded at all sites recovered >100 km away, 8.2% <400 km, most recoveries being concentrated in area of Gippsland Ls, central Murray R., w. Vic. lakes and Murray R. mouth, SA; six recovered Tas.; few travelled N of Murray R. Few birds banded in moulting flocks in Vic. recovered in same flock in subsequent years; some banded while moulting in w. Vic. recovered while moulting next year in Gippsland (Norman 1973). Similar results obtained for birds banded in se. SA (Norman 1971). In sw. Aust. migrate from Rottnest I. Oct. onwards to moulting sites on adjacent mainland, with some adults and immatures returning Jan. onwards (Riggert 1977).

FOOD Poorly known but appears to be a diverse range of vegetation and invertebrates. BEHAVIOUR. Employ many feeding techniques such as grazing, surface-dabbling, upending in shallow water, paddling, sifting biotic ooze, combing shorelines and other opportunistic behaviour. Able to drink highly saline water but ducklings need fresh water for 6 days after hatching and sudden switching to saltwater causes intoxication (Riggert 1977).

ADULT In **se. Aust.** (30 stomachs; Frith 1982) plants 100% freq., animals 90; plants incl. *Medicago*, *Trifolium* seeds & leaves 60, *Vallisneria*, *Potamogeton*, Cyperaceae, *Cynodon* 17, other Poaceae, *Azolla* 10, Chlorophyta 50, *Chara* 30; animals: molluscs, mussels; crustaceans, cladocerans 17; insects, mayfly larv., odonatans Zygoptera larv., bugs *Agraptocorixa* 40, beetles, flies Chironomidae ads., larv. 40. In **The Coorong** (ten oesophagi, four gizzards; Delroy 1974) main food *Lamprothamnium papulosum* tubers (oesoph. 78% vol., giz. 21), foliage (6, 0), *Ruppia* tubers (13, 15), seeds (2, 65), *Lepilaena cylindrocarpa* seeds (1, 0). **Other records**: plants *Arthrocnemum arbusculum*, *A. halocnemoides*, *Ruppia maritima* (Riggert 1971), Poaceae (Hall 1909) incl. *Avena sativa* (Shanks 1949), *Sporobolus virginicus* (Riggert 1971); animals, molluscs (Gould 1865) incl. *Coxiella striatula* (Riggert 1971); crustaceans (Gould 1865), incl. anostracans *Artemia salina* (Storr 1965; Riggert 1971), ostracods; insects, water boatmen, water beetles, ants (Vestjens 1977); small fish (Gould 1865).

DUCKLING At Rottnest I. (8; Riggert 1977) ducklings contained Chlorophyta, Chrysophyta, seeds *Sarcocornia quinqueflora*, crustaceans ostracods *Cypris*, insects: flies *Tanytarsus barbitarsus*, *Ephydra* larv., pupae.

SOCIAL ORGANIZATION During breeding season, solitary or in pairs. Outside breeding season, in flocks that become specially large during moult (Johnsgard 1978), composed of successful pairs with young, unpaired adults, subadults and pairs without young (Riggert 1977).

BONDS Monogamous. Although some birds create permanent pair-bonds, change of partners observed for all groups. Birds that fail to breed dissolve bonds, and bonds formed by juveniles rarely last for more than 3 months. First pairing may occur at 5–6 months (Riggert 1977), but birds must be at least 22 months old before they can breed (Frith 1982). Sex ratio of subadults in flocks on Rottnest I., WA, biased to females (Riggert 1977).

PARENTAL CARE Only female incubates, while male remains at brood territory. Both parents lead ducklings from nest-site to brood territory. Parents constantly accompany ducklings on territory during first 6 weeks.

BREEDING DISPERSION Nest solitarily, with closest distance between nests 10 m. Pairs disperse from non-breeding flocks (congregations) to breeding sites; establish well-defined territories in which broods raised; may be close to nest-site or several kilometres away, but must contain fresh water. Area defended determined by proximity of seepages (constant harassment from other pairs restricts size of territory if water sources close together) and irregularity of surroundings. Size of territory ranges from 200 m along shoreline or 1 ha wetland (Frith 1982; Riggert 1977) to 50 m of shoreline and 50 m over water. Usual size is 100 m of shoreline and 50 m out over water (Riggert 1977). Boundary lines continually defended with birds intolerant of intruders. Initially, female dominant in repulsion of trespassers, but commotion arising from defence encourages male to do most fighting. Once incubation begins, male defends territory alone. During early stages of incubation, male accompanies female from territory to nest-site each morning. Male rarely remains at nest-site but returns to territory to defend it (Riggert 1977). Establishment of brood territories is not a prerequisite to copulatory behaviour (Riggert 1977).

ROOSTING Outside breeding season, birds congregate to loaf during heat of day. While breeding, birds roost on brood territory at night (Riggert 1977).

SOCIAL BEHAVIOUR Occur in flocks outside breeding season forming major congregations during moult. General pattern is of peaceful coexistence but, as juveniles join flocks, pair-formation displays begin. Squabbling and bickering arise from unmated females intruding on established pairs. Flock arrangement: successful pairs with young remain on outside edge, while unpaired adults, subadults and pairs without young occupy central areas. Some groups within flock remain discrete, e.g. unmated females, or subadult males (Riggert 1977).

AGONISTIC BEHAVIOUR Squabbling and bickering may occur within flock, mainly as lone females intrude on established pairs; paired females are very aggressive when protecting mates, often resorting to physical clashes with rivals on ground. After establishment of brood territory (see below) it is vigorously and continuously defended. Initially, female dominant in defence, chasing all intruders away, but associated commotion draws male into most clashes. When female incubating, male defends territory alone. DEFENCE. Three dominant displays: **Mock Feeding** when male is feed-

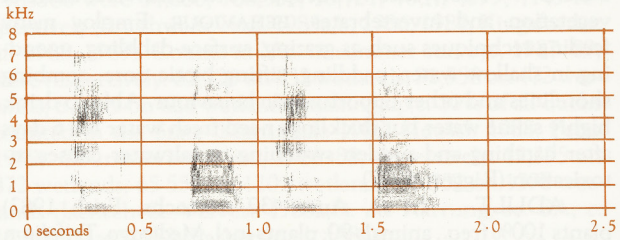
ing normally and intruder enters territory. Male goes through motions of feeding but no food taken and all attention focused on intruder; resumes feeding only after intruder has departed. **Standing Alert**: male stands in elevated position within territory, scanning surroundings. When conspecifics fly nearby, male begins lateral head throwing and utters short grunting whistles, presumably to indicate that area occupied. **Direct Chase**: when intruders enter territory, male physically (often violently) clashes with them. When female disturbed while incubating, produces low hiss that becomes louder with persistent disturbance. Parents quickly drive away lone females trying to acquire ducklings. Where sub-adults have paired, territories are aggressively defended, but rarely maintained against intruding adults (Riggert 1977).

SEXUAL BEHAVIOUR Similar to displays of other shelducks *Tadorna* spp (Johnsgard 1978). Initial stages of pairing involve **Mock Preening**, **Preening-behind-wing** and **Chasing**. Other displays performed on water, with female swimming a short distance from shore, then **Head-dipping** and **Bathing**. Unpaired females swim towards males and perform **Water-thrashing Displays**: head and neck outstretched and moved from side to side, making lateral pointing movements with much calling. As intensity of display increases, female attracts male by duck-diving below water surface for few seconds, emerging to give mock chase after male. Display repeated several times until male begins to dive and chase female in similar fashion. This pattern repeated by female, to one or more males until one responds to her **Inciting**; may take up to 30 min. If male does not respond, female may remain nearby and continue displays later, or more commonly, move to another male. When male responds, female manoeuvres him away from group by continuous Inciting. This is fundamental pair-bond behaviour, which females rely on to choose mate. Some juvenile females do this to one another, often with great effect: bond between them may remain until next pairing season. When unpaired females pursue paired males, their mates may attack unpaired female, or incite male to drive off lone bird. Once gone, male returns to mate, and performs sexual displays: **Mock Preening**, **Lateral Head-shaking** or **Chin-lifting** in the high and erect posture. However, some unpaired females remain in company of paired birds for up to four months (Riggert 1977). Two types of AERIAL DISPLAYS: (1) Flights by unpaired birds, resulting from aggressive display or inciting by one or more unmated females to lone male, who flies away, followed by female(s). Male pursued by females who try to force each other away from nearest position, while attempting to stay close to male for as long as possible. Display continues until male attracted to one female, who then drives off all other females. When male responds to female, pair land, with female immediately beginning to incite. (2) Paired birds avoid pursuits by unpaired female. May start on ground or in flight, wherever unmated female intercepts pair; unpaired female tries to separate mated pair by flying between them and maintaining position next to male for as long as possible. Paired female may grab tail of other female, forcing change in direction in order to gain favourable position and occasionally causing injury as birds collide with obstacles. Pair may land and attack unpaired female on ground (Riggert 1977). PRE-COPULATORY BEHAVIOUR. Female begins display by preening and flashing speculum, combined with Water-thrashing as male approaches; male begins Water-thrashing in similar manner. When male approaches, female swims in small circles with head and neck outstretched over water, circling male several times, mockingly grabbing at male's breast and lateral feathers. Female repeats performance by swimming 7–10 m away and calling male to her. Number of mock attacks increases until female swims round male with head down and bill half submerged in water, and body lowered and flattened causing bow-wave. Female then submerges beneath male to simulate position of copulation. Male responds by alternately dipping head and calling in erect posture. Display often performed several times before copulation, but full display does not occur with every coitus (Riggert 1977; Johnsgard 1978). Occurs in water of swimming depth. POST-COPULATORY BEHAVIOUR. Following treading, both birds rise on water, and raise wings on opposite side to partner's, with female often calling (Johnsgard 1978). Weather affects duration of displays: on cool overcast days displaying may continue all day; on warm sunny days activity is sharply reduced (Riggert 1977).

RELATIONS WITHIN FAMILY GROUP Incubation by female only. In territory, both parents attend young, and ducklings feed constantly with parents. Young defended by parents until able to fly at about 70 days old. Broods remain within territory for about 6 weeks, but as young grow, parents become less attentive and allow broods to amalgamate. When young can fly, abandoned by parents (see Breeding for more detail).

VOICE Most information from Riggert (1977), Frith (1982) and Wooller *et al.* (1984). Generally very noisy, particularly in flight. Voice generally loud and often harsh, honking or quacking. Sexes differ; call of female more highly pitched than male. Variation occurs between calls of individuals of same sex and these variations in adult calls may allow young to distinguish parents in darkness or when birds intermingle (Wooller *et al.* 1984).

ADULT MALE Predominant call is **Contact Call**, a low-pitched honk (second and fourth calls of sonagram A),



A J. Hutchinson; Wilga, WA, June 1977; P11

covering frequency range of 0–2 kHz, and lasting approximately 0.25 s (Frith 1982). Tone of honk develops wavering nature during courtship and threat displays, and rapidly produced in two syllables, spaced *c.* 1 s apart; first 0.25-s duration, second 0.10-s (Frith 1982). When defending brood territory, utter short grunting whistles accompanied by Lateral Head-throwing.

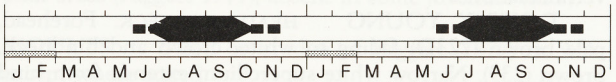
ADULT FEMALE More highly pitched honk than male, with frequency range of 0–9 kHz (first and third calls of sonagram A); rendered *ang-gankr* or *ow ow ow*. Calls of similar length, or slightly longer than male (Frith 1982; Wooller *et al.* 1984). May be equivalent to short (<0.5 s) buzzing calls heard from females on ground and in flight (J. Starks). When disturbed while incubating, utter low hissing sound that becomes louder if threat continues (Riggert 1977).

YOUNG Frequent *cheeps* emitted soon after hatching, but after few days only uttered when distressed. Cheeping

superseded by soft throated quack after 18–23 days; change to adult voice occurs gradually, but at no specific age. Sexing by voice possible at 4.5–5 months (Riggert 1977).

BREEDING Reasonably well known from studies on Rottnest I., WA by Riggert (1977) and Storr (1965). Information supplied by J.M. Peter. Breed solitarily in holes in trees, cliffs or ground.

SEASON Probably regular: mid-winter and spring (Frith 1982). Qld: (single record) 1 Aug. (Boles & Mueller 1979); sw. NSW, July–Nov. in good seasons (Hobbs 1961); Vic., Aug.–Oct. (Aust. NRS); Tas., Aug.–Oct. (Littler 1910); SA, no data; sw. WA, June–Sept. (Riggert 1977; Storr 1965).



SITE Usually hole in living or dead tree, especially broken-off limb or hollow spout, but occasionally hollow stump; in woodland, grassland or marshy areas or bordering crops (North; Campbell; Aust. NRS; Frith 1982). May be far (*c.* 9.5 km; Riggert 1977) from, or standing in, water (North; Frith 1982). On offshore islands, e.g. Rottnest I., WA, may nest in crevices and caves and holes in limestone cliffs (Riggert 1977; Storr 1965). Rarely, in rabbit burrows on treeless plains (Mathews 1910–27; Whitlock 1910; Sharland 1958; Hobbs 1961). Recorded nesting on ground among grass or on bare ground under *Polygonum* or *Xanthorrea* bushes (North; Campbell; Mathews 1910–27). Nest in hollow tree may be at ground level (Campbell). Entrance to holes 2–30 m high; mean diameter 45 x 23 cm; internal diameter 45 x 30 cm (Frith 1982; Aust. NRS). In limestone crevices, nest-bowl *c.* 45–55 cm in diameter and 7–8 cm deep (Riggert 1977). On Rottnest I., experienced birds choose sites protected from weather. Nests often difficult to find, especially where terrain inhospitable; good sites used repeatedly; closest distance between nests *c.* 10 m (North; Riggert 1977; Frith 1982). Competes with other species for nesting hollows: Galah *Cacatua roseicapilla*, Red-tailed Black-Cockatoo *Calyptorhynchus magnificus*, Long-billed Corella *Cacatua tenuirostris*, Barn Owl *Tyto alba*, Australian Kestrel *Falco cenchroides*, black-cockatoo *Calyptorhynchus* spp; for holes in limestone with Wedge-tailed Shearwaters *Puffinus pacificus* (Riggert 1977). Observed sharing nesting hollow with Red-tailed Black-Cockatoo (Saunders 1976). Pair selects site together, flying into trees and both looking into hollows (Frith 1982). On Rottnest I., male stationed on vantage point to detect intruders while female searches for site. Female walks from hole to hole, investigating, and may walk for up to 1 km doing so, and explore up to 46 holes. Experienced birds spend less time searching for nest-sites than inexperienced birds (Riggert 1977).

NEST, MATERIALS Nil, except natural debris in tree holes, lined with down (Aust. NRS; Campbell). In crevices in limestone, shallow bowl scraped into sand (Riggert 1977) and lined with down (Storr 1965). Unlike other *Tadorna* spp, no second entrances or escape routes (Riggert 1977). North, probably erroneously, claimed that nests on ground made of grass, sticks and debris. On Rottnest I., female cleans out suitable hole or hollow and prepares nest by scooping out shallow scrape in sand. Lining (of down) plucked from own breast as clutch nears completion (Campbell; Mathews 1910–27; Riggert 1977).

EGGS Oval or rounded; fine-grained, lustrous and glossy; pale creamy white to buffy cream. Often stained light brown (Campbell; North; Riggert 1977).

MEASUREMENTS:

Rottnest I. and mainland WA: 68.8 (2.2; 147) x 48.3 ± 1.0 (Riggert 1977)

69.31 (62.23–73.15; 26 from three clutches) x 49.59 (46.48–51.31) (Campbell; North).

WEIGHT: 88.3 (5.1; 22) (Riggert 1977).

THICKNESS OF SHELL: 0.33 mm; VOLUME: 79.8 ml (3.1; 147); SPECIFIC GRAVITY: 1.07 (n=22) (Riggert 1977).

CLUTCH-SIZE Generally reported as 8–14 eggs, but up to 25 and 50 eggs in one nest must result from dump-laying (Serventy & Whittell 1976). Mean clutch-size from 18 layings, 9.33 (C/4 x 1, C/5 x 2, C/7 x 1, C/8 x 4, C/9 x 2, C/10 x 5, C/13 x 1, C/14 x 1, C/19 x 1) (Frith 1982).

LAYING Usually one egg per day. Claim of 3-day interval (Frith 1982) surely erroneous. During laying period, female only present at nest when laying. At onset of laying, female may spend up to 40 min at nest but, as laying continues, time spent decreased; once recorded entering nest, laying egg and departing within 8 min. Repeated disturbance at nest may prolong laying period (Riggert 1977). Lay during daylight hours.

INCUBATION Only female incubates, male defends brood territory. At start of incubation, male accompanies female from territory to nest before returning to territory. During first 2 weeks of incubation, female remains on nest between mid-morning and late afternoon, and between sunset and *c.* 30 min before sunrise. On colder days, longer periods spent on nest. Every morning and afternoon some time spent on territory feeding and drinking, having covered eggs with down (Riggert 1977). INCUBATION PERIOD: 30–33 days in captivity (Delacour 1954–64).

YOUNG At hatching, downy; essentially brown above and white below with white patches on side of back and rump and along wing in pattern typical of all young shelducks (details in Plumages). When duckling emerges from egg, it is exhausted and wet with amniotic fluid. First movements are to preen down; 12 h after hatching can stand erect (Riggert 1977). At 2 days old, young led by parents from nest to brood territory, usually before sunrise (Riggert 1977) but sometimes during daylight (Harrop 1981). When called by parents, ducklings leap from nest to water or ground below, flapping wings and paddling legs as they drop (Campbell; North; Harrop 1981). Claims that adults carry young in bill to ground unacceptable (Mathews 1910–27; Campbell). Ducklings led overland to brood territory, occasionally several kilometres away (Riggert 1977; Frith 1982). Both parents attend young in brood territory (Storr 1965) with ducklings constantly feeding with parents (Sharland 1958; Riggert 1977). When brood threatened, young dive to escape detection, while parents flush in different direction from that taken by young (Sutton 1931a,b; Boles & Mueller 1979). When threatened on land, parents feign injury (Maclaine 1908; Harrop 1981) or directly pursue antagonist (Riggert 1977), while young conceal themselves and remain still (Belcher 1914). Parents defend brood until ducklings able to fly (Riggert 1977). Broods remain on territory for 6 weeks but, as ducklings grow, parents become less attentive, allowing broods to amalgamate. These mixed broods only attended by one pair of adults (Storr 1965). Soon before or soon after they can fly, young deserted by parents (Storr 1965). Can fly at 70 days (Riggert 1977). Pair when subadult, but do not breed until 22 months old (Frith 1982).

SUCCESS Many ducklings died between hatching and arrival at brood territories, but, having arrived, 60% survived to flapper-stage (Storr 1965). Riggert (1977) found that most ducklings died during first week at brood territory, with no decreasing mortality between then and flapper-stage. Australian Ravens *Corvus coronoides*, Silver Gulls *Larus novaehollandiae* prey on eggs (Riggert 1977). During journey from nest to brood territory, some ducklings are lost and die from exhaustion or exposure; others taken by feral cats and possibly foxes (Riggert 1977; Storr 1965; King 1967). Cormorants observed to swallow submerged ducklings (Storr 1965). In brood territories, ducklings can die from exposure, exhaustion or drowning after winter storms (Riggert 1977). On Rottnest I., each pair reared 4–5 young per season (Storr 1965).

PLUMAGES

ADULT MALE BREEDING Definitive alternate. Attained at 18–19 months. Age of first breeding in wild unknown, but probably greater than 21 months (Riggert 1977). Plumage fades mid-Sept.–Oct., just before pre-basic moult. HEAD AND NECK. Black-brown to black (89) with slight dark-blue or dark-green iridescence on crown and nape. Lores, chin and throat, dark brown (119A) to brown (119B). A few birds have some white feathering at base of bill. White collar, *c.* 15 mm wide, separates base of neck from mantle and breast. UPPERPARTS. Mantle mostly yellowish chestnut (123B); more rufous (136) near collar; feathers have concealed light grey-brown (greyish 119C) to whitish bases. Upper and central back and scapulars look black with fine cream (54) vermiculation. Feathers, brown-black, fading to brown (28) with wear, with fine irregular cream (54) bars near tips, which become more irregular near base to form small cream dots. Lower back, rump and upper tail-coverts black (89). TAIL, black (89). UPPERWING. Marginal, lesser and median coverts, white. Secondary coverts, white; innermost three have grey (84) inner webs, and all have concealed dark-grey (83) wash to base of inner web. Primaries, primary coverts and alula, black (89). Secondaries, dark brown (20), with dark iridescent-green (c262) panel on outer webs forming speculum. Inner webs of tertials and innermost secondaries brownish grey (79, 80 or paler) with faint cream (54) vermiculations on innermost feathers; outer webs rufous (reddish 340) merging to buff yellow (53) at tips and near shaft. UNDERPARTS. Upper breast as mantle, forming continuous band round body. Lower breast, belly and flanks black-brown with fine irregular cream (54) vermiculation; feathers as upper back. Axillaries white; under tail-coverts, black (89). UNDERWING. Remiges and greater coverts grey-black (82); primaries have black (89) tegmina. All other coverts, white.

ADULT MALE NON-BREEDING (ECLIPSE) Definitive basic. Blaauw (1894) described an eclipse plumage in captive males. Similar to breeding male but white collar 'less pure in colour' and 'not so clearly defined'. Breast, yellowish brown; feathers less 'silky and hairy in appearance' than those of breeding males. Frith (1977) reported that this range of variation occurs in breeding birds, so the eclipse can be recognized only in individually marked birds.

ADULT FEMALE Definitive; basic and perhaps also alternate; see above. Age of first breeding in wild unknown. Differences from adult male: HEAD AND NECK. Feathers at base of bill, white; nearly always white eye-ring, regarded as most reliable sexing character (Frith 1977). Some females have white patch on lores; sometimes connected with white feathering of eye-ring and base of bill. Collar narrower than in male, incomplete round hindneck, with slight brown mottling. UPPERPARTS. Mantle, rufous-brown (240–32), appearing more chestnut than in male. In some, feathers of central mantle rufous-brown (240–32), with grey-black (82) tips bisected by thin cream (54) subterminal band, giving barred appearance, lost with wear. Back and scapulars similar to males but cream (54) vermiculations less regular. TAIL. As male. WING. Dark glossy-green (c162A) speculum, duller and darker than male. Outer webs of tertials and inner secondaries, red-brown (32); in some birds traces of yellow-brown (c123B) at edges. UNDERPARTS. Upper breast, rufous-brown (240–32); tips of feathers fade to yellow-brown (123C) with wear. Lower breast, belly and scapulars as back. Under tail-coverts black (89); vent feathers nearer legs have cream (54) vermiculations.

DOWNY YOUNG HEAD AND NECK. Forehead, pale brown (223D) fading to white; crown and hindneck, brown (239). Narrow white supercilium extends from hind edge of eye onto forehead. Lores, dark brown (119A), fading with age. Rest of head, including lower eyelid, white. UPPERPARTS. Mantle and upper back, light brown (27). Centre of lower back and rump, brown (219B). Sides of lower back and rump, white, bisected by narrow brown (219B) line that broadens to form thick band running down flanks to feathering on tibia. TAIL, semi-plumulaceous and brown (119B), fading with age. WING. Base of trailing-edge, and end of leading-edge, white. Base of leading-edge, and end of trailing-edge, brown (219B). UNDERPARTS, white, save for tibia and flanks.

JUVENILE Sexes similar. Age 71–119 days; retained until at least late Mar. or Apr. in first autumn (Riggert 1977). Differences from adult female: HEAD AND NECK. Forehead, pale brown. Eye-ring and feathering at base of bill, off-white; feathers shorter than others on head. Rest of head looks mottled brown; feathers, dark brown (20) with light brown (223C) tips. Collar, off-white, mottled black; narrow, not extending to hindneck, and concealed in many postures. UPPERPARTS. Upper mantle, light brown (123A) blotched darker. Feathers, light brown (123A) with cream (54) tips, and black subterminal bars. Lower mantle as back of adults. UPPERWING. Median coverts and longest lesser coverts, white with grey (84) tips. Secondary coverts, grey (84) with broad white outer edge, and pale-grey (86) inner edge. Secondaries have slightly duller speculum than adults, and prominent white tips visible on underside (Riggert 1977).UNDERPARTS. Upper breast, reddish brown (between 121C and 38). Lower breast, belly and flanks, dark brown (c219) barred light brown (39); on breast and belly, pale bars are *c.* 4 times broader than in adults. Belly feathers inside thighs have white tips. Under tail-coverts, off-white with very fine grey-brown (119B) vermiculations; also described as 'chestnut-brown' (Riggert 1977).

IMMATURE First basic. Age 200–600 days (Riggert 1977). Similar to adults but birds of each sex retain juvenile wing for 18–19 months (Riggert 1977). Some juvenile belly feathers may also be retained for similar length of time.

ABERRANT PLUMAGES Female skin (HLW) collected in late Jan. has remarkably worn plumage; only feather bases remain in head, neck, mantle and breast, giving these areas pale grey-brown (c119D) appearance; white collar-feathers worn down to calamus, making collar inconspicuous. Primaries have worn down to tegmen, and faded to off-white; wear has not produced great differences in appearance in other parts of bird. Bird of similar appearance seen in Vic., 14

Feb. (Klapste 1981), may have had similar plumage wear.

BARE PARTS Based on photos in Pringle (1985) and unpublished, except where stated.

ADULT, IMMATURE Iris, black-brown (119). Bill, grey-black (82) to dark grey (83), with pink tinge near lamellae, on lower mandible. Feet and legs, dark grey (83); an immature (MV) had pink (3) patches on insides of toes.

DOWNY YOUNG Iris, black-brown (19). Bill, dark olive-green, turning light bluish grey (c88) within 24 h of hatching (Riggert 1977). Legs and feet, dark olive-green, turning light grey at 17–24 days (Riggert 1977). Bare part coloration of juvenile attained before all down lost.

JUVENILE Similar to adult, but webs have some pink areas (Riggert 1977); absent in some juveniles (MV).

MOULTS Based on studies of Riggert (1977) in WA, except where stated.

ADULT POST-BREEDING Pre-basic. Complete; flight-feathers simultaneous. Starts with body- and tail-moult about Oct. Wing-moult begins *c.* 90 days later, at which stage body-moult nearly complete. One or two tertials, and p10, p9, p8, p7 dropped in that sequence during 16 days; in following 5–6 days, all remaining wing-feathers, except tertials, shed; remaining tertials shed during period of regrowth. Riggert gave duration of flightlessness as 26 days, but perhaps overestimated, because apparently based on time taken to complete growth of secondaries. Wing-moult takes *c.* 60 days, giving duration of whole moult as 150 days. Wing-moult occurs in Jan. and Feb. On opening day of one duck-season (19 Feb.), 62% of adults shot in se. Aust. were moulting (Braithwaite & Norman 1974); on 17–24 Feb., 29.7% of adults caught at L. George were moulting (McKean & Braithwaite 1976). Difference perhaps due to different sampling methods, but small samples collected on opening days in different years (Braithwaite & Norman 1976; Norman *et al.* 1984) suggest there may be annual variation in timing of moult. Apparent moult-migration; large flocks congregate at large permanent lakes where wing-moult takes place (Frith 1977; McKean & Braithwaite 1976; Riggert 1977).

ADULT PRE-BREEDING Pre-alternate. Body-moult of unknown extent in autumn (Frith 1977).

POST-JUVENILE First basic. Partial, involving body and tail feathers; in at least some birds, moult of belly feathers incomplete (D.I. Rogers). Moult begins at *c.* 90 days and lasts *c.* 110 days; juveniles can be recognized until at least late Mar. or Apr. in first year.

IMMATURE 'PRE-BREEDING' First alternate. Some moult of body feathers, lasting *c.* 30 days, occurs at *c.* 10 months; no obvious sequence to feather loss or development.

IMMATURE POST-BREEDING Second basic. Complete; begins at *c.* 15 months; wing-moult occurs at 18–19 months. Sequence similar to adult post-breeding but moult begins *c.* 50 days earlier.

MEASUREMENTS 1. Adult skins (MV). 2. Recently dead adults (Frith 1977).

		MALES	FEMALES	
WING	(1)	382 (6.60; 376–391; 4)	338 (13.19; 323–353; 4)	**
	(2)	358 (318–392; 50)	331 (304–355; 144)	
8TH P	(1)	240 (5.50; 239–251; 4)	214 (8.16; 210–226; 4)	**
TAIL	(1)	113.0 (13.49; 99–126; 4)	109.5 (3.70; 105–114; 4)	
BILL	(1)	45.7 (2.81; 43.2–49.5; 4)	42.7 (1.18; 41.8–44.3; 4)	
	(2)	46 (41–49; 68)	42 (38–45; 184)	
TARSUS	(1)	65.4 (3.33; 60.8–68.8; 4)	58.5 (1.62; 57.0–60.0; 4)	**
TOE	(1)		62.6, 64.2, 70.3	

WEIGHTS Adult males 1559 (990–1980; 67), adult females 1291 (878–1850; 185) (Frith 1977).

STRUCTURE Wing, long, rather narrow. Eleven primaries; p9 longest, p10 1-6 shorter; p8 8–12, p7 24–28, p6 42–46, p5 61–69, p4 87–95, p3 107–118, p2 127–140, p1 142–158; p1 minute. Seventeen to 18 secondaries, including 5–6 tertials. Middle toe longest, outer *c.* 97%, inner *c.* 75%, hind *c.* 29%. Rest of structure as Paradise Shelduck *T. variegata*.

AGEING, SEXING Using cloaca and related structures described by Riggert (1977). Plumages, as above.

DIR

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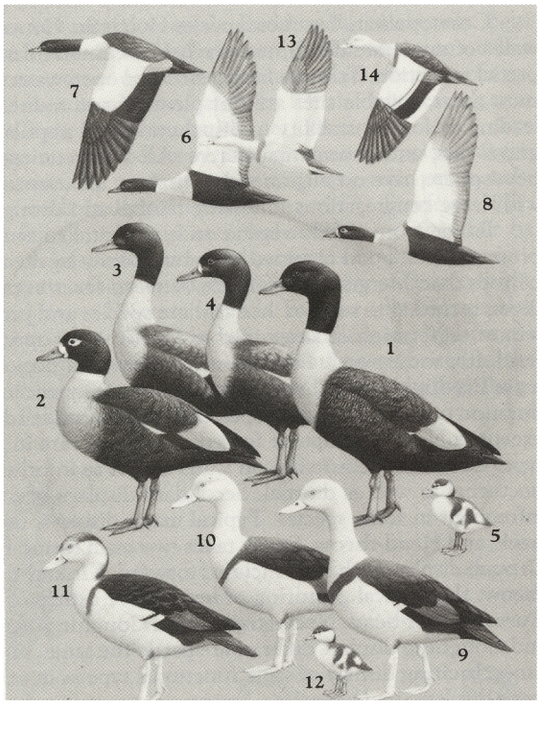

Volume 1 (Part B), Plate 87

Australian Shelduck *Tadorna tadornoides*
1. Adult male breeding
2. Adult female
3. Juvenile male
4. Juvenile female
5. Downy young
6. Adult male (flight), ventral
7. Adult male (flight), dorsal
8. Adult female (flight), ventral

Radjah Shelduck *Tadorna radjah*
9. Adult male
10. Adult female
11. Juvenile
12. Downy young
13. Adult male (flight)
14. Adult male (flight)