INTRODUCTION

For many years, Australian ornithology has been hampered by the lack of a comprehensive work setting out what is known about Australian birds. The possibility of a comprehensive handbook was first considered by H.J. Frith, who, as Chief of the then Division of Wildlife Research, CSIRO, circulated proposals to members of his staff on 13 March 1968. This attempt failed but in the late 1970s members of the then Field Investigation Committee of the RAOU re-opened the matter in discussions, partly as a necessary undertaking in its own right and partly as a sequel for co-operative work after the *Atlas of Australian Birds*, which was due to finish at the end of 1981. The appearance of Volume 1 of *The Handbook of the Birds of Europe, Middle East and North Africa — The Birds of the Western Palearctic* in 1977 was an inspiration. Concrete proposals were put forward to the Field Investigation Committee in April 1980 and approved in principle. A Handbook Sub-committee was formed and further details of operation, scope and content circulated to its members in June 1980. Planning and preparation of guides for contributors, with general discussions on methods, scope and format, took till the end of 1982, after the RAOU Council had decided on 28 February 1981 to put the proposals into action. Recruitment of contributors started in January 1983.

Overseas, handbooks of this kind have greatly stimulated progress in ornithological research. In Britain, H.F. Witherby contributed immensely to the development of all aspects of bird study, first with his *Practical Handbook of British Birds* (1922–24) and, twenty years later, in collaboration with F.C.R. Jourdain, N.F. Ticehurst and B.W. Tucker, with *The Handbook of British Birds* (1938–41). In its time, each work stimulated, and acted as a springboard for research by ornithologists and bird-watchers for a generation — perhaps more by showing what was not known than by recording what was. Thus, instead of simply 'mooning about with field-glasses', as Julian Huxley said, people could put some purpose into their activities by using the books to find out what was profitable to observe and record, on the assumption that what was not recorded in the handbooks was not known. At the same time, Witherby was publishing the monthly magazine *British Birds*, which gradually became a vehicle for publishing in critical detail all sorts of information from occurrence, identification and nesting to incidents of bird-life, which were often regarded as anecdotal and worthless. In the course of time, a large body of observers in Britain became trained to highly critical standards. Sensible, accurate and succinct recording was helped and made easy by means of reference books that collected a mass of information, otherwise scattered through the literature and often hard to find. The harvest of the surge in bird-study during the next 40 years is now being reaped in the publication of *Birds of the Western Palearctic*. Elsewhere in Europe and North America, similar progress had led to the publication of major compendia such as Dementiev & Gladkov's *Ptitsy Sovietskogo Soyuza* (*Birds of the Soviet Union*) (1951–54), Bauer & Gluz's *Handbuch der Vögel Mitteleuropas* (1966, in progress) and Palmer's *Handbook of North American Birds* (1962, in progress).

In Australia, settlement by Europeans has been fairly recent and the population small, with few people having the interest or opportunity to proceed beyond the stage of collecting and description. This phase lasted until the Second World War. At first, Australians had been well served by Gould's and Mathews' famous books, supplemented by North's *Nests and Eggs of Birds Found Breeding in Australia and Tasmania* (1901–14) and A.J. Campbell's *Nests and Eggs of Australian Birds* (1900). But these works, never perhaps particularly useful to the ordinary person interested in birds, became generally less so as they became rare, expensive and out of date. In the 1940s, the only two readily available books on Australian birds were J.A. Leach's *An Australian Bird Book* (1911) and N. Cayley's *What Bird is That?* (1931), neither of which attempted more than a brief description of what the birds looked like and where they occurred. Matters improved with the publication in 1948 of Serventy & Whittell's *Birds of Western Australia*, at least for Western Australians, but in the early 1960s it was still true to say that serious students of birds in eastern and northern Australia had little to help them except Leach's and Cayley's books, unless they had access to a good library or instruction from experienced local ornithologists. From the late 1960s, there has been an increasing stream of general and regional accounts of Australian birds, field guides, State lists and books on particular groups of birds. All have their merits and uses, but most provide only a generalized and partial account of fundamental aspects such as identification, distribution and nesting, without quantified data; behaviour is rarely treated; reference is not made to original sources; and often it seems that information has merely been copied from previous publications without personal experience by the writers or reference to the original author. Such, then, was the milieu in which a demand for a comprehensive handbook began to be expressed in the 1960s and 1970s.

In New Zealand, the pattern was similar. Sir W.L. Buller's famous books (1873, 1888, 1905) were the first major attempts to illustrate and describe the colony's avifauna, though only libraries and persons of means could afford to own copies. The wealth of ornithological detail in these books was not eclipsed and brought up to date until 1930 when W.R.B. Oliver produced the first edition of his *New Zealand Birds*, though P. Moncrieff's *New Zealand Birds and How to Identify Them* (1925) was a valuable guide. Oliver's second edition (1955) was so enlarged and rewritten as to constitute a new work, and this has remained the single most detailed reference on the subject until the present Handbook. Since then, various field guides, checklists, popular books of a general nature (e.g. *Reader's Digest Complete Book of New Zealand Birds*, 1985) and the OSNZ's *Atlas of Bird Distribution in New*

Zealand (1985) have been published, all with their uses and merits, but none attempts more than a summary of the habits and characters of the birds, usually without detailed references, and some are concerned simply with distribution and occurrence.

As for Antarctica, R.C. Murphy's monumental *Oceanic Birds of South America* (1936) went a long way to cover the avifauna, especially in the American sector. R.A. Falla soon provided complementary coverage of the avifauna of the Australasian and Indian Ocean sectors with his report on birds for the *Reports of the British, Australian and New Zealand Antarctic Research Expedition of 1929–31* (1937, *Ser. B*, Vol. II). These two works have remained the major references for Antarctic birds until now. G.E. Watson's *Birds of the Antarctic and Sub-Antarctic* (1975) is the only other work that has tried to cover the whole region, providing brief summaries of the birds. Earlier, Watson *et al.* (1971; *Antarctic Map Folio Series* 14; American Geophysical Union) produced detailed distributional maps and summaries of Antarctic and subantarctic birds.

At the start in 1982, the idea was to cover Australia within its continental shelf as far north as 10°S, except for the eastern end of New Guinea. All along, it was decided that we could not make the work truly and completely Australasian from a biogeographical point of view, simply because the task would be too great. However it was decided that we ought to include the Australian dependencies of Cocos-Keeling, Christmas (Indian Ocean), Lord Howe, Norfolk, Macquarie and Heard Islands, and Australian Antarctic Territory, because otherwise such isolated and outlying places would never be covered in referenceworks and field-guides. We did not consider including New Zealand nor did we approach New Zealanders on the matter because we understood that they were preparing their own Handbook. These original intentions were soon modified. It was found that the inclusion of the islands near New Guinea but within Queensland politically would add only two or three species to our list; so, our northern limit became 10°S or the political boundary, whichever was farther north. Then, largely on the representation of Dr A.N. Cowan, it was decided to include the whole Antarctic continent and, thatbeing so, it seemed sensible to include all subantarctic islands above or closely below the Antarctic Convergence. Again, it appeared that this ought not greatly to enlarge our task. Most Antarctic or island species were already on the Australian list, if only accidentally, and thus it meant that accounts for a good many such species would have to be expanded only with sections for behaviour and breeding. This coverage was clearly more compact and coherent than that originall planned and complemented much better Murphy's coverge in his *Oceanic Birds*. There remained a gap over New Zealand and its islands. It was, therefore, most welcome when inJune 1985 the Ornithological Society of New Zealand suggested that the New Zealand region ought to be included. This expansion was obviously going to enlarge the work considerably but, for all that, was accepted very gladly.

In the end, our coverage is as follows, without being specific across the oceans: Australia within the limits of the continental shelf, north to 10° or the Queensland–New Guinea political border, whicheve lies farther north, but excluding the eastern end of New Guinea and adjacent islands above 10°S; New Zealand and its islands from the Kermadec Group to Campbell Island; the Antarctic Continent; the subantarctic islands (Marion, Prince Edward, Crozet, Kerguelen, Heard and Macquarie, and islands of the Scotia Arc: South Georgia, South Sandwich, South Orkney and South Shetland Islands); Cocos-Keeling, Christmas (Indian Ocean), Lord Howe and Norfolk Islands; reefs and islands of the Coral Sea.

CLASSIFICATION AND NOMENCLATURE

The arrangement and nomenclature of orders, families and species closely follows those of Condon in the *Checklist of the Birds of Australia*, Part 1 (1975), and of Kinsky in the *Annotated Checklist of the Birds of New Zealand* (1970), both of which are essentially those of Peters' *Checklist of Birds of the World*, Volume 1 (1979), and that in itself is much the same as the Wetmore order of 1960. At the generic level, admitted to be the most arbitrary, controversial and mutable taxon in the system, we have avoided sub-genera for the most part and thus differ from the above standards in one way or another. In some genera (*Pterodroma*, *Sula* and *Phalacrocorax*), we do so because proposed sub-genera seem not yet to be widely accepted; in *Ardea*, because the proposed sub-genera are hard or even impossible to separate. Further, we have treated some isolated, sedentary and insular forms of shags and ducks as full species rather than as subspecies because that seems to be more sensible biologically. Preparation of our first volume has coincided with the preparation of the Catalogue of Australian birds for the Australian Biological Resources Survey (ABRS) by Dr R. Schodde, and of the third edition of the New Zealand checklist. Originally we hoped that both would be published well before our first volume, but in the event we were obliged to commit ourselves taxonomically before they appeared. Thus, in spite of full co-operation and help from the compilers of these works and their helpers, we cannot be sure that our arrangement and those of the ABRS list and the new New Zealand checklist will be the same. Sibley, Ahlquist and Monroe (*Auk* 105: 409–23) have recently proposed a new classification of birds based on DNA-hybridization. Whether or not this comes to be generally accepted, it came too late for us to use. To have done so would have meant scrapping much work and preparation, and delaying production intolerably.

Names of the birds in Dutch, French, German, Japanese, Malay, Maori and Russian, as far as they are available, are listed in an appendix at the end of the book. There is also a separate appendix for Aboriginal names. The official attitude of the RAOU to the use of English names is set out in the Supplement to *Emu* 1977, Vol. 77 (*Recommended English Names for Australian Birds*). It favours an international rather than a parochial or insular approach to the matter and we have done so throughout. We have departed from the *Recommended English Names* in two cases: we have used Salvin's Prion for *Pachyptila salvini* (in place of Lesser Broad-billed Prion; see explanation in masthead of *P. salvini*) and Australian White Ibis (in place of Sacred Ibis) for *Threskiornis molucca*, which we have considered a separate species. English names for species endemic to New Zealand are usually taken from the *Annotated Checklist of the Birds of New Zealand* (Kinsky 1970) and amendments (*Notornis* 27, Suppl.).

TREATMENT AND PRESENTATION

The bulk of the book is set out in standard systematic form with brief introductory remarks for taxa above the level of genus, written from the point of view of Australia, New Zealand and Antarctica, and detailed accounts for each species. The introductions for orders characterize the sorts of birds concerned, list constituent families and outline taxonomic arrangements that differ from ours. This may be transferred to

the introduction for a family where there is only one family in the order. Introductions for families usually cover the types of birds concerned, number of sub-taxa and informal groupings such as superspecies, world distribution and representation in our region, and chief morphological and behavioural characters. Below the level of species we have avoided as far as possible any treatment of subspecies except in the paragraph for Geographical Variation at the end of the Plumages section. Subspecific discrimination is a valuable and necessary tool in museum studies and with birds in the hand, but not generally in the field.

The species accounts are divided into sections for Field Identification, Habitat, Distribution, Movements, Food, Social Organization and Behaviour, Voice, Breeding, and Plumages and related matters. If information on population is available it is included in the section on Distribution. The original plan was to have an editor for each section and to solicit an account for each species from experts, which the editors would then treat for consistency of style, arrangement and presentation. This simply did not work. For various reasons, some of those who originally agreed to be editors could not carry on through the long period of preparation, and many contributors could not meet our onerous demands. Many *ad hoc* reorganizations had to be made and so we cannot give a simple list of editors and contributors. Detailed acknowledgements are made below.

Details of the scope of each section, with an explanation of conventions and abbreviations used and special problems, are discussed in separate introductions for each section below. Some abbreviations and conventions are used throughout the work; others apply only to a particular section. The general ones are explained separately (see page 45).

About 900 species of birds have been recorded within our limits, depending somewhat on the classification used and including vagrants, introduced species with viable feral populations, and those extinct within historical times. In this volume we cover 196 species, of which most (162) breed within our limits and so receive full treatment in ten sections, as mentioned above. Many pelagic and Antarctic birds are, of course, rare and seldom found in Australian and New Zealand waters but breed in Antarctica or on subantarctic islands. Others (27) are regarded as non-breeding visitors, vagrants or accidentals, though some could be more regular migrants annually to Australian or New Zealand seas or to little-known areas on land. For them, sections on Food, Social Organization and Behaviour, Voice and Breeding are omitted, as may be detailed descriptions of plumage if material for study was not available (however, some very recent occurrences or vagrants to Antarctica or subantarctic islands have only a short paragraph). All these breeding and non-breeding species and most vagrant species are illustrated in colour, to show the plumages that can be identified in the field, from downy young to breeding adult. Further, there are seven species that are extinct in historical times or that have not been recorded since 1900 or for which we think that the record is doubtful, definitely erroneous or otherwise unacceptable. These are not illustrated and have only a short paragraph, setting out the evidence. Fossil and subfossil species are not covered.

FIELD IDENTIFICATION

This section sets out the characters by which a species may be identified in the field, even without the help of illustrations. It goes without saying that the recognition of many features often or usually depends on the circumstances and wear of plumage, especially for birds at sea, and this should be kept in mind when making and evaluating observations. For the most part we have not presented differences between subspecies here, because we do not wish to encourage the idea that subspecies can be identified in the field, except in the case of a few, very well-marked examples. References are not usually given in this section.

The presentation is in four paragraphs. The first is designed to help those who are ignorant of A'asian birds, or even of birds in general, to decide whether they are on the right track for identification. It gives a rough indication of the size, shape, appearance and type of bird being described. Measurements of total length, wingspan and weight are given in gross terms, as a guide to the size of the bird, and, where necessary with a broad indication of the proportions of head and neck, body and tail (detailed measurements are in the Plumages section). Brief mention is then made of outstanding characters of plumage or other features, especially if they are diagnostic, and it is indicated whether differences occur by age, season or sex.

The second paragraph (DESCRIPTION) describes the various stages of plumages as seen in the field. Here, as necessary, descriptions are given of adult male and female, breeding and non-breeding, downy young, juveniles and immature stages, as well as morphs and phases. After the first mention of a character, it is not usually repeated, only the differences being emphasized. It is hoped that with this information on the different stages in plumage, field observers will be encouraged to discriminate more carefully between sexes and ages than is often done, because important data on patterns of movement, age at first breeding and social behaviour can thus be collected.

The third paragraph (SIMILAR SPECIES) sets out those species that may be confused with the species in question, sometimes even to a point that may seem ridiculous or impossible. Field conditions, however, can play some strange tricks and one must be careful. There is nothing worse than publishing a doubtful or incorrect identification as a certainty, which will be perpetuated and is hard to eradicate or correct (see discussion in Distribution introduction). Some care has been taken to make comparisons between species in the same way: species X, Y or Z always first, smaller, paler, etc, than species A, which is the subject of the account.

The fourth paragraph tries to give an outline of less concrete aspects of identification and is generally the weakest part of the section. It is not easy to remember to record aspects of habitat, gait, swimming, flight and so on, which one assumes are perfectly obvious and well known. There is probably much scope for improvement here, because contributors and editors had a good deal of trouble in covering the field, even as a general outline. Usually fuller information (and references) on various aspects discussed here may be found in other sections.

It has been thought necessary to condense substantially the very detailed descriptions and comparisons submitted by some contributors for the second and third paragraphs. It is hoped that such condensation has not gone too far and that nothing really important has been left out.

HABITAT

The ideal habitat description for a particular species of bird presents an analysis of the critical factors determining distribution and the suitability of particular sites, taking into account needs for different purposes (e.g. feeding, breeding,

roosting, moult); of the dynamics of use of habitat daily, seasonally or for longer periods; and of the effects of alteration of habitat, naturally or by human agency. It ought to apply throughout the species' geographical range, or, at least, a large part of it. It ought to be predictive as well as descriptive and present possibilities and ideas for management.

By these criteria, there is scarcely a species within our region for which a comprehensive description of habitat can be compiled. The difficulties are the same as encountered in BWP and apply globally; particularly the lack of detailed studies for most species and the imprecise and inconsistent use of terms of description.

The most intractable difficulty is the lack of comprehensive studies on use of habitat by birds. This is a problem worldwide, but is exacerbated for us by low density of population, remoteness, inaccessibility and severe climatic conditions in some parts. In compiling these texts, the authors and editors have attempted to integrate and condense published information to produce a generalization for each species. For some species, we were fortunate to be able to draw on systematic studies. Also valuable were the observations and insights of experienced field observers. But all too often, in the absence of these sources, we gleaned information from numbers of short notes, papers on other topics, and annotated bird lists, much of it inevitably anecdotal, superficial and fragmentary. Even where there have been studies of habitat, often the focus is on aspects that are obvious or most amenable to study; for example, there is little quantitative information on use of airspace and underwater zones, and the study of the marine ecology of seabirds in our region is still in its infancy. Information from small areas is rarely interpreted with a view to integrating it into the wider geographical picture, and, perhaps most frustratingly, much valuable information remains unpublished or exists only in sources that are difficult to find.

Thus far, studies of avian habitats in our region have generated a bewildering variety of approaches to classification of habitat. The criteria used have in general been subjectively chosen, without evidence that they are relevant in determining the occurrence and abundance of birds, and many are appropriate only over small areas. Even where there are systems of classification covering wide areas and in widespread use in other disciplines, they have as yet received little attention from ornithologists e.g. Specht's (1981) structural classification of vegetational formations in Aust.

In compiling this section, therefore, we have used terms for habitat description that are familiar and regularly used by both amateur and professional ornithologists, assigning to them reasonably precise meanings. Any more restrictive approach would exclude most information available at present. A glossary follows. This presents terms used in the text that may be unfamiliar to some readers or that have other meanings in common usage in our region.

The Habitat section for each species discusses in sequence the biogeographical settings of distribution, broad terrestrial and aquatic groupings, details of habitats used for foraging, breeding, roosting and moulting, and relations with humans where these are pertinent. Although it is difficult to choose references for citation in a work such as this, we have attempted to provide primary sources, especially acknowledging sources of significant facts and studies of particular species or groups. It is impossible that such listings should be exhaustive.

This work holds, with few exceptions, the first attempts to integrate all information available on habitat use by bird species using the A'asian and Antarctic regions. Probably the work's most important function will be to stimulate further studies and encourage publication of existing information.

GLOSSARY

This glossary defines the principal terms used for habitat description in our text, in recognition of the need to standardize and increase the precision of such terms. A number of other terms are used throughout according to general English usage and are not defined here. References used in producing this compilation are Moore (1949), Press & Siever (1978), Corrick & Norman (1980), Gosper (1981), Pearce (1981), Specht (1981), Corrick (1982), Ainley & Boekelheide (1983), Ainley *et al.* (1984), McDonald *et al.* (1984), Aust. Atlas, and BWP.

ACACIA SCRUB. Vegetation dominated by shrubs of the genus *Acacia*; includes open-scrub, tall shrubland, tall open-shrubland and low open-shrubland of Specht (1981).

ANABRANCH (anastomosing plus branch). Branch that leaves river and re-enters it downstream.

ANTARCTIC CONVERGENCE. See *Polar Front.*

ANTARCTIC SLOPE FRONT. Oceanic zone overlying Antarctic continental slope, where shelf-water meets circumpolar deep water, and strong gradients of temperature, salinity and turbidity occur.

AQUATIC VEGETATION. Plants growing in water; may reach but not project above surface.

ARID ZONE. Regions where mean annual rainfall is less than 250 mm.

ATOLL. Coral reef in the shape of a ring or horseshoe, broken or continuous; enclosing a lagoon.

BACKWASH. Return flow of water down beach after wave has broken.

BILLABONG. Properly an ox-bow lake, formed when a meander of a river is cut off as the river modifies its course; popularly used for other water-bodies.

BORE. Hole drilled in the ground from which underground water is pumped and reticulated.

BOUNDARY CURRENTS. Fast-flowing currents concentrated along edges of major oceans. Poleward currents on western edges of oceans are very intense and are known as WESTERN BOUNDARY CURRENTS.

BRAIDED RIVER (STREAM). Intricate system of interlacing channels, formed in wide river-beds choked with coarse sediments.

CAY. Flat mound of sand built up on reef flat slightly above high-tide level.

CLEAR-FELLING. Forestry operation in which all trees on a site are cut down.

CLIMATIC ZONES. GLOBAL. Five main zones into which Earth is divided according to climate. Comprise **Tropical Zone**: region lying between the Tropics of Cancer (23°27'N) and Capricorn (23°27'S); **Frigid Zones**: regions enclosed by Antarctic Circle (66°33'S) and Arctic Circle (66°33'N); **Temperate Zones**: regions lying between Tropical and Frigid Zones. MARINE. Climatic zones of oceanic surface water defined by Ainley & Boekelheide (1983). **Tropical Zone**: waters with sea surface-temperature (SST) of at least 22.0 °C. **Subtropical Zone**: SST 14.0–21.9 °C. **Subantarctic Zone**: SST 4.0–13.9 °C. **Antarctic Zone**: SST below 4.0 °C.

CONTINENTAL SHELF. Underwater plateau extending from coast to a depth of about 200 m; shelf-waters: zone of water over the continental shelf.

CONTINENTAL SLOPE. Beyond edge of continental shelf, ocean floor slopes to the abyssal plain (often at depths >4000 m). Worldwide, slope averages 4° but round Aust. may be up to 40° (Bunt 1987).
CREEK. Stream of less volume than a river; small tidal channel through a coastal marsh; wide arm of a river or bay. Popularly applied in Aust. to any, rather small, drainage channel or waterway, permanent or impermanent, inland or coastal.
DAM. Small (<10 ha), artificial water storage formed by excavation or impoundment; used for stock watering, irrigation or domestic supply in agricultural or pastoral regions.
DRY SEASON. Season in monsoonal areas when little rain falls; usually Apr. to Nov. in ne. Aust.
DUNE. Hill or ridge of sand formed by wind-blown sand or other granular material. CONSOLIDATED DUNE. Dune stabilized by cover of vegetation.
EMERGENT VEGETATION. Plants projecting above canopy or water surface.
EUTROPHICATION. Formation of superabundance of algal life in body of water, caused by influx of nutrients.
FIORD. Former glacial valley with steep walls, now occupied by sea.
FLOODPLAIN. Plain bordering a river; formed from sediments deposited during intermittent or seasonal flooding, and characterized by billabongs, swamps, meandering creeks.
FOREST. Vegetation of trees, usually over 10 m high, with projective foliage cover of more than 50%; includes tall open-forest, open-forest and low open-forest of Specht (1981).
FRONT (OCEANIC). Line or zone of separation at sea surface between water-masses of different physical characteristics, particularly temperature.
GIBBER PLAIN. Level land covered with pebbles, usually in arid regions; little vegetation; barren stony waste.
GUANO. Compacted mass of faeces of colonial species of birds; accumulated over many years.
HEATH. Vegetation dominated by shrubs; includes closed-heathland, open-heathland and dwarf open-heathland of Specht (1981).
HERB. Non-woody plant.
ICE. Types discussed in the text are: SHELF-ICE: floating seaward extension of continental glaciers; SEA-ICE: ice formed by freezing of sea water; PACK-ICE: unattached sea-ice, varying from open to fully consolidated; FAST-ICE: sea-ice attached to shelf-ice or land; ICEBERG: mass of land-ice broken off from glacier and afloat at sea; ICE-FLOE: small mass of floating ice detached from pack-ice, limits usually within sight.
IMPROVED PASTURE. Pasture to which fertilizer has been applied.
ISLAND. Piece of land surrounded by water. Marine islands can be classified according to origin; CONTINENTAL ISLAND: formed by separation from continental mainland; OCEANIC ISLAND: formed in ocean independent of mainland; VOLCANIC ISLAND: volcanic in origin; CORAL ISLAND: built by action of coral polyps.
ISOTHERM. Contour line joining points of equal temperature or equal average temperature; oceanic or atmospheric.
KRILL. Marine crustaceans; Arthropoda, Crustacea, order Euphausiacea, *Euphausia* or *Nyctiphanes*. Form swarms in Antarctic and subantarctic seas.
LAGOON. Strictly an enclosed coastal lake, pool or inlet, separated from ocean by broken or continuous banks of sand, earth or shingle; or waters enclosed by an atoll. In Aust. applied popularly to any rather shallow or small water-body such as billabong, pool or pond.
LEVEE. Natural ridge along bank of creek or river formed by deposition of silt during flooding; also artificial barrier to floods constructed in similar form.
LITTORAL. Intertidal area of sea or ocean.
MALLEE. Multi-stemmed eucalypt growing from subterranean rhizome; also vegetation in which mallee is dominant; corresponds to open-scrub of Specht (1981).
MANGROVE. Rhizophoraceae; many genera in Aust.
MEADOW. Seasonal or transient shallow freshwater wetland characterized by cover of low emergent vegetation, particularly semi-aquatic herbs.
MEANDER. Broad curves in creek or river forming as water erodes outer bank of curves and deposits sediment against inner bank.
MONSOON. Climatic regime in which the wind blows in one direction for about half the year and in the opposite direction for the other half. Prominent in tropics on e. sides of continents; in ne. Aust., moist onshore winds prevail in summer.
MONSOONAL REGIONS. Regions affected by the monsoon, and experiencing distinct wet and dry seasons. Within our limits, coastal and subcoastal ne. Aust. and adjacent islands.
MORAINE. Deposit of debris and rock fragments at margin of glacier.
PARK. Enclosed piece of public ground in urban areas, used for ornamental and recreational purposes; often planted with exotic grass, shrub and tree species, and containing artificial pools or lakes.
POLAR FRONT. Circumpolar Zone where cold Antarctic surface-water sinks below less dense subantarctic surface-water; northernmost extent coincides with 2 °C subsurface isotherm.
RAINFOREST. Dense forest growing in areas of heavy rainfall; trees are evergreen and predominantly broad-leaved; includes tall closed-forest, closed-forest, low closed-forest and closed-shrub of Specht (1981).
REED. Herbaceous erect plant, particularly of the genus *Phragmites*.
REEF. Ridge of rock or coral (CORAL REEF) in sea, just above or below the surface.
RIP. Narrow, fast-flowing ocean current.
RUSH. Herbaceous erect plant of the families Juncaceae, Typhaceae.
SALT LAKE. Lake, usually in arid or semi-arid zone, where evaporation exceeds inflow, so that water highly saline; in arid Aust., usually dry with flat barren surface-deposit of salt.
SALTBUSH. Vegetation in which chenopods are dominant, particularly *Atriplex*, *Enchylaena*, *Rhagodia* ; includes low-shrubland, low open-shrubland and very open sedgeland of Specht (1981).
SALTFIELD. Set of ponds for production of salt by natural evaporation of seawater.
SALTMARSH. Low-lying, flat land regularly or intermittently flooded by saline or brackish water and covered or fringed by halophytic vegetation; coastal or inland.
SALTPAN. Semi-permanent saline wetland; some aquatic plants (e.g. *Ruppia*, *Lepilaena*) in shallow waters; little or no emergent vegetation.
SCORIA. Congealed lava or lava fragments containing large number of vesicles.
SCREE. See TALUS.
SEAMOUNT. Submarine mountain rising at least 900 m above ocean floor.
SEDGE. Herbaceous erect plant; Cyperaceae and some other families.

SEMI-ARID ZONE. Regions with mean annual rainfall of 250–500 mm.
SHRUB. Woody plant <8 m tall, with many branches and ample foliage; replaces BWP's BUSH; in common usage in Aust. for remote or undeveloped country.
SPINIFEX. Vegetational association in which mound-forming grasses, known collectively as spinifex, are dominant; Gramineae, *Triodia* and *Plechtrachne*.
STACK. Rocky islet or pillar near coastline, isolated by erosive action of waves.
SWAMP. Wetland area, permanent, seasonal or ephemeral; typically richly vegetated with emergent and aquatic plants. BWP classifies vegetated wetlands as MARSHES and SWAMPS on the basis of persistence of water, but the dry climate over much of our region ensures that few wetlands, shallow enough to support rich plant growth, are permanent.
TALUS. Deposit of angular fragments of weathered rock accumulated at base of cliff or steep slope.
TUSSOCK GRASSLAND. Grassland dominated by grasses forming discrete but open tussocks.
UNDERSTOREY. Shrub or tree layer below uppermost stratum.
VOLCANO. Vent in earth's crust through which lava reaches surface; includes deposits surrounding vent. VOLCANIC ASH. Fine particles of lava ejected from volcano in eruption and deposited as sediment on land. VOLCANIC OR CINDER CONE. Conical hill built up of material ejected from volcano and deposited around outlet.
WET SEASON. Season in monsoonal areas when most rain falls; usually Dec.–Mar. in ne. Aust.
WOODLAND. Vegetation association of well-spaced trees less than 30m high; includes open-forest, low open-forest, woodland, low woodland, open-woodland and low open-woodland of Specht (1981).

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DISTRIBUTION AND POPULATION

In this section we try to present a summary of the known distribution of each species, within our limits with a mention of extralimital range. Maps of distribution appear for all species except accidental vagrants and, like good cartoons, obviate the need for much text. However, they can be presented only on a small scale and so some fairly detailed explanation has to be appended to make them useful. Distribution is inextricably linked with movements though we try and avoid overlap with that section.

After a summary of world distribution of the species and its occurrence in our region, details of distribution are given, generally for Aust., NZ, the territories of Lord Howe, Norfolk, Christmas and Cocos-Keeling, Kermadec and Chatham Is, in that order, followed by records in subantarctic islands and vagrants elsewhere. For Antarctic and pelagic species, the main distribution is usually given first and then records in more temperate regions in the same order as above. Breeding distribution is then considered. The last paragraphs give estimates of population (if not already with breeding distribution), and the status of the species. The history of introductions and colonizations is outlined where necessary.

Breeding distribution and Population. It hardly needs saying that, as regards the speciation and classification of birds, a vital consideration is interbreeding with accompanying gene-flow. One assumes that this takes place only within the breeding range. It is on the basis of breeding range that the question of sympatry or allopatry is established. Thus, the breeding range of a species is surely what is fundamentally important from a biological point of view. However, there is surprisingly little information on the present breeding range of many A'asian species. Within Aust. it may be thought that the *Atlas of Australian Birds* and RAOU *Nest Record Scheme* would meet requirements, but the Atlas relied primarily on records of presence or absence, and evidence for breeding came a poor second. Records in the NRS are usually too scattered and fragmentary to be of much use. In consequence, one has no means of knowing whether breeding occurs in all blocks where the birds were seen during the Atlas work, though one may be quite certain that it did not do so. Later work, such as organized waterbird surveys in Vic. and WA, has enabled us to fill some gaps. For NZ, the situation is even worse because the *Atlas of New Zealand Birds* does not indicate breeding. For most colonially nesting species, each colony known to us is listed, with its size in recent years. However, for some species, such as ibises, only the larger or long-established colonies are listed, with references to sources. The estimated figures may or may not give a reasonable idea of populations at the present time. They ought, however, to provide a measure against which future fluctuations can be judged. They ought also to encourage people to fill the gaps that must be there. Similarly, figures of recent surveys of waterfowl are recorded, as an index of the numbers of birds seen rather than as actual censuses. All the same, there are no estimates of populations for many species.

Accidental and vagrant species. First records for species in Aust. and NZ, records of a species far outside its normal range and records of vagrants generally present difficulties. It is no use burking this question, and the fact is that, until recently, reporting and vetting of such records in Aust. has been deplorable. Until recently, there has been no official body to which records have to be submitted for critical appraisal and acceptance before publication. In consequence, publication has often been made without any acceptable supporting justification and acceptance has been lax. Indeed, we have found that some such records accepted in the *Atlas of Australian Birds* are not acceptable by modern standards.

In 1975 the RAOU established the Records Appraisal Committee for reviewing unusual records of all sorts. Unfortunately, for many reasons, the Committee has vetted few records and has not yet achieved much authority. The Committee has been reformed and is now evaluating published and unpublished records. At the same time, within the last 20 years or so, the standard of exact and critical observation in the field has been improved immensely by the enthusiasm and abilities of a new generation of field observers, particularly as regards waders and seabirds, and by the organizing of regular

boat-trips across the continental shelf. In this way, a great deal of valuable information on occurrence, status and distribution of species hitherto little known in our region has accumulated, but unhappily not much of it has been published satisfactorily. This is fair neither to the observers, who have not received their due credit, nor to general ornithologists, who have to accept the observations on hearsay or not at all. In a work that is trying to assemble the facts, the situation is unsatisfactory at best, impossible at worst. In various ways, we have tried to compromise by allowing that there is knowledge beyond our reach, while recording only acceptable fact. As far as possible, we give references to the original source for all vagrant and unusual records and comment on their acceptability.

Maps. Distribution for each species is shown on one, or more, of the following maps: World, Polar, Aust. and NZ, Aust., NZ, or Tas. We usually present the minimum number of maps in each account: for example, if a species occurs only in NZ, then only that one map is used. However, for many species, distribution (including extralimital range) is shown on a world map and, in more detail on, say, the Aust. and NZ map. All maps have breeding and non-breeding distribution shown in the same manner: breeding distribution is coloured full red. Areas where birds are recorded without known breeding are coloured half-tone red. Vagrant records far from any area of usual occurrence are simply small half-tone red dots or arrows. For islands, and sections of the coast of Antarctica and some coasts elsewhere, breeding and non-breeding are indicated by full red and half-tone red arrows respectively. For seabirds, distribution at sea is in half-tone red without separation into summer and winter or breeding or non-breeding ranges because so little is known of that matter for most species. Where differences between summer and winter range are known it is discussed in the text on distribution or movements rather than shown on a map.

One of the chief difficulties has been to distinguish between breeding and non-breeding ranges, at any rate for species of Aust. and NZ landbirds (see above). When mapping breeding distribution, where ought the lines to be drawn? This can only be a matter of personal judgement, and each person's judgement will differ. As a general rule, we have tried to outline those areas, based on Atlas blocks, in which the Atlas and other data record breeding as having occurred in the recent past, usually in the past two decades. These areas are coloured full red and include any isolated blocks where breeding was not recorded that are inliers in such areas. The uncertainties of the presentations ought to encourage and give scope to observers to find us at fault.

Movements also were a problem. For species dealt with in this volume, simple migration between breeding and non-breeding areas either does not take place in a clearly defined seasonal manner in our region, except for a few procellariiforms, or movements that do take place are not well enough understood to depict. In short, for the species in Volume 1, it is hardly feasible to present the vagaries of such movement in a succinct form and they are not indicated on maps of distribution.

Much of the information in this section comes from bird reports published in Aust. or NZ. For NZ, annual reports of unusual or interesting records are published as *Classified Summarised Notes* in *Notornis*. In Aust., there is no national bird report. However, most States publish or have published bird reports and *Corella* (formerly *Australian Bird Bander*) continues to publish accounts of breeding birds in its *Seabird Islands Series*. These references have generally been abbreviated as follows; each is followed by the year of the report (not the year of publication) except for CSN, which is followed by the volume of *Notornis* in which it is found.

REPORT	PUBLISHED IN OR BY
Qld Bird Rep.	*Sunbird* (Qld Orn. Soc.)
NSW Bird Rep.	*Aust. Birds* (NSW Field Orn. Club) (formerly *Birds*)
Vic. Bird Rep.	Bird Observer's Club of Australia
Tas. Bird Rep.	*Tasmanian Bird Report* (Bird Obs. Assoc. Tas.)
SA Bird Rep.	*S. Aust. Orn.* (SA Orn. Assoc.)
WA Bird Rep.	WA Group of the RAOU
CSN	*Notornis* (OSNZ)

MOVEMENTS

This section describes the timing and geography of migration and other long-distance movements rather than orientation or physiology. Each account begins with a brief summary of type of movements, whether **migratory** (all or most individuals moving between breeding and non-breeding ranges), **partially migratory** (some individuals migratory, others resident), **dispersive** (movements apparently random within suitable habitat, though this designation may reflect limited knowledge and mask regular migration by part of the population), **resident** (most individuals non-migratory though some may move long distances) or **sedentary** (most individuals not normally moving more than 50 km). Other types of movement include eruptions from breeding areas, irruptions into areas outside the normal range, aberrant migration (movement in the opposite direction to most members of the species), post-fledging dispersal, post-breeding dispersal and moult-migration (movement from a breeding area to a moulting site). The term 'nomadic' is generally avoided because it seems to be little more than a cloak for our ignorance, and a vague synonym for 'dispersive'.

For regular migrants, the direction and timing of departure, movements in the non-breeding season, direction and timing of return to the breeding area and movements in the breeding season are set out separately.

Banding returns are generally summarized separately. We have drawn together all records of movements of more than 100 km for Aust., NZ and Antarctica, except for birds banded by the British Antarctic Survey and those banded by the United States Bird Banding Laboratory within the limits of the book but recovered outside it. For a few species, banding returns have been adequately summarized in the literature; otherwise banding returns are either mapped or summarized thus:

46S51E	03	P	U	14	2837	288	CRBPO
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

(1) Co-ordinates of banding site (degrees latitude, degrees longitude); (2) month of banding; (3) age at banding (J = juvenile, P = pullus, 1 = 1 year-old, 1+ = >1 year old, etc.); (4) sex (M = male, F = female, U = unknown); (5) number of months between banding and recapture; (6) minimum distance to location of recovery (great circle); (7) direction to location of recovery (degrees from N); (8) scheme under whose auspices bird banded (listed below).

Maps. For some species, banding recoveries are presented on maps; the symbols used are listed below. In all cases, recoveries are pooled by grid-cell, the centres of which are

shown by the symbol; size of the grid-cell is specified at the foot of each map (e.g. 1°lat. x 1°long.; see below, Fig. 1). Where less than 100 recoveries are mapped, an open circle represents one or more recoveries in a grid-cell. Where more than 100 recoveries are mapped (a percentage [%] symbol appears in the legend), the symbols + and 1 to 9 represent a **percentage (%) of the total number of recoveries** for that map; i.e. 2 indicates that between 20% and 29% of the total number of recoveries were recorded in that grid-cell.

SYMBOLS

✳ = banding site O = recovery of one or more birds

\+ = 1%-9% of recoveries

1 = 10%-19%	2 = 20%-29%	3 = 30%-39%
4 = 40%-49%	5 = 50%-59%	6 = 60%-69%
7 = 70%-79%	8 = 80%-89%	9 = 90%-99%

Maps have legends in following format:

34S150E	1X1	%	ABBBS
(1)	(2)	(3)	(4)

(1) Banding site (degrees latitude, degrees longitude); (2) size of grid-cell in degrees latitude by degrees longitude; (3) when present indicates that more than 100 recoveries are mapped and that figures on maps are percentages of the total number of recoveries. (4) banding scheme codes (see below);

Codes for contributing banding schemes are as follows:

ABBBS	Aust. Bird and Bat Banding Scheme, ANPWS, Aust.
BMRC	Bird Migr. Res. Center, Yamashina Inst. Orn., Japan
BBL	Bird Banding Lab., Fish Wildl. Serv. US, Dept Int., USA
CEMAVE	Centro Estudos Migr. Aves, Brazil
CRBPO	Centre Rech. Biol. Popul. Ois., Natn. Mus. Hist. nat., France
IAC	Inst. Antarct. Chileno, Chile
MAPS	Migr. Animal Pathol. Survey (McClure 1974)
NZNBS	NZ National Banding Scheme, NZDOC, NZ
SABRU	S. Afr. Bird Ringing Unit, Univ. Cape Town, Rep. S. Africa
SOPAN	Stajca Orn. Polska Akad. Nauk, Poland
VH	Vogelwarte Hiddensee, East Germany

FOOD

The description of food and feeding behaviour is open to many biases and much variation between place, time and individuals. For most purposes, therefore, the generalized description of the diet provided in the first sentence of each food section will be adequate; for no species of wild bird has the acquisition of and requirements for nutrients and energy been completely described. Nevertheless such understanding can only be achieved by numerous studies conducted in as much detail as possible with the techniques available and these are comprehensively summarized in later paragraphs.

Until recently, there have been few detailed studies of the diet of A'asian birds. Earlier works gave general descriptions of the gut contents of a few individuals (e.g. Campbell; North; Mathews 1910–27; Lea & Gray 1935, 1935–36; Cleland 1910, 1911; Cleland *et al.* 1918) but these are of little use in terms of the biology of the species. Only in the last decade have thorough and biologically useful analyses been conducted for individual species or groups of species in our area. More recently, Barker & Vestjens (1989) have listed the foods of Aust. birds using published and their own unpublished data.

In the first paragraph feeding behaviour is described, quantitatively where possible. In unquantified studies it should be remembered that unusual feeding behaviour is more likely to be described in the literature. For seabirds and herons, nomenclative descriptions of feeding behaviour have been standardized using the following texts: **seabirds**: Ashmole & Ashmole (1967), Ainley *et al.* (1984), Harper *et al.* (1985); **ardeids**: Recher *et al.* (1983).

The rest of the text, except the last paragraph, contains detailed descriptions of the diet, including complete lists of food eaten with whatever measures of quantity are available. Such data are undeniably difficult to read but to present it in less detail would severely limit its utility. Methods of describing the importance of different foods, each of which has flaws and merits, include the percentage of the total weight (wet or dry), percentage of the total volume, percentage of the number of items or the frequency of occurrence. Occasionally these measures have been combined into some form of index or presented as raw quantities but, wherever possible, the data have been re-analysed into one of the four measures listed above. Further, size of items is sometimes indicated when available (e.g. length of crustaceans and fish); these are presented in our standard arrangement for simple statistical data: mean (standard deviation; range; sample size) or a subset of this, depending on availability of data.

Analyses are prone to numerous forms of bias such as differential rates of digestion, post-mortem breakdown, secondary ingestion (where stomach contents of the prey species are mixed with those of the bird) or incomplete sampling (particularly with regurgitation). These must be borne in mind when interpreting the results. Where possible, precedence has been given to those analyses most likely to reflect the true intake (oesophageal over gizzard samples, multiple-flushed regurgitations over single-flushed regurgitations).

Detailed description of diet is largely confined to data collected in Aust., NZ or Antarctica. For several Antarctic and tropical seabirds, however, detailed studies conducted extralimitally (Falkland Is, Aldabra, Hawaii) have been described in full as have studies of trans-equatorial migrants in their non-breeding range. Otherwise, extralimital data have been summarized in less detail.

All scientific names have been checked by authorities at

the Museum of Victoria, the Australian Museum, the Western Australian Museum, CSIRO Division of Entomology or the University of Queensland, where possible basing the taxonomic order and nomenclature on the *Flora of Australia*, the *Flora of New Zealand* or the *Zoological Catalogue of Australia*. Vernacular names have been used only for birds and mammals and follow the RAOU *List of Recommended English Names* or the *Zoological Catalogue of Australia, Vol. 5., Mammalia* (Canberra: AGPS).

The final paragraph includes information on intake, feeding frequency and nutritional physiology.

ABBREVIATIONS. A number of abbreviations unique to this section are used in the detailed descriptions of food:

% wt.	% wet weight.	% vol.	% volume
% no.	% number	% freq.	% frequency
unident.	unidentified	excl.	excluding
incl.	including	ad.	adult
tr.	trace	imm.	immatures
ads.	adults	larv.	larvae
fru.	fruits	fl.	flowers
sh.	shoots	sd.	seeds
lvs.	leaves		

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SOCIAL ORGANIZATION AND SOCIAL BEHAVIOUR

These are based on the similar sections of Social Pattern and Behaviour in BWP. The intention is to summarize in two sections observations and studies of each species: (1) Social Organization — where information on the main characteristics of society is presented, including types of associations and spatial separation between individuals or groups of birds. (2) Social Behaviour — where mutual interactions between individuals are described (see e.g. Tinbergen 1953; Krebs & Dawkins 1984). The accounts are largely factual but interpretative comments have been included; often they are purely descriptive. Sometimes, very little is known on the species; if so, information has been gleaned from published notes or personal observations of naturalists and ornithologists. When possible, the material has been prepared in consultation with ornithologists having special knowledge of the species concerned. By presenting the facts, the accounts will provide a source for use in future analyses of the behaviour of the species and taxa. When possible, the accounts have been standardized and follow the style given below but some flexibility has been maintained to accommodate details on some species.

SOCIAL ORGANIZATION

This concentrates on the relations between individuals or larger assemblages of birds, and their dispersion within the habitat. For general reviews of this topic, see especially Lack (1954, 1968), Wynne-Edwards (1962), Crook (1965, 1970), McKinney (1973) and Wilson (1975). We begin by giving an impression of the social grouping typical of the species, i.e. gregarious (in family parties, flocks), in pairs or solitary. The rest of the paragraph summarizes seasonal changes from the typical pattern, and gives details of flocks, i.e. size, sex and age composition. The account then proceeds under three subheadings (usually three separate paragraphs): **Bonds**, **Breeding dispersion** and **Roosting**.

BONDS The type of mating system (the social organization of the breeding unit, especially relating to copulation and breeding cycle) is presented in terms of pair-bonds between individuals and share of parental care taken by birds involved in breeding. Pair-bonds are normally heterosexual; although homosexuality is common in captive birds, it is rare in the wild. Generally pair-bonds have been treated as (1) monogamous, (2) polygynous, (3) polyandrous. When no true pair-bond is established, it is termed (4) promiscuous. Within a species these mating systems are not always mutually exclusive. (1) **Monogamy** is the most common system in birds and often involves joint care of the young. The bond between a single male and female can be: **seasonal**, being for all or part of one breeding cycle, a new partner being obtained next cycle; **sustained** or **long-term**, where the bond is kept for a longer period, with or without breaking the association during the non-breeding period; **life-long**, where the bond is maintained until death or disappearance of partner. Other than in seasonal monogamy, a pair is said to **divorce** if one member pairs with a new mate when their old mate is known to be alive (Richdale 1951). The general term for pairing with two or more individuals is **polygamy**. (2) In **polygyny**, during one breeding cycle a male typically bonds with two or more females, each female often caring for her own brood without any help from the male. (3) The least common system is **polyandry** where, during one breeding cycle, a female bonds with two or more males, each male usually caring for his own brood without help from the female. Polygyny and polyandry may be either **simultaneous** or **successive** (serial). In polyandrous species, the female often plays the leading part in advertising and courtship and may also be the larger and brighter sex. Some polygamous species form **harems** where a male and a group of females (**mate-defence polygyny**) or a female and group of males (**mate-defence polyandry**) associate together. Others form **leks** where males (**male-dominance polygyny**) and occasionally females (**female-access polyandry**) display and are visited by the opposite sex solely for copulation. (4) **Promiscuity** is when birds pair only for mating. It may be the only type of sexual relation in a species, or it may be an additional feature to one of the mating systems listed above e.g. individuals maintain stable pair-bonds with their mates while having promiscuous matings with other individuals of the opposite sex. Promiscuity may be **species-characteristic** (frequent and widespread) or **casual** (only occasionally seen). After discussing pair-bonds, we present information, if available, on sex-ratios, age of first pairing, and stage of the annual cycle when pair-formation starts and ends. A summary is given of contributions of individuals of a pair or family to breeding, which covers the topics of co-operative breeding and parental care. Aust. has a large number of co-operatively breeding species (Ford 1989; Russell 1989) but, as none of the species covered in this volume breed co-operatively, introductory details will be presented in a later volume. Details of division of labour between pairs are sometimes given here;

elsewhere it was more appropriate to include these details in the paragraph in Social Behaviour on **Relations within family group**. Finally any associations outside family group are included e.g. créching.

BREEDING DISPERSION Though this paragraph mainly focusses on breeding birds, some information is given on non-breeding territories. The species is usually categorized as a solitary or colonial nester, although sometimes it may adopt either. Any details, if known, are given on distances between nests. A species may also be territorial, non-territorial or both (depending on time of year, habitat etc.). A territory may be best defined as 'any defended area' (Noble 1939; but see Emlen 1957) occupied exclusively by a single bird, pair or larger social unit. It is usually, but not always, fixed in space, has clearly defined boundaries and ownership is proclaimed with distinctive behavioural displays and vocalizations (Davies 1980). Nearly all information relating to territories, including outside breeding season, is presented at this point. Size, important characteristics of habitat and seasonal changes are detailed, as are activities restricted to territories. For information on functional categories such as feeding territories, breeding territories, and further general details see Lack & Lack (1933), Nice (1941), Hinde (1956), Tinbergen (1957), Davies (1978) and Davies & Houston (1984). If known, data are also given on home-range — the area in which individuals, pairs or groups of birds are active.

ROOSTING This deals with the roosting (sleeping) and loafing (comfort-behaviour e.g. resting, preening) patterns of the species. Birds may roost or loaf solitarily or communally; nocturnally or diurnally. We then summarize: sites, e.g. protected, unprotected, traditional, temporary; seasonal changes; arrival and departure times from roosts; other factors known to affect patterns, e.g. tidal regime in birds using littoral habitats for feeding. For review of functions of communal roosts see Ydenberg & Priss (1981), Amlaner & Ball (1983).

SOCIAL BEHAVIOUR

This section is largely restricted to describing the interactions between individuals of a species, leaving interpretation to the reader. Causal analyses of motivational factors involved in displays have generally been considered to be beyond the scope of this work. Usually the material has been divided into three main categories (ordinarily presented as three paragraphs) — **Agonistic behaviour**, **Sexual behaviour** and **Relations within family group**. Often little is known and categories have been omitted, combined, or sometimes, when most observations occur at the nest, presented as one paragraph headed **Behaviour at site**. Generally, much emphasis has been given to describing visual DISPLAYS, these being loosely defined as movements (e.g. those associated with nest-building, comfort-behaviour etc.) that have become specialized (ritualized) signals in social communication (see e.g. Daanje 1950; Tinbergen 1952; Morris 1956; McKinney 1965; Smith 1977; Krebs & Dawkins 1984). Because they are more easily made, observations of displays and behaviour are often based on birds in captivity. This is especially true of the ducks. Some attention is paid to calls and other auditory signals, but generally these are dealt with in the Voice section. Display names follow those given in the major references and are customarily given initial capital letters. Use of the same or similar names for displays in different species does not imply homology. The following outline for the account was adhered to when possible but sometimes it has been inappropriate to present the material in this manner.

The introductory paragraph first gives an idea of how well the species has been studied, and the major references and ornithologists that have contributed to the account. Often references are given only at this point to allow for easier reading by avoiding continual repetition. Thus, the reader can assume that all the material has been extracted from these initial references. This is followed by comments on the ease of observing, and the conspicuousness of, displays; aspects serving to integrate members of a flock e.g. flight-intention signals; lastly, any particular behavioural attributes that are not covered in the three main categories mentioned above e.g. comfort-behaviour.

AGONISTIC BEHAVIOUR This section concentrates on behaviour associated with conflict, centering on displays and observations related to threat, attack and defence. Birds may compete for food, nesting and roosting sites, and mates. Most aggression occurs within a species but limitations in some resources also lead to aggression between species. The paragraph begins by giving the distance round itself that an individual defends. This may be a small area centred on itself, its mate or family, or it may be a larger territory; it may vary seasonally or according to the activity the bird is performing. This gives the reader an idea of the circumstances in which conflict may arise. Most of the rest of the paragraph describes behaviour related to the passage from threat to fighting, including any appeasement displays to avoid attack, or submissive displays during attack. When **threatening**, an individual repels or intimidates an opponent without actually fighting. **Fighting** is used here to denote physical contact between birds. It is rarely used by birds as it carries risks of exhaustion, injury or death, but it is often described as it is conspicuous. **Appeasement** and **submissive** displays serve to reduce the aggressiveness of the birds to which the displays are directed. Details are then given on **escape** behaviour, triumph ceremonies and social dominance. 'Ceremony' is the usual term for mutual displays between paired birds, a **triumph ceremony** being one which follows a successful aggressive encounter. **Social dominance** behaviour may lead to groupings such as hierarchies and peck-orders, and reduces the likelihood of attack, see e.g. Pulliam & Caraco (1984). Such behaviour when recorded for captive birds should be treated cautiously as it may only arise in conditions of artificial crowding. Then follows a description of any **anti-predator** behaviour, e.g. distraction displays such as injury-feigning or mobbing. However, sometimes anti-predator behaviour is best placed in the **Relations within family group** paragraph as it often deals with the communication between parents and young. For more information on aggression see Maynard Smith (1979).

SEXUAL BEHAVIOUR Signal patterns are most explicit between mates or potential mates during pairing and breeding. This category describes interactions between birds, usually of the opposite sex, during these times. When a number of birds gather to display, it is termed communal. Many of the displays of pair-formation or pair-bond maintenance reduce aggressiveness between partners or potential partners. The term **courtship** has been used broadly to mean behaviour between the sexes at, or before, the onset of breeding, including that between established pairs or individuals attempting to form pairs. When possible, it is presented more specifically under the headings of Advertising, Pair-formation, Courtship-feeding, Greeting and Allopreening and where and when each of these activities occurs. **Advertising displays** can

have a dual function: that of repelling rivals from territories and attracting a mate to territory. However it is usually treated here rather than in Agonistic behaviour. In **pair-formation**, where there are complex behavioural features, special headings are sometimes needed: e.g. Water-courtship in the Podicipedidae (grebes), Pursuit-flights in the Anatinae (ducks). **Greeting** displays are observed when members of a pair meet after temporary separation and are often associated with change-over at the nest. Such displays are often seen in colonially nesting birds. Also mentioned is any special type of searching behaviour performed if a pair loses contact. Sometimes, displays between pairs seem unrelated to courtship and are more extensive than greeting displays, and we have used the heading **pair-bond maintenance**. In **courtship-feeding**, generally seen only in pairs, one partner feeds its mate, which usually begs in a manner similar to begging in young. If it occurs in a species, it is most often seen before laying but may continue during incubation (see e.g. Lack 1940; Krebs 1970). The degree to which this activity is ritualized can vary and in extreme cases no food is actually passed between the birds. **Allopreening** (Cullen 1963) may or may not be ritualized and may be performed by the pair simultaneously, reciprocally or unilaterally. **Copulation** is usually the final topic covered and includes details on pre- and post-copulatory behaviour, and speed, frequency and conspicuousness of copulation. Any revival of sexual activity outside the breeding season is also given at this point.

RELATIONS WITHIN FAMILY GROUP This section outlines both behaviour of young and between members of a family, and how this changes over time. Sometimes it includes social aspects between members of a pair that are related to nest-building, incubation and chick-raising and that have not been covered above (in some instances overlaps with material in the Breeding account). The main intention, however, is to describe behaviour associated with feeding of young and aspects of communication between adults and young, and between siblings. Sometimes it has been more appropriate to treat anti-predator behaviour, including the alarm signals given by adults and the responses of young, here rather than in the agonistic paragraph.

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VOICE

A full introduction to this section is deferred until a later volume because at that stage a text will be needed to do justice to the detailed problems of dealing with descriptions of voice for true songbirds. Then we intend to deal with developments in methods and equipment for sound-recording and the proper documentation and storage of reference material; we shall give much closer treatment to details of analysis and quantification of sounds and hope to review, briefly, matters concerning production and reception of sound in the bird and the rapidly advancing knowledge of the importance of sound in the behaviour of birds. For the present it is recommended that the reader consult appropriate sections in Bennet-Clark (1981), Campbell & Lack (1985) or the references listed below, for clarification on many matters and, for more technical details, the excellent account given in the revised Introduction to the section on 'Voice' in Volume 5 of BWP (pp 21–32). We have prepared much of this present section from these sources.

The vocalizations of birds have been of interest for a long time. The history of human interest in bird songs and calls dates back to earliest literature and is discussed in detail by Armstrong (1969). However, the scientific study of vocalizations of birds has developed only recently. Recent advances are almost solely due to the development of light-weight recording equipment (particularly tape-recorders [reel-to-reel and cassette] and directional microphones) and the development of the audio spectrograph, which allows us to print a visual impression of a sound (see later). All the same, there has been little scientific study of the vocal behaviour of birds or of the role of sounds in their life-histories in A'asia and Antarctica; there is much work to be done. It is lamentable that few observers take any serious interest in bird calls, though today good quality sound-recording equipment is readily available. We know little about most of the species covered in Volume 1 but many are better known than species to be covered in future volumes. As said in BWP (Vol. 5), 'Comprehensive and critical studies exist as yet only for a small minority. Most authors have felt compelled by this situation to confine themselves to piecemeal assembly of odd scraps of information, too often merely copied, with variations, in one work after another.' We have experienced the same difficulties but hope that by presenting in many cases what meagre data we have been able to assemble it will be much easier to see where critical observation should be profitable in future.

Primarily, vocalizations of birds are controlled by the syrinx, which is located at the base of the neck and in the thoracic cavity at the junction where the trachea divides to

enter the two bronchi that in turn lead to the lungs. The syrinx varies in complexity but is generally bony and cartilaginous with membranes that are set in vibration by the passage of air. Some groups of birds have specialized modifications associated with the syrinx in the form of swellings on the trachea. Notable among birds in this Volume is the presence of a tracheal bulla, often very complex, which is important in production of sounds in males of many Anseriformes. The mechanisms of the syrinx and sound production are still imperfectly known and much work remains to be done (see Greenewalt 1968; Warner 1972; Brackenbury 1982; Gaunt 1983; Gaunt & Gaunt 1985; Nowicki 1987; Fletcher 1988).

The functions of vocal signals are an integral part of the social organization and behaviour of many species and we are beginning to realize the importance of vocal signals and communication. In field identification, the usefulness of sounds is often underrated but has become increasingly important, e.g. to ecologists engaged in surveys. In nocturnal species, vocalizations are often well developed and have an important role, often replacing visual displays (e.g. in many Procellariiformes, Strigiformes). They are used for communication within and between species and can have different meanings in different circumstances. However, functional analysis of vocalizations is complicated and has been attempted for only a few species in our region. It is often difficult to ascribe a function to particular sounds and we have avoided doing so unless there is good evidence. It can be said, however, that vocalizations function to: (1) attract mates; (2) repel conspecifics, especially in the circumstances of territorial behaviour and defence; (3) allow individual members of pairs or parents and chicks to recognize one another; (4) maintain pair-bonds; (5) attune partners or a group to one another. Vocalizations have been shown to be important in some very specific circumstances, e.g. playback of male vocalizations stimulated laying in captive Budgerigars *Melopsittacus undulatus* (Brockway 1962, 1965).

VOCALIZATIONS, SONGS AND CALLS Vocalization is a term that covers all vocal sounds produced by a bird, both calls and songs. The difference between **calls** and **songs** is somewhat artificial and arbitrary. We use these terms rather loosely, 'call' generally for the more simple and stereotyped vocalizations of most species; however, we use 'song' for a number of species (or groups) where we felt it more appropriate. **Calls** have been defined as usually short, fairly simple vocalizations, usually used by both sexes, throughout the year and often given in response to particular stimuli. **Songs** are generally more complex and longer vocalizations and are generally restricted to males during the breeding season, though are sometimes given by females; delivery is periodic, can occur spontaneously and is often given from particular perches or sites and associated with specific postures (Catchpole 1982; Campbell & Lack 1985; Konishi 1985). The term 'song' is often used only for song of passerines (Konishi 1985). In this sense, song is a relatively complex pattern of utterances that may be repeated exactly, and so is recognizable not only at the level of species but often at those of groups and individual (BWP). Individuals have a **repertoire** of distinctive songs or calls that may range from one song or call to many hundreds. Songs or calls are distinct combinations of phrases, notes or syllables; phrases are made up of **syllables** that are discreet units of a song or call that may be repeated within or between songs; syllables may be individual notes or a combination of notes. **Notes** (sometimes called elements) are defined as a continuous trace on a sonagram (see later) and are the main units of songs. Notes vary enormously in structure and frequency (pitch; see later). A **song-bout** is a period of continued singing.

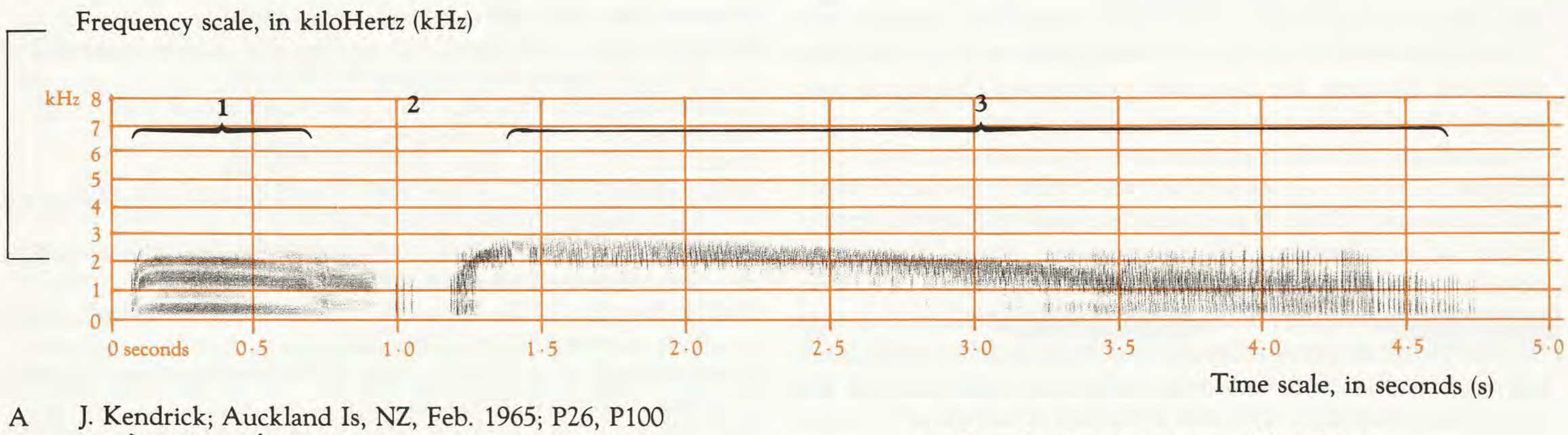
DESCRIPTIONS OF SOUNDS Sounds of birds are difficult to put into words. There are several components to the vocalizations of birds that need to be described. Frequency (pitch); amplitude (loudness); rhythm and tone or *timbre* (the quality of sounds). The latter is difficult to convey but requires words to indicate purity, harshness, sweetness, nasal quality; 'reedy' or 'flute-like' and so on. These can be important descriptions because tonality is more difficult to interpret from sonagrams (discussed later) than the other characteristics, except with experience, but it can be crucial to a good description of voice. Tonal quality is the means by which we can recognize a violin from a piano, an oboe from a clarinet. It is complex and concerns, among several factors, the nature of the harmonic structure of the sounds and often the transients or brief initiating noises that precede and may follow the steady state of a particular sound. Words simply cannot do justice to all of these matters and that is why the objective understanding of bird vocalizations had not made much progress until it was possible to record their utterances, so that they could be played back again and again, and until the sounds could be quantified in some way. The application of frequency spectrum analysis has been the means by which insight has been gained.

Phonetic renderings of sounds are a crude and subjective attempt to convey the quality and sound of a vocalization; they are often quite inadequate in dealing with complex songs, and even more so where there is much variation. Nevertheless, any competent descriptions accompanied by syllabic renderings can tell us something useful about the pattern, pitch, and tone of a vocalization. Onomatopoeic renditions are often wide of the mark. Our perception of the sounds made by birds is often erroneous; one common fault, for example, is the difficulty that human hearing has with the rapid onset of many bird utterances that leads us to think we hear a starting consonant; in fact this is almost always untrue. Thus to convey correctly the sound of a call in words it is usually necessary to use consonants even though a bird sound usually does not have them. Generally the vowel sounds give fewer problems because they are longer. Phonetic renderings are highly subjective and descriptions of the same sound by different field workers often vary. Rarely are one's expectations from reading a phonetic rendering matched in the field. However, many bird-watchers and ornithologists who are unfamiliar with sonagrams prefer using phonetic renderings to gain an insight into the type of sounds a bird makes. Indeed, such renderings are often simplified to mnemonics.

We usually try to describe sounds using phonetic renderings. However, we have made no attempt to standardize these renderings and have relied upon published sources or information supplied by our contributors, though we have, when possible, tried to indicate whether published examples are appropriate for the known vocalizations.

SONAGRAMS Sonagram is the trade name for prints from a Kay Elemetrics Corp. 'Sona-Graph'. The sound spectrograph or audio-spectrograph is an instrument that produces a frequency-spectrum-analysis. Most simply, sonagrams are graphs of frequency (pitch) against time (Fig. 1). Sonagrams are a permanent visual record of sounds. Sonagrams show, for example, the structure of a call or song, its duration, rate of repetition, intervals between utterances or the parts of utterances and the sound-frequencies involved. All sound is cre-

Fig. 1 Sonagram



ated by vibration; some vibrations are too slow and others too fast for the human ear to detect. Sound travels in waves and frequency is a measure of vibrations in these waves. Sounds of low frequency have long wave-lengths; sounds of high frequency have short wave-lengths. The frequency of a sound is the main factor that determines the subjective pitch (which is the auditory perception of frequency); however, pitch varies with time, intensity and complexity of the sound (Hinde 1969).

Frequency is generally measured in cycles per second, the unit being a Hertz (Hz); scale is often given in kiloHertz (kHz). The higher the number, the higher the frequency or pitch of the sound and, on the sonagram, the higher above the baseline will be the trace. In conventional sonagrams, the frequency scale is portrayed as linear. Harmonics are exact doubling of frequency so that the musical notation of octaves expands through the range thus: 1–2 kHz is an octave; 2–4 kHz an octave and 4–8 kHz an octave. About five octaves fall below about 1 kHz but discrimination to the human ear is poor in the lowest part of this range. Most bird calls fall within the range of 1–8 kHz and are readily heard by the human ear. As a guide, the keyboard of the piano ranges from 27.5 Hz at bottom A to 4186 Hz at top C, with middle C at 261.63 Hz, and the human voice has peak energy levels (relative power) at about 400–600 Hz in men and 800–1000 Hz in women (Tremaine 1959). The smallest interval perceived by the human ear can be as little as 2 Hz. A semitone (the smallest musical interval in western music — the 12 keys on the piano through one octave), is about 60 Hz at the frequency of 1 kHz and therefore is easily measured in that part of the range or above on the sonagram. Many sounds have simultaneous emphasis of several frequencies; very often these frequencies are related as harmonics and these harmonics are the components of a sound wave that has frequencies that are simple multiples of the fundamental frequency. The **fundamental frequency** is the lowest component frequency of a complex sound wave. **Amplitude** is a measure of changes in air pressure of a sound; in a wave, it is measured as the maximum displacement of the wave. Amplitude is measured in decibels (dB), which is a relative term, but we give no precise measurement of amplitude in this Volume and need not discuss this unit further. Sonagrams readily show that sounds differ or resemble each other and allow similarities in calls or songs of different species to be objectively compared. Sounds that are identical can be recognized. Changes in pitch are easily seen; a monotonic whistle will show as a horizontal line for however long the whistle is held; a sound falling in pitch slopes downward from left to right; a sound increasing in pitch slopes upwards from left to right. Sonagrams also show amplitude (loudness) of a sound by the darkness of the tracing on the print. Contrary to many expectations, few bird sounds occur at high frequency but energy levels are often very high at frequencies where the sensitivity of the human ear is falling. Time resolution of sounds by birds is thought to be much better than in humans but there is some controversy on this matter (see Dooling 1982). Sounds fuse at about 50 ms intervals or less to the human ear, but it has been suggested that birds may be able to discriminate sounds only 5 ms apart.

RECORDINGS Rather few studies of vocalizations of birds have been attempted in A'asia but there has been much interest in sound recording. At present, in Aust., recordings of all indigenous birds are being compiled and published (Buckingham & Jackson 1983, 1985, 1987, 1988, 1990, and in progress) and similarly for NZ (McPherson 1988, 1989a,b,c, and in progress). Fullagar & Robinson (1987) provide a guide to published discs and cassettes (likely to be available) and other sources of recordings of Aust. birds. Recordings of most Aust. and many New Guinean, NZ and Antarctic species are lodged with the ANWC — represented by the CSIRO Collection of Wildlife Sounds held at CSIRO Div. Wildl. Ecol., Canberra. In NZ, many recordings are held by NZ Wildl. Serv. Sound Library, NZDOC, Wellington. For more details on these and other major libraries of wildlife sounds see Kettle (1989).

The diversity of research on vocalizations of birds has resulted in many general reviews of the topic; important references are: Thorpe (1961), Hinde (1969), Thielcke (1976), Jellis (1977), Catchpole (1979), Kroodsma & Miller (1982) and Baker & Cunningham (1985) for dialects.

ARRANGEMENT

The Voice section is organized in two main parts. The first paragraph provides a general introduction to the species: any detailed studies (those that analyse voice and particularly include sonagrams); the main source(s) of information; how noisy or quiet the species is; general quality of vocalizations; periods of calling — daily, seasonally and annually; locations of calling (e.g. at nest-sites, over colonies). Individual and sex-

ual differences and geographical variation in vocalizations are also discussed here. Non-vocal sounds are noted. Generally, we discuss all variation in sounds, regardless of scale over which that variation occurs, including dialects or geographical variation. Dialects are discussed only when they have been specifically discussed in a paper. The concept of dialects in vocalizations of birds is still controversial (see Baker & Cunningham [1985] and commentary and references therein for a full discussion). Dialects are a discrete and well-defined 'population' of vocalizations (e.g. song-types) shared by a local population of birds or subunits of that population. They occur when a population of birds uses a similar call- or song-type (or repertoire of types) different and discrete from neighbouring populations. Non-vocal sounds are summarized at the end of the first paragraph. The rest of the section deals with vocalizations and other sounds of adults and young. The descriptions are split into separate paragraphs for male and female if sexes differ. The last paragraph describes vocalizations of chicks and juveniles and, where known, the development of adult vocalizations. For reviews of the ontogeny of bird song see Konishi (1985).

Sonagrams have been included when recordings were available. Recordings from published sources have been preferred (specially those included by Buckingham & Jackson 1983, 1985 and McPherson 1988, 1989a,b; mentioned above). Other recordings were sought only when these first sources did not include the required sound. Reference to the actual sound used for many sonagrams is therefore possible and the sound can be checked. Several other published recordings were needed to cover the full range of species included in this Volume and the full list is as follows: Bigwood & Bigwood (no date), Wildlife Service (1980), Scott & Dudderidge (1982), Crouch (1982), Griffin & Swaby (no date), Hutchinson (1972, 1978) and Gillard (1988). For some species published sound recordings were not available and recordings were sought from various sources. The British Library of Wildlife Sounds, London, kindly supplied material. Recordings held by The Library of Natural Sounds, Cornell Laboratory of Ornithology, Ithaca, New York, the CSIRO Collection of Wildlife Sounds, Canberra and some uncatalogued material from private sources were needed to complete our coverage. Many sounds could not be illustrated because we could not trace an appropriate recording and most species accounts fall far short of being comprehensive; for most species we can do no more than present some of the more common and well-known vocalizations or other sounds as sonagrams. Captions to each sonagram indicate details of source, date and locality of recording and recorder. All recordings were analysed in the sound laboratory of the CSIRO Division of Wildlife and Ecology using a Kay Elemetrics Corp. 7800 digital storage Sona-Graph and a Kay 7900 hard-copy printer. We are specially indebted to Sir Frederick White FRS, former Chairman of CSIRO, who generously made possible the purchase of this equipment with the intention that it be used in part for the HANZAB project. All sonagrams are reproduced direct from the original prints to retain the true tonal contrasts but, as far as possible, irrelevant sounds (background noises and intrusions) have been eliminated. All recordings were analysed using 0–8 kHz scale with a 300 Hz analysis filter. Each sonagram is shown with a contrasting overlay (red) giving scale for time divisions at 100 ms and frequency divisions at 1 kHz.

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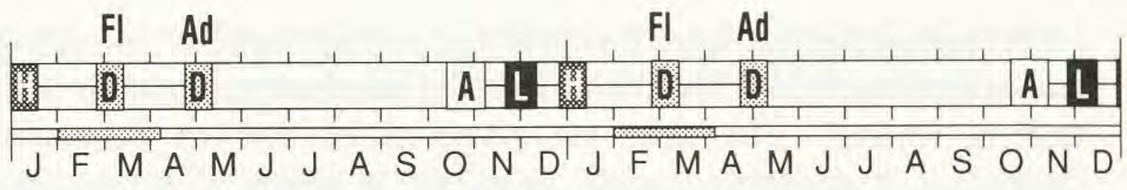
BREEDING

This section starts with a paragraph that briefly outlines the chief sources of information, mentions the contributor of the information and summarizes the sort of breeding habits and habitat of the species. The chief references are identified with the place at which the work was done. Thereafter in the text, reference is made only to the place where the observations

were made and it can be assumed that the reference is to the publication already mentioned for that place. In this way, we avoid a litany of bracketed references throughout, which can only irk a reader. The section is divided into subsections for Breeding Season, Nest-site, Nest and Materials, Eggs, Clutch-size, Laying, Incubation, Young (Nestling), Growth, Fledging to Maturity and Breeding Success.

SEASON. We take the view that breeding seasons can be determined only by reference to the date of laying of the first egg in a clutch. Pre-laying activity that heralds nesting, such as displays, pair-formation and the like, cannot be timed so exactly and varies in duration. Once a clutch is started, all other breeding events (hatching, fledging, etc) follow inevitably and their timing can be calculated if the periods of incubation and fledging are known. Moreover, once a bird starts to lay, it will go on doing so with later broods or with replacement clutches after loss until something intervenes to stop it, such as regression of the gonads, moult or even inclement weather. Those birds that lay only one egg in a season and make no attempt to replace it after loss or to start a second brood after success are merely the start of a line that ends with species that have multiple broods or will replace losses many times. It is less significant to record young in a nest than to be able to estimate within reasonable limits when the eggs that produced those young were laid. In the accompanying diagrams of annual breeding cycles (see below), we have therefore tried to emphasize the period of laying. These diagrams are in linear form and not in the customary circular form because the linear form saves space, allows the depiction of events at more than one place and is the only convenient way of displaying the breeding cycle of species that breed only in every second year. The breeding season is so sketchily known for some species that a diagram is not worthwhile; it could only mislead. Most pelagic species such as penguins and procellariiforms have synchronized periods of laying and their annual cycle is well adapted for the linear form of diagram where also periods of hatching, crèching, fledging and moult can readily be shown to help people to see quickly when the birds are likely to be at different stages in the reproductive cycle. On the other hand, diagrams are difficult to draw for many species of waterbirds in Aust. For various reasons, the nests of some species of cormorants, herons, ibis, ducks and others are hard to watch systematically, and in consequence, exact data for many aspects of their nesting are few. Such as there are generally provide little information beyond occupation of active nests and have been reported in such a way that ageing of the nest is mere guesswork. Yet, it seems that for many widely distributed species, populations in n. Aust. lay mostly in autumn to spring (Apr.–Aug.) whereas those in s., se. and sw. Aust. lay mostly in spring and summer (Sept.–Jan.). Undoubtedly, many of these species have protracted laying periods but for all or most of them the matter is greatly complicated by the influence of erratically fluctuating wet and dry conditions that cannot be predicted. Thus, what happens in a locality in one season is a poor guide to what will happen in the next. The facts, such as we have judged them to be, are given in the text, supplemented by a diagram where it seems justified, but there is still much scope for observers to correct and improve our interpretation.

Diagrams of breeding cycles. For many pelagic and colonial species (e.g. Fig. 1), we show dates of arrival, laying, hatching, departure and other events, such as formation of crèches, fledging (before departure) and independence of young. For other species, mostly land birds (e.g. Fig. 2), we



Fl = departure of fledgelings.
Ad = departure of adults.

Fig. 1 Chinstrap Penguin

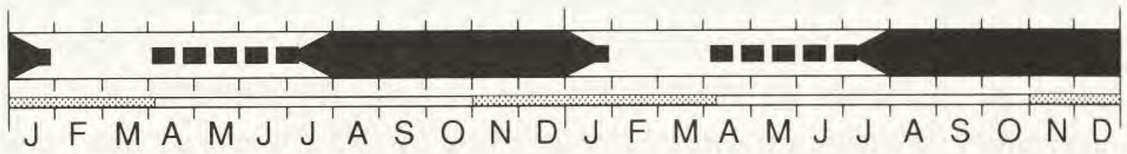


Fig. 2 Freckled Duck

LEGEND

A	arrival	L	laying	H	hatching
Cr	crèche formation	D	departure		

Other symbols used are explained at the base of the figure.

simply show when eggs are laid, by a solid black bar, which may taper to show increases or decreases in laying; black dashes indicate when eggs have been found. When available, information on primary moult is shown in the narrow bar below.

NEST-SITE, NEST AND MATERIALS. Most species dealt with in Volume 1 do not place their nests in obviously special sites, build rather simple nests, if any at all, and for the most part use any material that is at hand. Measurements of all sorts relating to aspects of sites, height above ground, depth of water, size and shape of nest and so on are mostly imprecise. In consequence, information on these matters is usually generalized. The subject could as well be treated under one heading and usually needs further investigation. However, we have tried to make a distinction between the precise siting of a nest and the nest itself, even if that is not clear in, say, species that nest in burrows. Broader aspects of nesting habitat are given under Habitat. Material used in nests is not often described in detail in the literature and often we can only follow with generalizations. The roles of the sexes in selection of sites and building, and the pattern of building, are also not well recorded and often need further investigation.

EGGS. The shape, texture and colour of eggs are described briefly, mostly after descriptions by earlier authors like Campbell and North. Measurements are always in millimetres arranged as average length (standard deviation, if available; range; size of sample) x average breadth (SD; range). The size of the sample thus ranges from satisfactorily large (>50) to very meagre (<10) or even to measurements of single eggs. Where possible, measurements from different parts of the breeding range are given. Because so many different species in this Volume lay uniformly white or pale-coloured eggs, descriptions even with illustrations do not help identification greatly and measurements are more important in this respect. Schönwetter's work (1967, *et seq.*) has been used for some species but we have not incorporated it for others that have been studied well by other workers.

CLUTCH-SIZE. As far as possible, data are presented only from nests in which laying has been recorded to completion (i.e. from the first egg to the same number of eggs for two inspections made at an interval greater than the normal

interval of laying or for those with the same number of eggs on two inspections during incubation at an interval greater than that of laying). The data are given as an average (standard deviation, if available; range; number of nests). If such quantified data are not available, and even sometimes as a supplement to small quantified samples, the range as generalized in standard references is stated, with the qualifying phrase 'said (claimed) to be ...' to show the unsatisfactory state of our knowledge. For those species that lay few eggs (1–2), there are no problems except perhaps for the controversial finding of three eggs in the nests of some penguins. For species with large clutches, there are problems. Nests of colonial species may be difficult to visit with the regularity needed for the accurate determination of completed clutches, either because visits to a colony cannot or have not been made often enough or because nests are not readily accessible. Thus the reliability even of quantified data may be doubtful. Further, there is often a possibility or probability of two females laying in the same nest and that leads on to the supreme difficulty of dump-nesting in ducks. If a respectable sample of critically assessed clutches is not available for a quantified presentation, the few recorded acceptable clutches are given in detail. Where dump-nesting is proved or suspected, there is little to be done beyond mentioning the likely limits of true clutches. Sometimes it has to be admitted that we do not know what the clutch-size of an individual may be. For many species, there is need for more critical observation of clutch-size. Replacement of clutches in a season is discussed in this subsection.

LAYING. Primarily this part is for recording the intervals at which, and the time of day when, birds lay their eggs in a clutch, again a matter that is usually poorly known. Details of synchronization of laying in colonially nesting species, which may have been mentioned in the subsection for Season, are given here.

INCUBATION. The start of incubation, the role of the sexes and the pattern of shifts of incubation are given. For some closely studied species, especially among penguins and petrels, these can be given in considerable detail but in other groups there is often little information. Though these aspects are generally similar among all members of a family or genus and may be inferred without much danger of error, descriptions are given only where the behaviour has actually been recorded. The incubation period is detailed, where possible, as the period from laying to hatching of individual eggs or as the period from laying of the last egg of a clutch to the hatching of the last young. Most of the species covered in Volume 1 have long periods (>25 days) and more variation occurs than in birds like passerines with short periods (<20 days). Moreover, especially among the procellariiforms, eggs may survive quite long periods of desertion. In consequence, there is not much object in trying to express the incubation period within narrow limits because that could give an impression only of spurious accuracy. All the same, more investigation and recording of the period is needed for many species.

YOUNG OR NESTLING. Either term may be used because, though a young petrel that stays in its burrow until fledging may reasonably be called a nestling, a duckling obviously cannot be so described. The state of development at hatching is given first in standard terms (altricial, semi-altricial or precocial) with those for subsequent behaviour (nidicolous, semi-nidicolous or nidifugous) being generally characteristic of whole orders or families. Some description of the young and its plumage development is then given (fuller details in Plumage section), designed, it is hoped, to enable observers to give an approximate age to young seen on a single visit and thus be able to estimate a date for laying of the clutch, which greatly enhances the value of a record. Parental care and the roles of the sexes in brooding, guarding and feeding the young are then described but only when they have been definitely recorded for a species. These activities, being characteristic of orders and families rather than of species, can be inferred to occur in all members of the larger groups but we mention them only if that has been confirmed and recorded. In many species covered in Volume 1, parents feed their young by regurgitation: **complete** if the food is spewed out onto nest or ground; **incomplete** if the food is retained in the parent's beak or throat and collected there by the young. The nestling or fledging period of species in Volume 1 is usually poorly known and often varies quite considerably, being influenced by climatic factors, an irregular food supply or other variables. Moreover, the age at departure from a colony or the first flight of precocial, nidifugous or semi-nidifugous young may be hard to determine. In any case, this period usually lasts for several or many weeks and it is hardly important to determine it closely.

GROWTH. Some details of growth (weights, measurements, etc.) may be given here, as further help towards ageing of young in the field; references are made to original studies or to the Plumage section for full details.

FLEDGING TO MATURITY. The period during which young depend on their parents after fledging or first flight is mostly known very poorly. It may be perfectly correct to assume that the young of pelagic species are completely independent once they go to sea, but for other species there is little known about the matter. Similarly, the ages at which birds first return to colonies, form pairs and start to breed are known in only a few species.

BREEDING SUCCESS. Hatching, fledging and total success are given, even if samples are small and apply only to a single season. They may have little significance for long-lived species in which reliable figures can be had only from long-term studies, especially in erratically fluctuating conditions such as prevail in Aust. Here mention is made of what little is known of predation and loss of eggs and young, mostly greatly generalized.

REFERENCES

Schönwetter, M. 1967, *et seq. Handbuch der Oologie.*

PLUMAGES AND RELATED MATTERS

PLUMAGES

All feathered parts are described here; the rest of the integument is described in the section **Bare Parts**. The descriptions in this section are based on museum skins, unless otherwise stated. The section is intended chiefly for use with the bird in the hand, but may be helpful in other situations. Usually only one subspecies is described; others are covered in the section **Geographical Variation**. Plumages are dealt with in the sequence: adult breeding, adult non-breeding, nestling or downy young, juvenile and immatures. When plumages differ between the sexes, males are described first.

Nomenclature of Plumage and Moult

Two terminologies for moults and plumages are widely used. That introduced by Dwight (1900), with slight modifications, was used in BWP and is generally used in the Old World. The terminology introduced by Humphrey & Parkes (1959) has a

Table 1. Nomenclature of plumages and moult. Plumages are given in bold print, moults in italics. Square brackets denote plumages or moults absent in some birds. Supplemental plumages, which are rather rare, are not included in the table. A few species have more immature stages than indicated here.

BWP	Humphrey & Parkes	Notes
Natal	**Natal**	
Pre-juvenile	*Pre-juvenile*	See also Breeding section
Juvenile	**Juvenile**	
Post-juvenile	*First pre-basic*	Extent varies; generally incomplete
[First Immature]	**First Basic**	
[First Immature 'pre-breeding']	*[First pre-alternate]*	
[Second Immature]	**[First Alternate]**	
[First Immature 'post-breeding']	*[Second pre-basic]*	Complete
Adult, [Adult non-breeding]	**Definitive Basic**	
[Pre-breeding]	*[Second pre-alternate]*	Generally partial
[Adult breeding]	**[Definitive Alternate]**	
Post-breeding	*Pre-basic*	Complete

strong following in North America. We have used the terminology of BWP for all plumages, because it is more familiar to A'asians and more readily applied to bare parts. Sometimes, this terminology may give a misleading impression of a plumage, and then we have also applied the nomenclature of Humphrey & Parkes, or given additional notes, or both. Accordingly, both schemes are summarized in Table 1 and outlined below.

A plumage is a single generation of feathers, which may not include the entire feather covering of a bird; feathers attained by a partial moult also constitute a plumage. Wear of feathers or transitional stages from one plumage to another often affect appearance. Where we have felt it necessary to cover such variation under separate headings we have done so.

In the BWP scheme, **breeding plumage** is defined as that worn during part or all of the breeding season. In some species, the breeding plumage alternates regularly with a **non-breeding plumage**, acquired during the post-breeding moult. In others, one plumage is worn throughout the cycle (defined in glossary) and is termed **adult**. The first pennaceous plumage of a bird is called **juvenile** in all species, even in those in which it appears identical to adult plumage. In some species, juvenile plumage is followed by one or more recognizable immature plumages. These are called **first immature, second immature**, etc. in increasing order of age. If there are no other recognizable plumages, the juvenile plumage is said to be replaced by the first adult plumage.

The above nomenclature for plumages is easily understood, and is also popular because it 'links the various plumages with the phases in the life cycle for which they have evolved' (BWP). However, there are examples in which the nomenclature is inappropriate. For example, the terms 'adult' and 'immature' suggest sexual maturity, or lack of it. This is clearly misleading in procellariiforms, most of which have an adult plumage for several years before they begin to breed. It is equally confusing in Golden Whistlers *Pachycephala pectoralis*; immature males can breed in a plumage that resembles the adult female rather than the adult male. In many species, the above terminology implies a relation between plumages and breeding or development that has not actually been determined. Where the nomenclature of BWP seems open to misinterpretation we have drawn attention to it next to the plumage headings.

The nomenclature for moults and plumages introduced by Humphrey & Parkes (1959) has a terminology independent of other phases in the life cycle. The scheme has also been described by Palmer (1962, 1972, 1988) and Wilds (1989). It is difficult to explain their scheme without mentioning their nomenclature for moult. They named moults by adding 'pre-' to the name of the plumage they produce.

Adult birds that have one plumage per cycle almost invariably lose and renew their plumage in a complete moult. This is called the **basic plumage**; it is renewed in the **pre-basic moult**. The pre-basic moult can also be recognized as a complete moult in adult birds that have two plumages per cycle. These birds have a separate moult, usually partial, termed the **pre-alternate moult**. It results in an **alternate plumage**; birds in alternate plumage generally also have retained feathers (usually remiges and rectrices) from the basic plumage. A few birds have more than two moults in a cycle. The plumage resulting from such an additional moult is called the **supplemental plumage**. It may be worn before or after the alternate plumage.

As in the BWP scheme, the first pennaceous plumage is termed **juvenile**. It can be replaced in a complete moult, but more commonly there are stages of partial moult. The moult in which replacement of juvenile plumage begins must be termed pre-basic, whether it is complete or not, because it is the only moult that can be expected in the first cycle of all birds. In species that have identifiable age-classes for some time, it is convenient to qualify the names of the plumage stages with a numerical prefix. This results in such terms as **first basic plumage**, **first pre-basic moult**, etc. Humphrey & Parkes suggested that the term **definitive** be applied to plumages that do not change any more with age.

Some aspects of Humphrey & Parkes nomenclature have been criticized (Stresemann 1963; Amadon 1966), particularly the underlying assumption that the basic plumage is homologous across groups of birds. Even if this assumption is untrue, the nomenclature often has advantages. Examples in which the terminology of BWP is misleading were mentioned above. There is no misinformation conveyed when an adult procellariiform is termed definitive basic, or an immature male Golden Whistler is said to be in its first basic plumage.

Humphrey & Parkes' nomenclature has not been applied to all plumages in this book, because it is often difficult to use. Partial moults of body-feathers that produce no change

in the appearance of a bird may be undetected in many species, yet strictly speaking the resultant plumage is alternate. Some birds (e.g. some grebes; Piersma 1988b) are in body-moult practically continuously. In large birds, body-moult is often prolonged or obscure. Then it can be impossible to identify plumages consisting of one generation of feathers.

Various terminologies have been used to categorize calendar age (Anon. 1985; Rogers 1989). None seems comprehensive enough for consistent application to all birds in a region extending from the Antarctic to the Tropics. The age of a bird in a given plumage is usually made clear in the moult sections; sometimes additional information is given next to the plumage headings.

DESCRIPTIONS

Plumages are described in the sequence: head and neck, upperparts, tail, upperwing, underparts, underwing. Within these parts, we have generally worked from the front to the rear. In a few of the briefer descriptions, this sequence is modified to save space. Figures 1–21 illustrate the various parts. Some terms are defined in the glossary.

The appearance of individual feathers is described in the wing and tail. For other parts of the plumage, both feathers and general appearance of a given part are described. Where individual feathers are not described, the description of the tract also applies to the feathers (e.g. if a mantle is described as black, it consists entirely of black feathers). Terms used to describe patterns of feathers are shown in Figure 22.

The identity of colour depends on the light in which it has been seen and how precisely it needs to be defined. The greatest problem is that different people perceive colours differently. One man's sepia is another's fuscous, and so on. We have observed all skins in diffuse natural light or under a daylight globe (Phillips 60W Daylight). Names of colours given in the text are simple (e.g. dark brown) so that readers unfamiliar with complex colour descriptions (e.g. burnt umber with a trace of cinnamon) will not be misled. Where two colours are combined the last named colour is most dominant (e.g. buff-yellow is more yellow than buff); sometimes, the suffix '-ish' is added to a colour, denoting a weaker tinge of that colour (e.g. buffish yellow has a weaker tinge of buff than buff-yellow). Further, **light** is darker than **pale**.

The F.B. Smithe *Naturalist's Color Guide* (1975, 1981) has been used for descriptions of all colours. The identification numbers for the closest equivalent from this guide are bracketed in the text, after the simple names of colours. When the match is not particularly close the colour number is qualified, often with the abbreviation c. No numbers are given for colours which have no equivalent in the guide. If we have not been able to compare colours with the guide and if this is not clear from the context, we have denoted such colours (–). The names given to colours themselves in Smithe's colour-guide have not been used; these were used by Smithe only to convey a sense of familiarity. Many (e.g. Pratt's Payne's Gray) are probably meaningless to most readers, and others 'differ from widely held concepts' (Pratt & O'Neill 1976).

BARE PARTS

These are described for the same subspecies as described in the plumages, in the sequence: iris; bare areas on head (if any); bill; leg and foot. Conventions for describing colours follow those used for plumages. Colours of bare parts cannot be studied satisfactorily in museum skins, because they generally change after death. We have therefore relied on colour photographs, our descriptions of recently dead, and live (mostly captive) birds, and on information on specimen labels or in literature.

MOULTS

Nomenclature of moult was partly discussed above and summarized in Table 1. This section summarizes what is known of the pattern and timing of moult; where we have enough information, primary-moult is shown on the diagrams of annual cycle. Sequences of primary, secondary- and tail-moult are given where possible. Primary-moult from the carpal joint to the outside of the wing is called **outwards**; this sequence has often been called descendant in the past. Other terms describing patterns of moult are defined in the glossary. Conventions in numbering remiges and rectrices are described under Structure.

In species for which there are few data, we have recorded or scored moult of individual birds. Moult of remiges and rectrices is recorded with a system in which each feather is scored on a scale from 0 to 5 (Ashmole 1962; Ginn & Melville 1983). An unmoulted old feather is scored 0; a fully grown new feather is scored 5; a feather scored 1 is in pin; scored 2, less than one-third grown; scored 3, between one- and two-thirds grown; scored 4, two-thirds to fully grown. Primary-moult is recorded from the inside to the outside; superscripts denote the number of adjacent primaries of a particular score. For example, the shorthand $N^{6}3^{1}1^{1}0^{2}$ describes the primary-moult of a wing in which primaries 1 to 6 are new, primary 7 is between one- and two-thirds grown, primary 8 is in pin, and primaries 9 and 10 are yet to be moulted. Similar conventions are used for describing secondary- and tail-moults. Secondary-moult is recorded from the carpal joint inwards, and tail-moult from above, from the outer left to the outer right.

A moult-score is the sum of feather scores; we have sometimes applied it to primaries or the tail. In birds with 10 primaries the primary moult-score will lie between 0 (all feathers old) or 50 (all feathers new). Unless otherwise stated, we have scored the moult of both halves of the tail, and the primaries of one wing. We have not recorded condition of moult of the remicle, or used it in moult-scores.

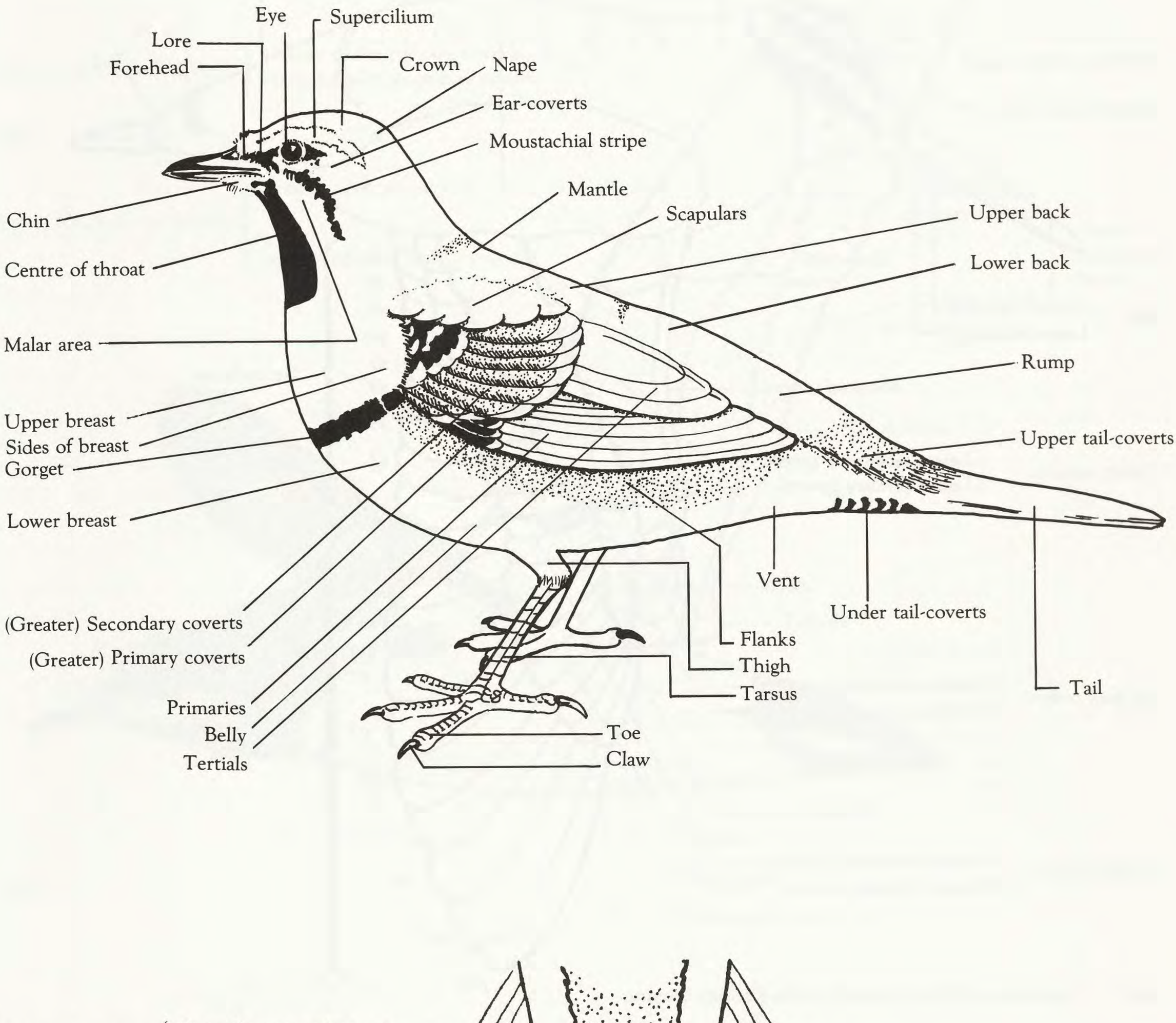
MEASUREMENTS

Measurements taken

For most species, measurements are given for length of wing, eight primary, tail, bill, tarsus and middle toe. Total length of head, and width and depth of bill have also been recorded for a few species. All measurements are recorded in millimetres. Our own measurements of dried museum skins are given. Measurements of skins and of live birds from the literature and other sources are presented separately, because there is variation in measurements taken by different individuals and because post-mortem shrinkage can have substantial effects on measurements. We used the methods described below.

WING-LENGTH. Maximum chord of the wing was measured to the nearest millimetre: from the carpal joint to the tip of the longest primary. This section of the wing is flattened against a rule and straightened as much as possible; maximum chord is thus the longest measurement possible between the carpal joint and the tip of the longest primary. We did not measure wings in which the longest primaries had severe abrasion. Measurements of maximum chord can vary somewhat between measurers, especially because the experienced tend to take longer measurements (e.g. Jenni & Winkler 1989 and

Fig. 1 Cinnamon Quail Thrush *Cinclosoma cinnamomeum*



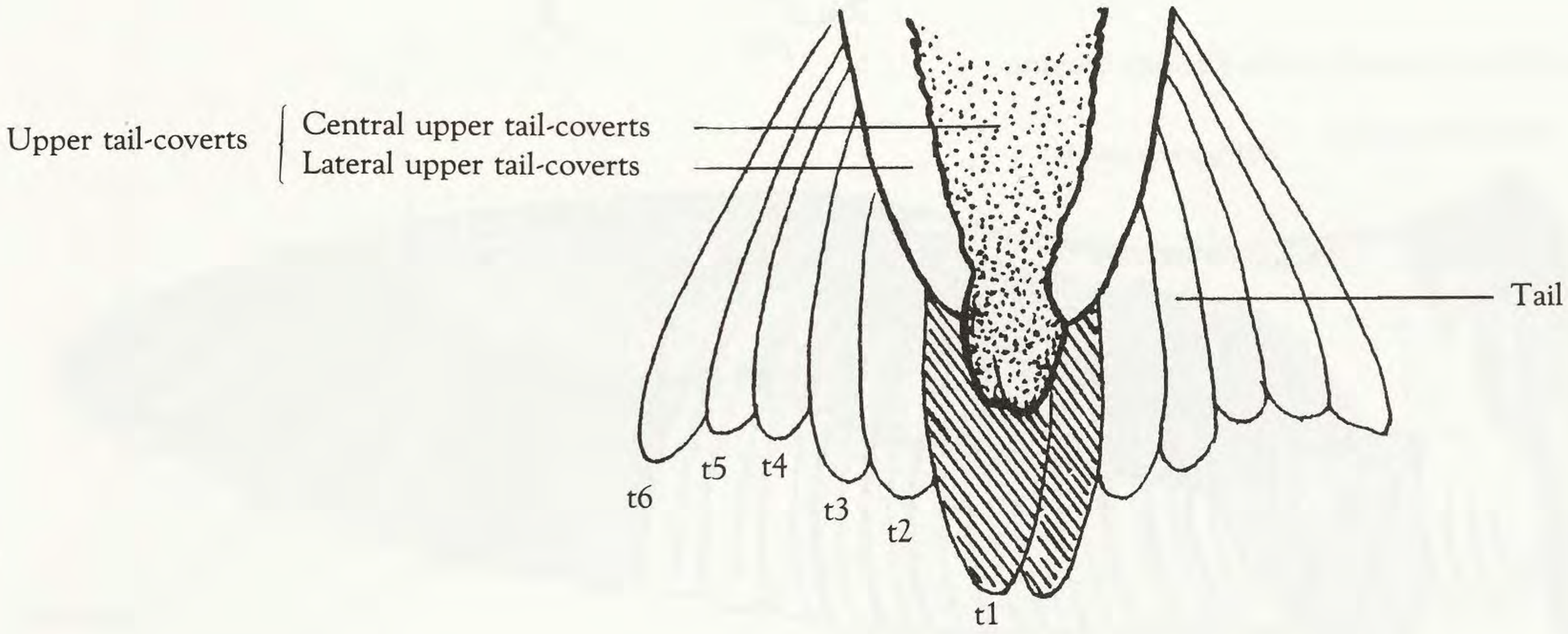


Fig. 2 Tail of Red-necked Stint *Calidris ruficollis*

Fig. 3 Dorsum of Latham's Snipe *Gallinago hardwickii*

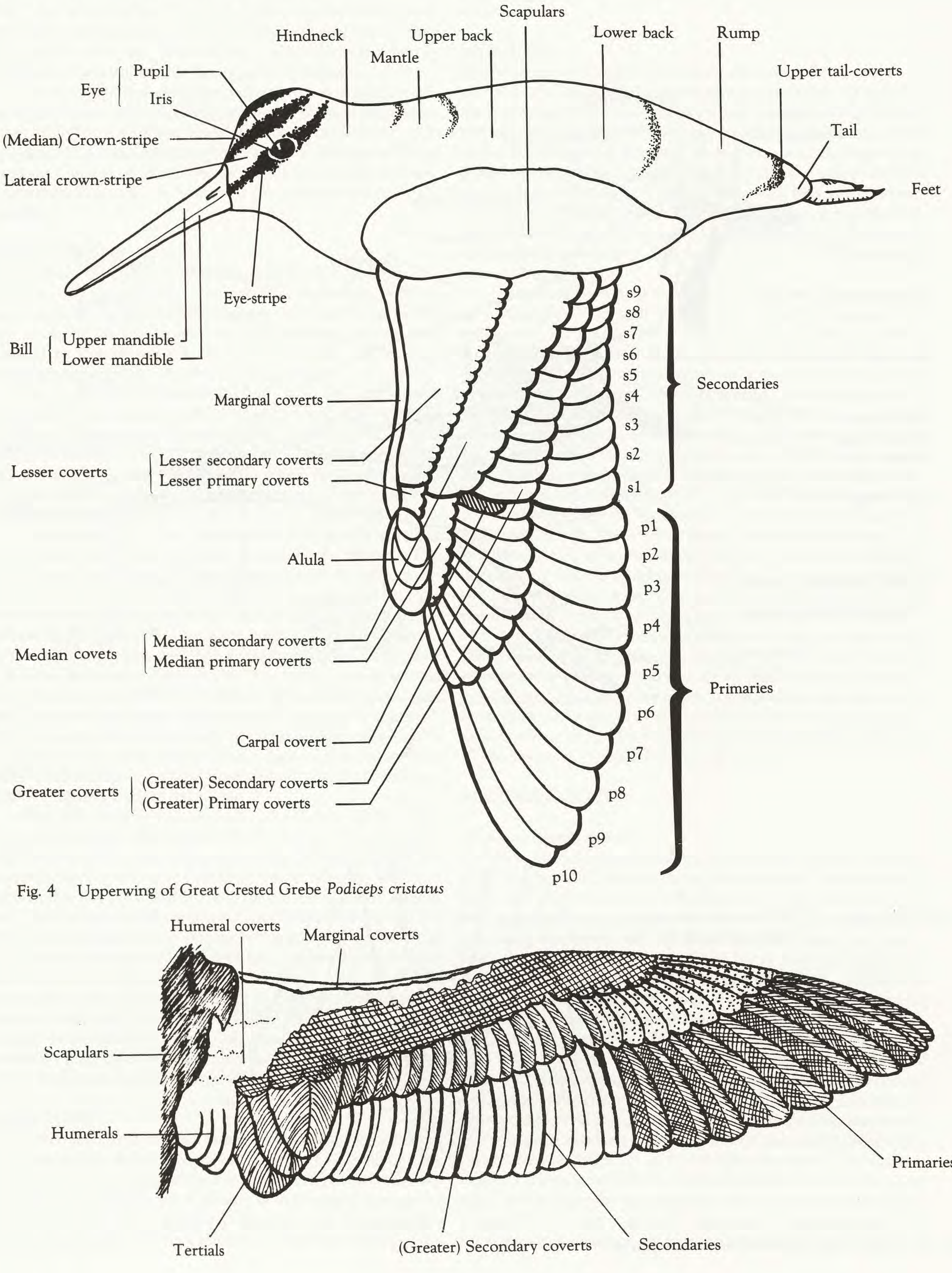


Fig. 4 Upperwing of Great Crested Grebe *Podiceps cristatus*

Fig. 5 Underwing of Fluttering Shearwater *Puffinus gavia*

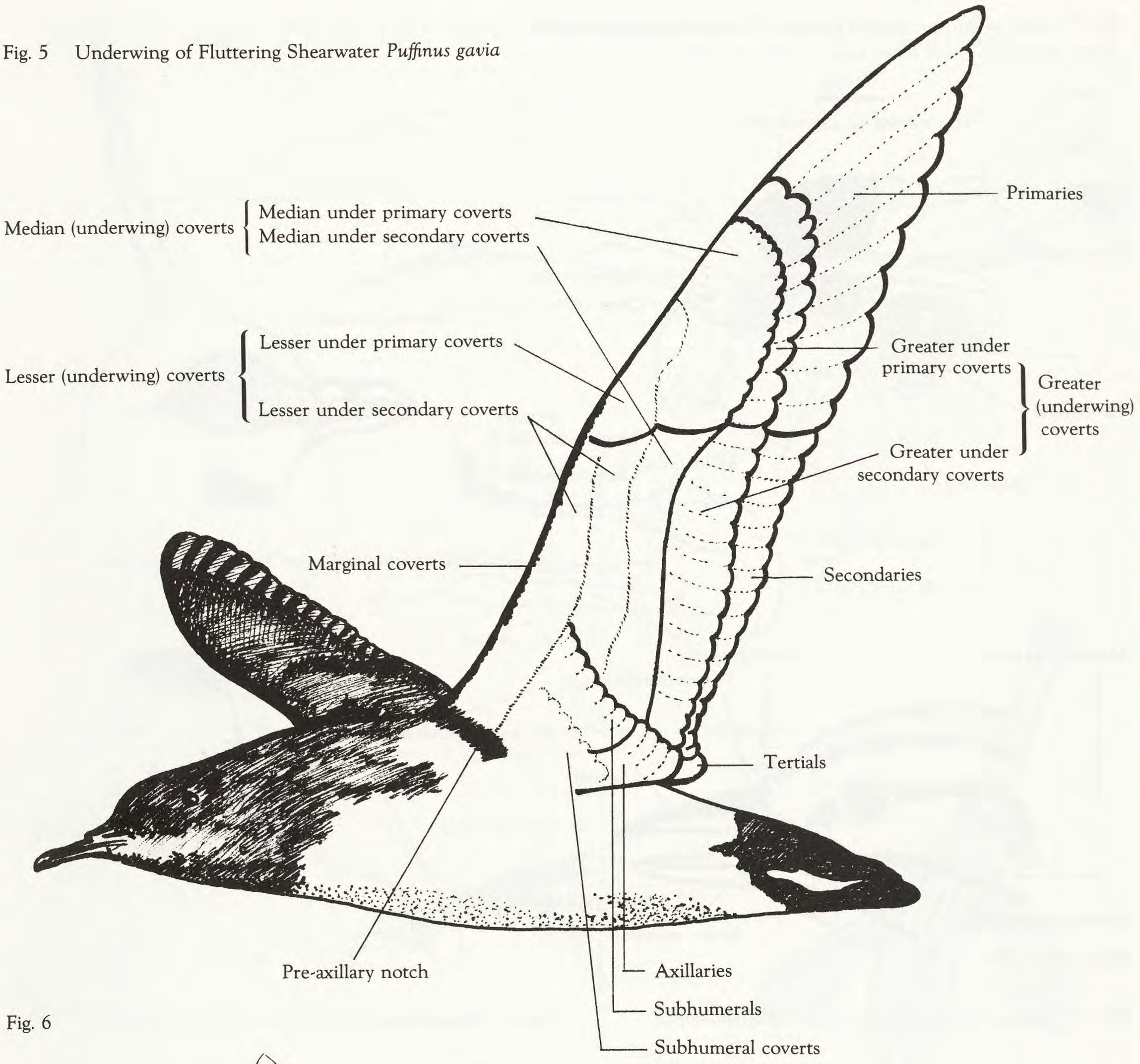
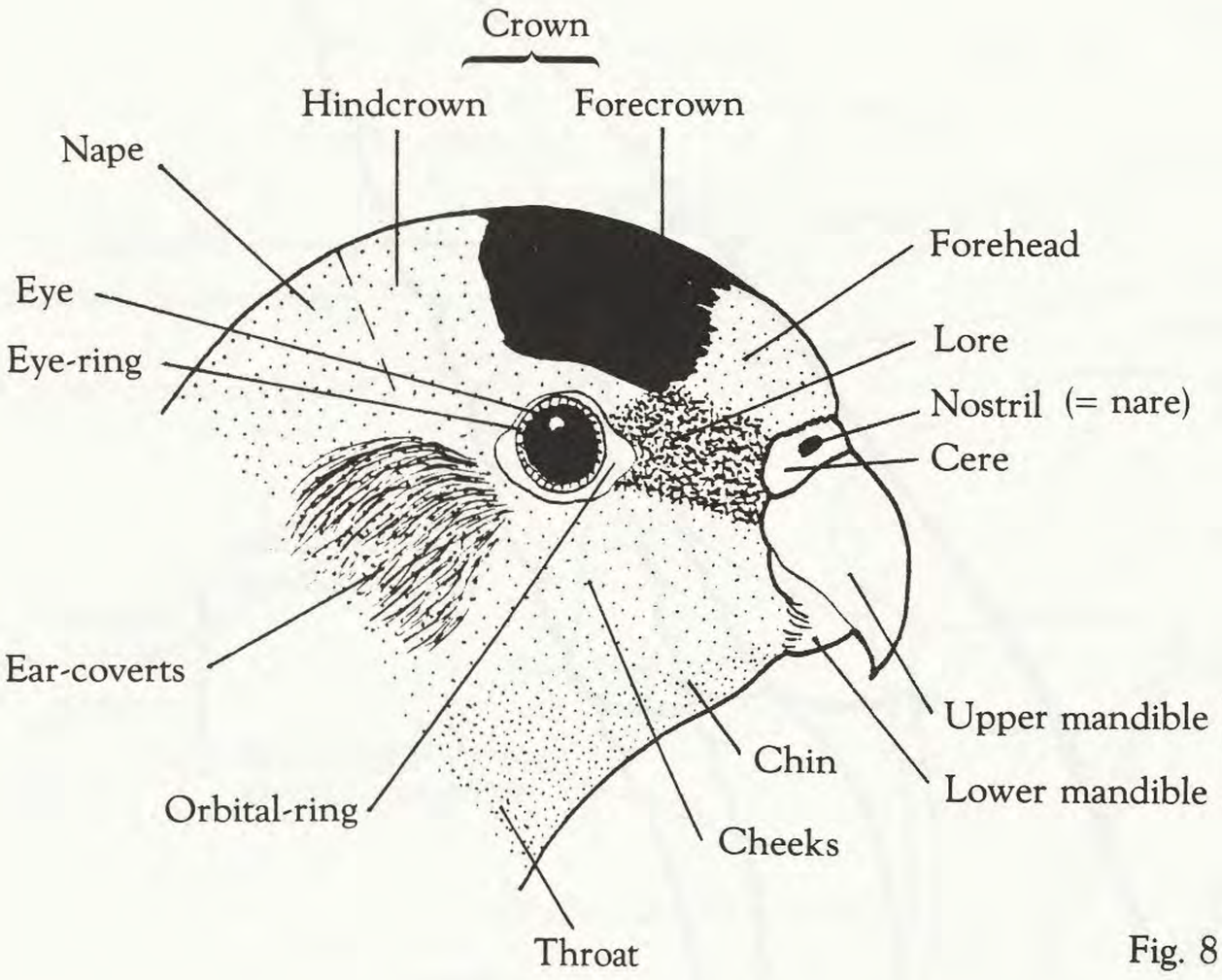


Fig. 6

Fig. 7 Head of Purple-crowned Lorikeet *Glossopsitta porphyrocephala*



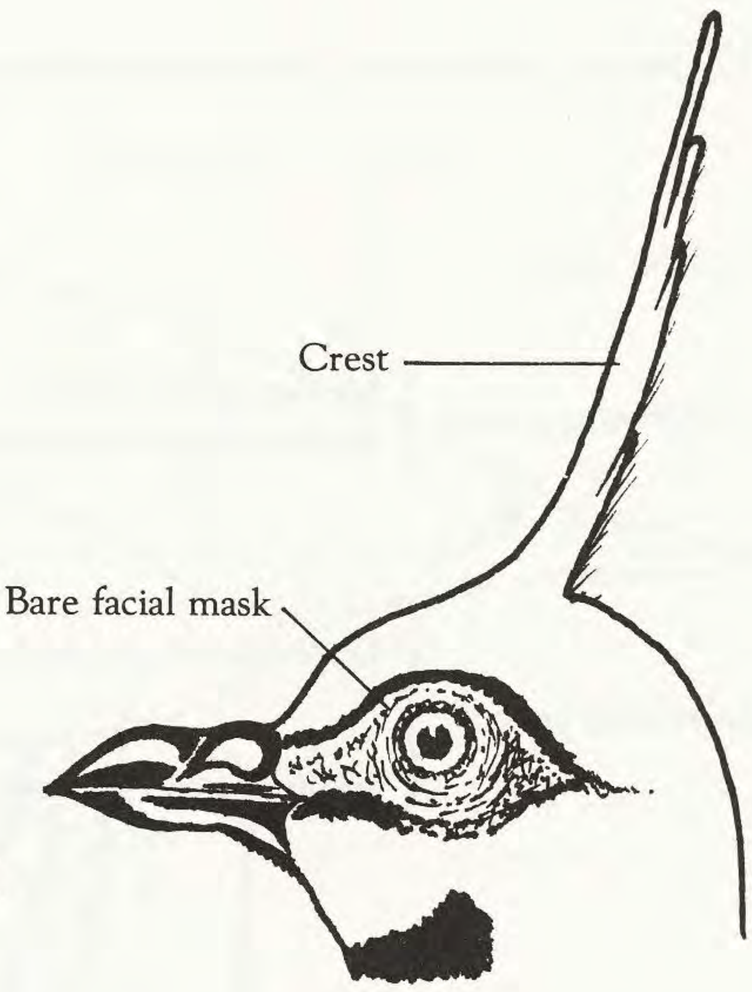


Fig. 8 Head of Spinifex Pigeon *Petrophassa plumifera*

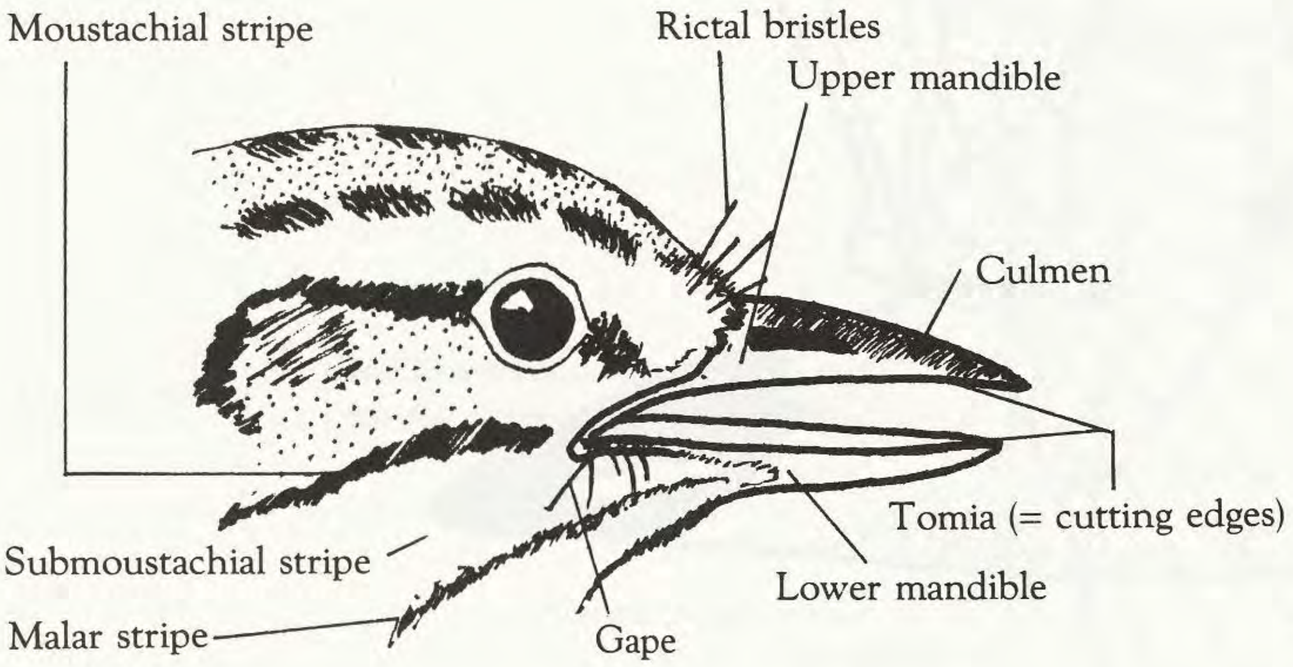


Fig. 9 Head of Richard's Pipit *Anthus novaehollandiae*

Fig. 10 Masked Lapwing *Vanellus miles novaehollandiae*

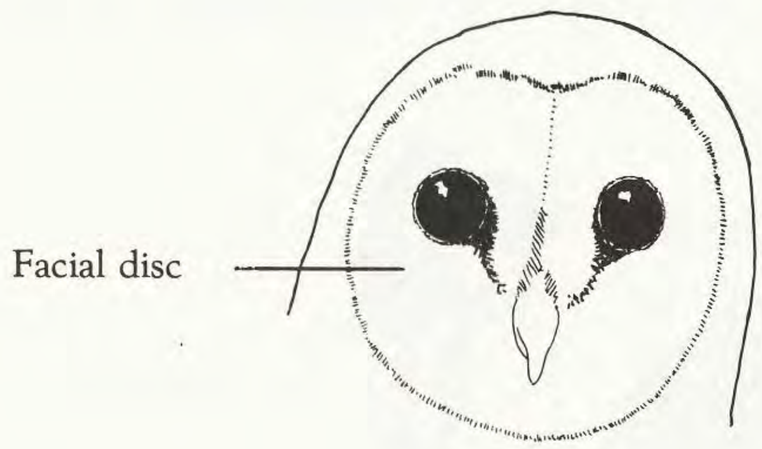


Fig. 11 Head of an Owl *Tyto sp.*

Fig. 12 Black-faced Shag *Leucocarbo fuscescens*

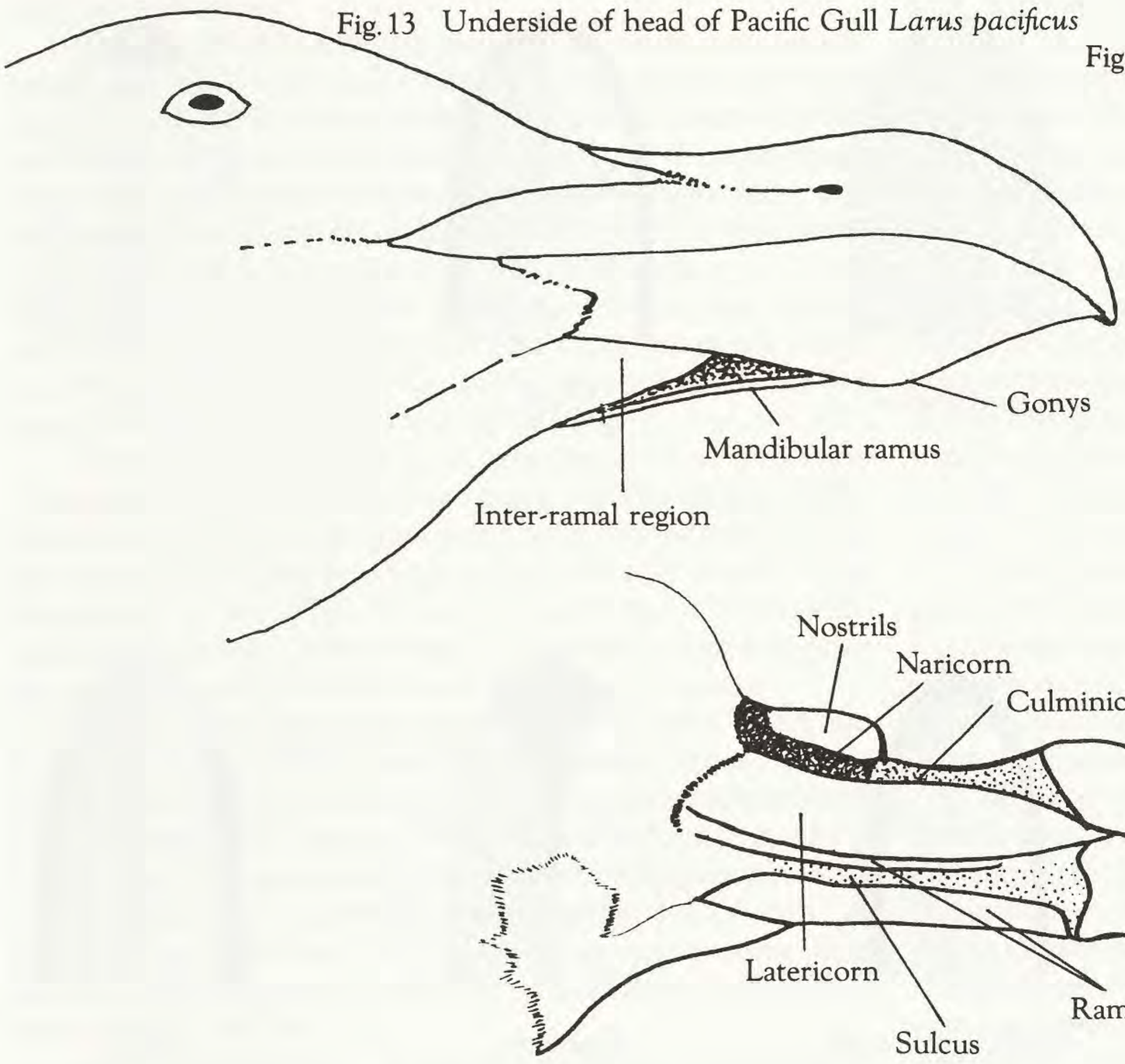


Fig. 13 Underside of head of Pacific Gull *Larus pacificus*

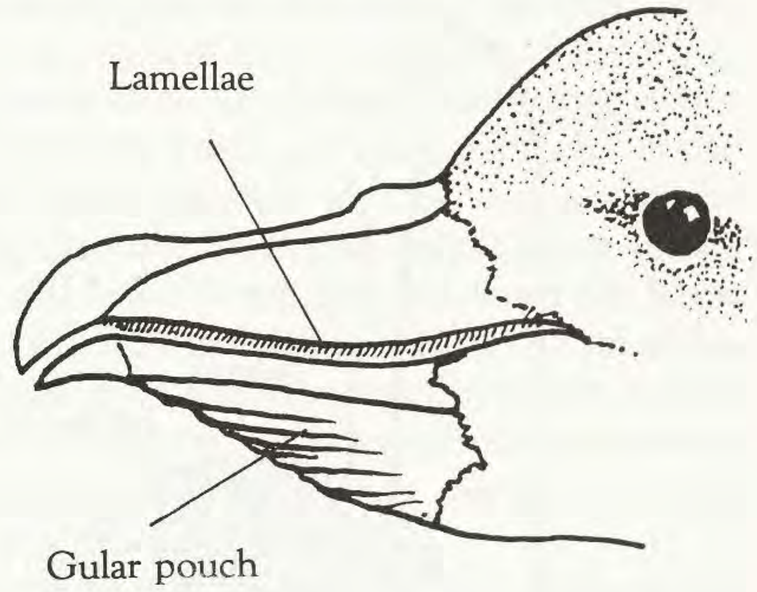


Fig. 14 Bill of Broad-billed Prion *Pachyptila vittata*

Fig. 16 Syndactyl foot

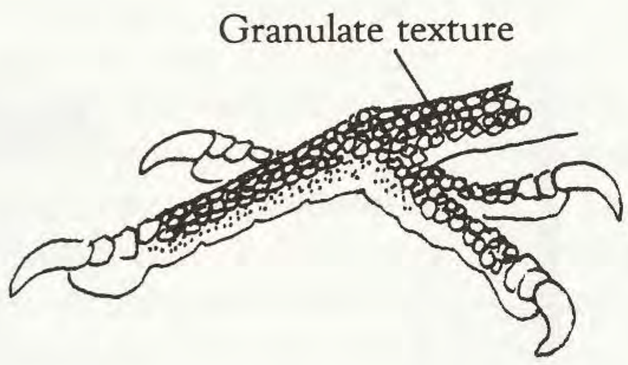


Fig. 17 Zygodactyl foot

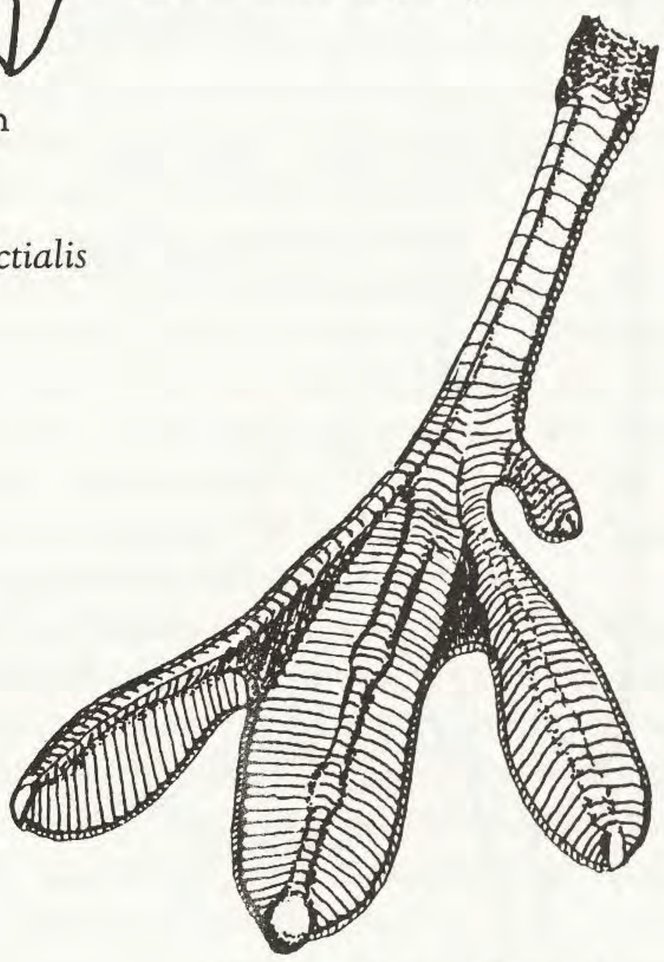


Fig. 18 Lobed foot of a grebe

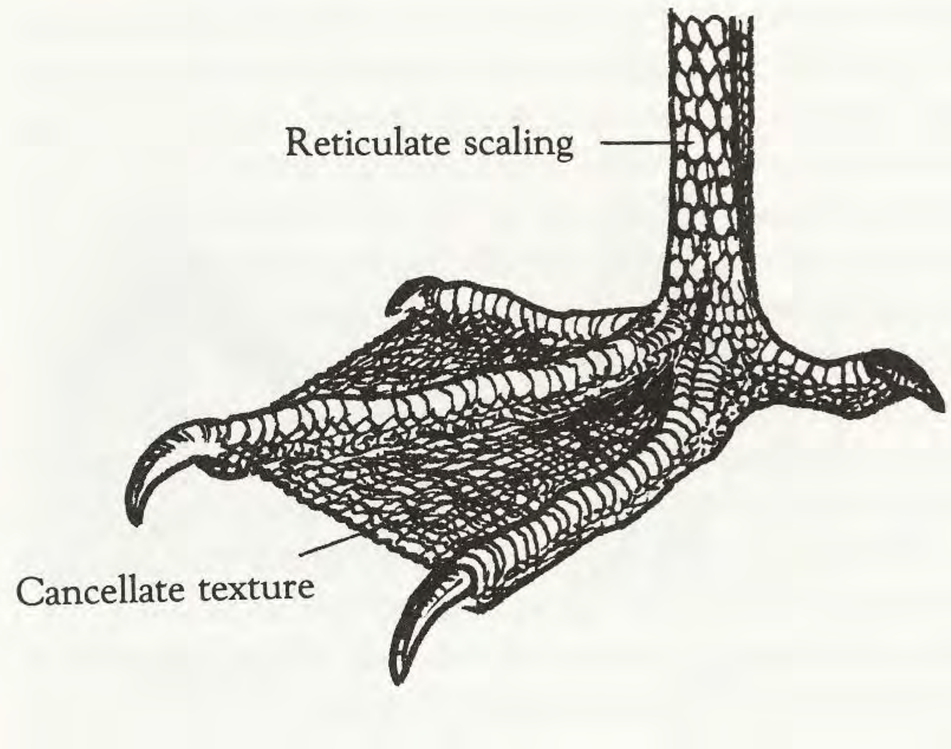


Fig. 19 Webbed foot of a Whistling Duck *Dendrocygna sp.*

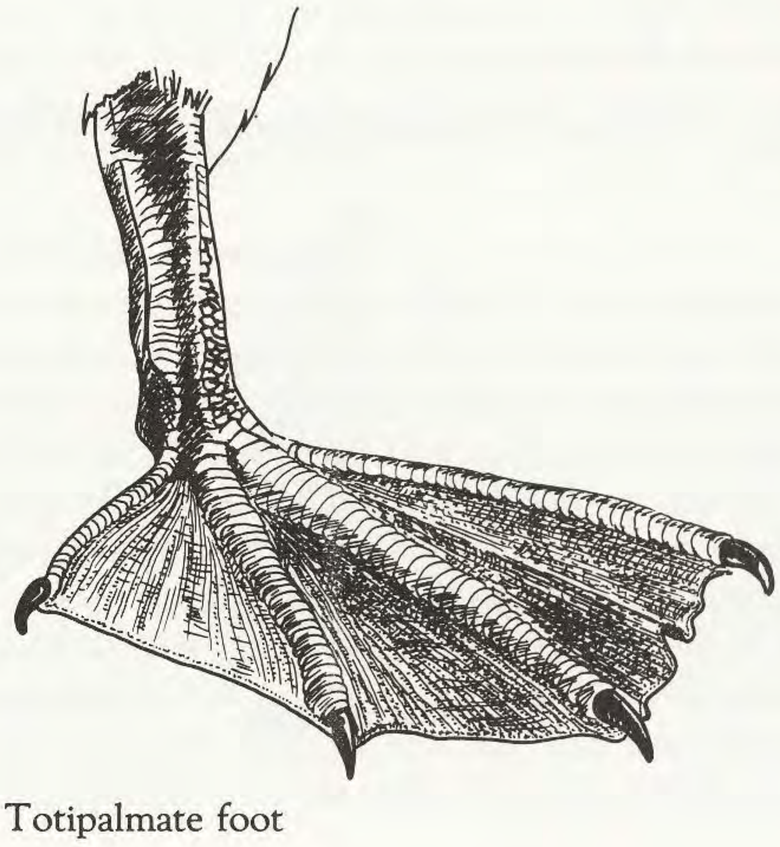
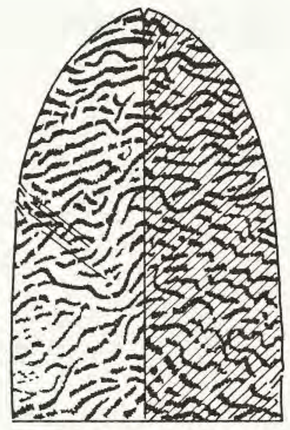


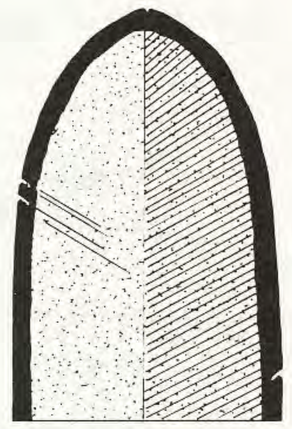
Fig. 20 Totipalmate foot

Fig. 15 Bill plates of White-chinned Petrel *Procellaria aecquinoctialis*

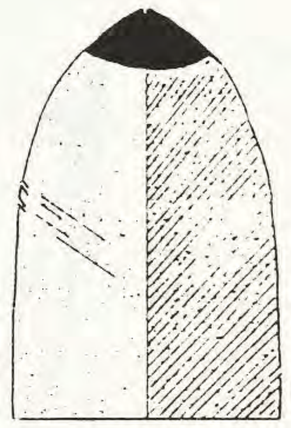
Fig. 21 Feather patterns



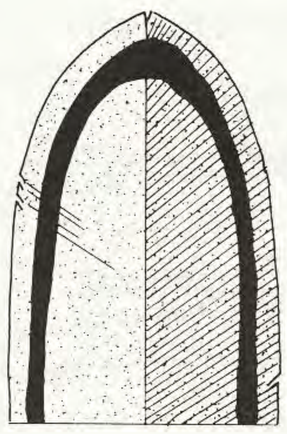
Vermiculation



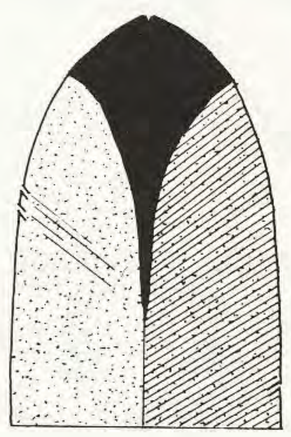
Fringe



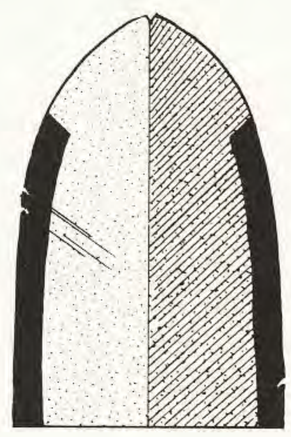
Tip



Subterminal fringe



Rosethorn



Edge

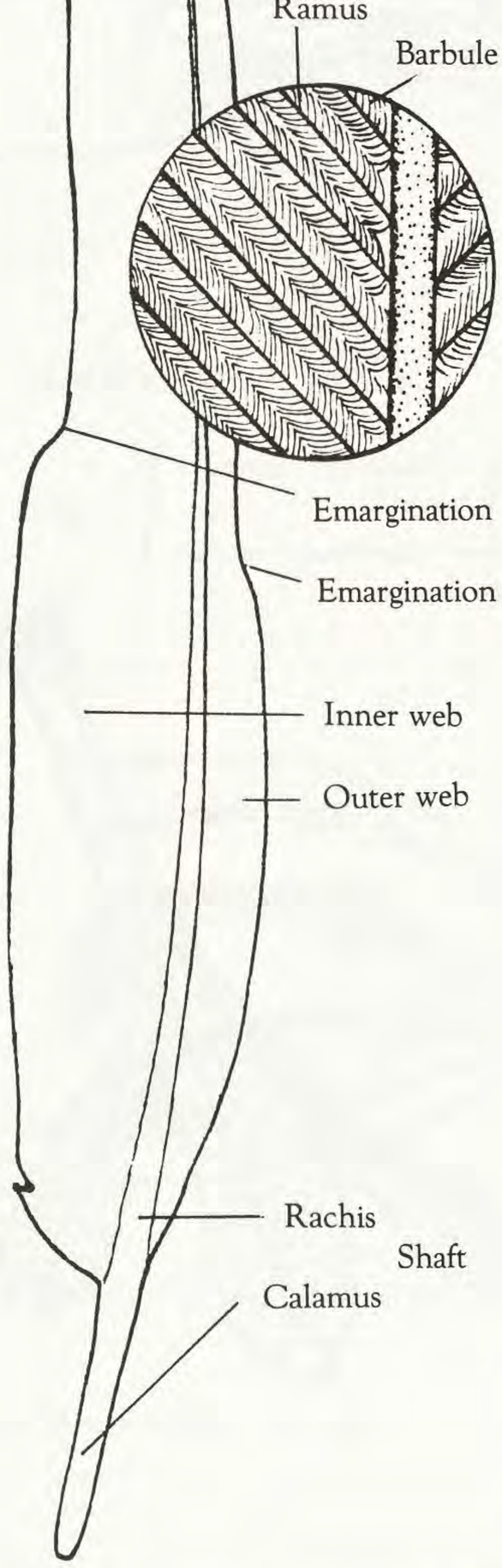
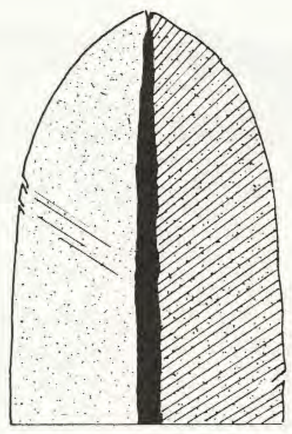
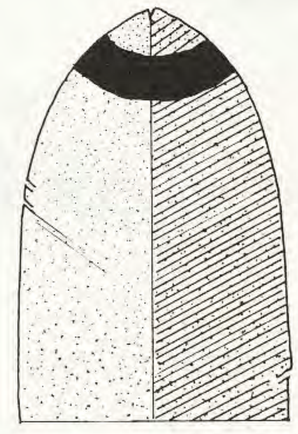


Fig. 22 Primary of Brown Goshawk *Accipiter fasciatus*

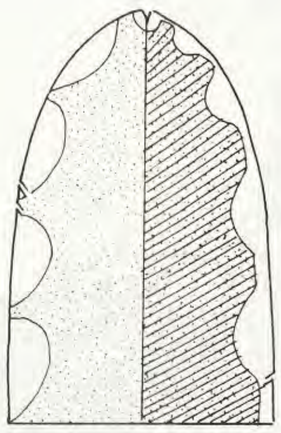


Shaft-streak

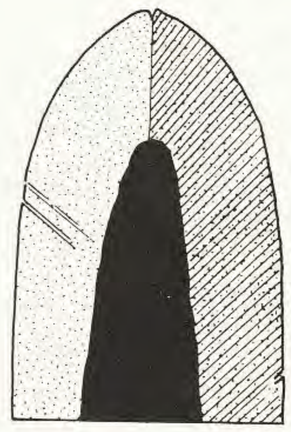


Subterminal band

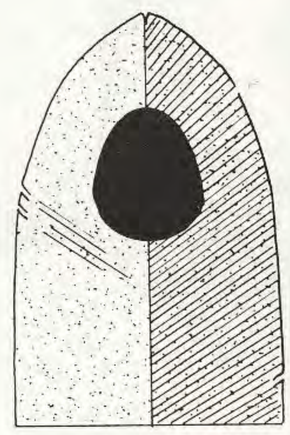
Barred



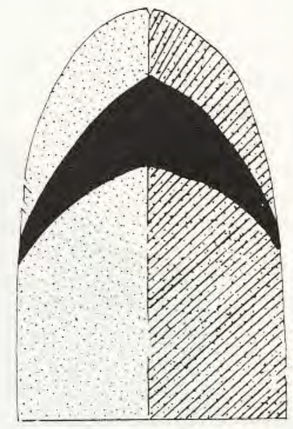
Spotted edges



Dark central wedge



Spot



Chevron

references therein).

Natural chord, and flattened chord, measurements of length of wing, are measured from the same points, but both give a considerably shorter reading. We have taken neither, but frequently quote from literature in which these methods have been used. In the former, no straightening or flattening of the wing is used (see Baldwin *et al.* 1931; BTO 1984); in the latter, the wing is only flattened (see Witherby *et al.* 1938; BTO 1984). Both were more widely used in the past, but are now believed to be less easy to repeat than maximum chord (e.g. Evans 1964; Ewins 1985), partly because primaries can straighten somewhat when wet (Evans 1964).

Wing-length decreases in museum specimens. Shrinkage of between 0.39 and 3% has been reported (Herremans 1985). Most studies of shrinkage have been done on waders. In these, the amount of shrinkage is larger in species with longer wings (Engelmoer *et al.* 1983). There is a good deal of individual variation in amount of shrinkage. Thus, it is probably impossible to apply a single conversion factor to all species.

Shrinkage continues in skins until they have dried out. Engelmoer *et al.* (1983) found this took over 2 years in some waders, but shrinkage may stop in as little as 2 months in some auks (Harris 1980; Ewins 1985). Slight increases in wing-length after drying out have been reported (Engelmoer *et al.* 1983). These are unexplained; possibly wings can be stretched, or ligaments cut, by frequent remeasuring. Our samples were not large enough for us to attempt to eliminate these sources of bias.

EIGHTH PRIMARY. This measurement was described recently (Berthold & Friedrich 1979). As far as we know, there are no publications on its use on A'asian birds. We took the measurement with a narrow ruler, inserted between the bases of the eighth and ninth primaries. The correct point of insertion can be seen by turning back the primary under wing-coverts. The distance from this point to the tip of the stretched eighth primary was recorded to the nearest millimetre. Jenni & Winkler (1989) recommend the use of a piece of folded graph-paper rather than a ruler; our measurements were taken before their paper was published.

Measurements of eighth primary are recommended by EURING, and they may supersede measurements of wing-length, being more exact and more easily repeated; there is considerably less variation between measurers; the measurement may be less likely to injure live birds (Berthold & Friedrich 1979; Jenni & Winkler 1989). In small European passerines, there is no post-mortem shrinkage in measurements of the eighth primary. It is not known if shrinkage occurs in larger birds. Piersma (1988a) has shown that shrinkage in wing-length is not caused by a decrease in length of the feathers, but preliminary data of Jenni & Winkler (1989) suggest that some shrinkage occurs in large birds, presumably caused by contraction of skin between the primaries. Length of eighth primary and wing-length are closely correlated, and conversion factors from one to the other can be developed. In passerines, the eighth primary is measured rather than other primaries, because it usually has the closest correlation with wing-length. It is not known whether this is so in other groups but measurement of other primaries may be more appropriate in some groups. For reference throughout and for further information, see Jenni & Winkler (1989).

TAIL-LENGTH. Length of tail was measured to the nearest millimetre: as the distance between the point of emergence of the central tail-feathers from the skin to the tip of the longest feather. Post-mortem changes in tail-length are slight and not well understood; decreases (Greenwood 1979) and increases (Bjordal 1983; Herremans 1985) have been reported.

BILL-LENGTH. Length of bill was measured with calipers to 0.1 mm. We generally measured exposed culmen, the chord of the culmen from the bill tip to the frontal feathering. In some birds, the junction of the frontal feathering is not clearly defined, and other methods are used. BILL (S) is the chord of the culmen from the bill tip to the naso-frontal hinge. BILL (N) is the distance from the distal corner of the nostril to the bill tip. BILL (C) is the distance from the front edge of the cere to tip of bill. In **procellariforms**, the tip of the upper mandible is hooked so that in some the curve of the maxillary unguis, and not the tip, is farthest from the base of the bill. In these circumstances, culmen is measured to the curve of the unguis and not the tip.

Post-mortem changes in dimensions of the bill may depend on its structure (Fjeldså 1980); for example, no changes have been found in most waders studied (Greenwood 1979; Engelmoer *et al.* 1983), but significant decreases and increases as great as 2.9% have been reported in some species (Summers 1976; Engelmoer *et al.* 1983).

BILL-WIDTH, BILL-DEPTH. Depth of bill (BILL D) is measured from the junction of frontal feathering with the exposed culmen, to the lower edge of the mandibular ramus below; it is the minimum depth possible at this point. Width of bill (BILL W) is the distance between the tomia at the same point. Other conventions for taking these measurements are used for some species; these are given in the text. Width and depth of bill are subject to a great deal of shrinkage (Kinsky & Harper 1968; Fjeldså 1980) and are seldom used on skins.

TOTAL HEAD-LENGTH (THL) is measured to 0.1 mm with calipers, from the back of the skull to tip of bill. The measurement is becoming widely used for live birds because there is little variation between individual measurers. We have included it when data are available. THL cannot be taken consistently on skins, because the backs of their skulls are removed to differing extents during preparation.

TARSUS. Length of tarsus was measured to 0.1 mm from the midpoint of the hindside of the joint between the tibia and tarsus, to the midpoint of the joint between tarsus and middle toe in front. Shrinkage of tarsus is generally insignificant; Bjordal (1983) attributed the few reported post-mortem changes to difficulty in applying the measurement to exactly the same points in fresh and dried legs.

MID-TOE. Middle toe is measured from the joint at the base of the middle toe (in front of the leg) to tip of middle claw. In some groups it is customary to measure the middle toe without the claw. Length of toe decreases by about 2% after skinning (Fjeldså 1980; BWP [Vol. 5]). Its measurement is also difficult to standardize from museum skins because preparation and alignment of feet vary.

Presentation of Measurements

The tables of measurements are prefaced by information on the samples measured. Geographical location and age (where known) is recorded, and we mention whether measurements were taken on live birds or skins. The source of the data is given in brackets; all measurements of skins for which we simply give the institutes holding the specimens, were taken by R. O'Brien or D.I. Rogers. Museum sources are specified using our standard abbreviations (see Abbreviations and Conventions). Measurements of recently dead birds with similar citations were taken by the staff of the cited institutes. Except where stated, measurements were taken as above; if methods

of measuring are unknown or different, this crucial fact is always mentioned. Different methods are described briefly. Some authors who published measurements without giving their methods have since described them to us. Measurements are presented in the standard fashion: mean (standard deviation; range; number of birds measured). Where sample sizes are of three or less, we present measurements of individuals. The statistical significance of the difference between two means is tested with a two-tailed t-test (e.g. Sokal & Rohlf 1969; Fowler & Cohen n.d.). When the probability of differences being due to chance (P) is less than 0.05, this is denoted *; when $P<0.01$, this is denoted **. Where values differ markedly from those given elsewhere, this is discussed.

WEIGHTS

Weights are taken from specimen labels, from published or unpublished data on birds captured for banding, and from other sources in the literature. Except where stated, weights are given in grams. They are presented in the same way as measurements. Information on variation in weight is summarized if available.

STRUCTURE

The following points are treated: shape of wing; number of primaries, secondaries, tertials and humerals (if present); wing formula (see Glossary); shape of tail, bill, and leg; other structural peculiarities. Primaries are numbered from the carpal joint outwards. Individual primaries are indicated by a p and a number, p1 being the innermost, p10 the outermost functional primary in most species. The secondaries (including tertials, see glossary) are numbered from the carpal joint inwards, abbreviated as s1, s2 etc. The tail-feathers are numbered from the central pair outwards: t1, t2 etc. All wing formulae were taken on skins; wing formulae can be affected by post-mortem shrinkage (Mead 1977; Knox 1980) but no other source of data was available.

AGEING, SEXING

Characters that can be used for ageing or sexing or both that have not been covered in Plumages or Bare Parts are described here.

RECOGNITION

Sometimes included for species that are difficult to identify. This section deals with characters that are only usually visible in the hand; other characers are given in Field Identification.

GEOGRAPHICAL VARIATION

The general nature of the geographical variation is summarized (even where no forma subspecies are recognized) and differences between the recognized subspecies are given. An outline of taxonomic opinions on disputed treatments is usually given.

GLOSSARY

Based chiefly on BWP, Cambbell & Lack (1985) and Lucas & Stettenheim (1972). Terms in italics in the definitions are defined elsewhere in the glosary or shown in the topographical illustrations.

ALULA. Small feathers attached to first digit of wing; also called bastard-wing.

AXILLARIES. Feathers in the 'armpit', attached to the body.

BARB. A branch from the father shaft; collective term for a *ramus* and the *barbules* attached to it.

BARBULES. Lateral branches of a *ramus* that interlink *barbs*.

BODY-FEATHERS. All *pennaceous* feathers of a bird except the remiges and rectrices.

BRISTLE. Stiff hair-like feather, usually with a few barbs at the base of the shaft.

BROOD PATCH. A region of bare, vascular and oedematous skin on abdomen that increases transfer of heat from incubating bird to eggs.

CALAMUS. The hollow base of the feather shaft; no *barbs* are attached to it.

CARPAL JOINT. The wrist joint, forming the forward pointing prominence of the folded wing.

CENTRIFUGAL. Moult that begins in the middle of a row of feathers and progresses in both directions.

CENTRIPETAL. Moult that begins simultaneously at the two extremes of a row of feathers, and progresses towards the centre.

CLINE. Gradation in one or more characters in populations of a species across its geographical range or part of it.

CLOACAL RING. Feathers circling the rim of the cloaca.

CONTOUR-FEATHER. Feather with *pennaceous* vanes forming part of visible external surface of body.

COVERTS. Feathers that overlie, dorsally or ventrally, the bases of *remiges* and *rectrices*.

CULMEN. Dorsal ridge of upper mandible.

CYCLE. Shortened version of plumage cycle, which runs from a given plumage or moult to the next occurrence of the same plumage or moult. Cycles do not always last for a year, e.g. Sooty Tern (Chapin 1954), King Penguin (Stonehouse 1960).

DIASTATAXIS. Arrangement of feathers in wing in which the fifth upper secondary covert has no corresponding secondary.

DISTAL. Pertaining to part of feather, wing, tail etc. farthest from the body.

DORSUM. Upper-surface of body.

DOWN-FEATHER. Feather with fluffy vanes formed by *plumulaceous* barbules.

EUSTAXIS. Arrangement of wing-feathers in which fifth upper secondary covert has a corresponding *secondary*.

FILOPLUME. Fine hair-like feather with a small tuft of *barbs* at the tip; occasionally there are a few barbs elsewhere.

FORM. Neutral term indicating an individual variant or a taxonomic unit.

HACKLE. A long slender feather on the neck.

HUMERALS. Remiges attached to the humerus, the innermost wing-bone (see *subhumerals*, *tertials*, *humeral coverts*).

HUMERAL COVERTS. Upper wing-coverts covering the base of the *humerals*.

INTEGUMENT. External covering of a bird, including skin and feathers.

INWARDS. Moult of a row of feathers proceeding from the outside to the inside. Common in secondaries.

IRREGULAR. Pattern of moult in a row of feathers that cannot be described as *simultaneous*, *outwards*, *inwards*, *centrifugal*, *centripetal*, or *staffelmauser*.

LAMELLAE. Fine hair-like or plate-like structures lining the bills of some filter-feeding birds.

MANDIBLE. Used here as a term applying to either jaw, including the horny covering.

MANDIBULAR RAMI. The two halves of the lower *mandible*, separated by the soft tissue at the base but uniting distally at

the gonys.
MANTLE. Area of *upperparts* between the hindneck and the anterior base of the wings.
MASK. A patch of contrasting colour on the face that surrounds the eyes and lores, meeting at or above the lores.
MORPH. One of two or more well-defined *forms* in the same populations of a species.
MOULT. Process by which all birds periodically shed and replace their plumage.
NASO-FRONTAL HINGE. Junction between the culmen and the skull, flexible in some birds.
OUTWARDS. Moult in a row of feathers from inside to outside. Seen in the primaries of most birds.
PAPILLA. Small conical protruberance.
PENNACEOUS. Compact, closely knit texture forming coherent vanes in *contour-feathers*.
PLUMAGE. A single generation of feathers brought about by a single moult. Sometimes applied to the aggregate of feathers covering a bird.
PLUME. Type of ornamental feather.
PLUMULACEOUS. Pertaining to long flexible barbs that are not close-knit, and give a vane a fluffy texture.
POWDER-DOWN. Soft friable down-feathers, producing fine dust particles used in care of plumage.
PRIMARIES. Flight-feathers borne on the manus, outside the carpal joint.
PROXIMAL. Pertaining to part of feather, wing, tail etc. closest to the body.
PTERYLOSIS. The way in which *contour-feathers* are arranged on the skin. Contour-feathers occur in orderly tracts called pterylae; the intervening spaces are called apteria.
RACHIS. The long distal portion of a feather-shaft, bearing the vanes.
RAMUS. A branch projecting from the *rachis*. *Barbules* are attached to, but not part of, the ramus.
RECTRICES (singular: rectrix). Tail-feathers.
REMICLE. Vestigial outermost primary.
REMIGES (singular: remex). A cumulative term for the primaries, secondaries and humerals, the flight-feathers forming the hind margin of the wing.
RICTUS. Skin at the junction of the mandibles.
ROSETHORN. See Fig. 21.
RUMP. The area between the upper tail-coverts and the back; its upper boundary is generally the line between the tips of the secondaries in birds with outstretched wings.
SCAPULARS. A group of feathers on the upperparts, situated at the base of the wing.
SECONDARIES. Flight-feathers attached to the ulna, including the *tertials*.
SIGNIFICANT. Shown by statistical test as unlikely to be due to chance (said of difference between means of two or more samples).
SIMULTANEOUS. A type of *moult* in which a group of feathers is shed at more or less the same time, inducing a period of flightlessness.
SKIN. A stuffed, unmounted study-specimen.
SPECULUM. A patch of distinctive colour on the wing; usually applied to the metallic patch seen in dabbling ducks.
STAFFELMAUSER. A pattern of *moult* in a row of feathers in which a wave of moult begins before the preceding wave is complete. This sometimes produces two or more active moult-centres in a row of feathers.
STANDARD DEVIATION. A statistical term describing the scatter round the mean in a sample of data. In a normal distribution, 99% of a sample lies within 2.58 S.D. from the mean, 95% within 1.96 S.D.
STREAK. Pattern of colour oriented longitudinally on feather.
SUBHUMERALS. Under wing-coverts covering the base of the *humerals*; they are continuous with *axillaries*, which differ in being attached to the body.
SUBHUMERAL COVERTS. All small coverts at the base of the underside of the wing, between the *subhumerals* and the marginal coverts.
SUBORBITAL PATCH. A patch of contrasting colour immediately below the eye. Post-orbital patches are found just behind the eye.
TARSUS. Strictly, shortened form of tarsometatarsus, osteologically the upper foot of birds. Also used as a general term for this area of the leg, the part between the toes and the tibia.
TEGMEN. Term coined by Gladstone (1918) for broad translucent film bordering the ramus on the underside of the remiges of some birds.
TERTIALS. The innermost secondaries; on the outstretched wing their tips do not line up with the line formed by the tips of the outer secondaries. The term has also been applied to *humerals*; we have not used it in this sense.
TERTIARIES. Synonym for *tertials* and apparently preferred choice in Campbell & Lack (1985). 'Tertials' is obligatory in Anseriforms and used throughout Plumages section here but may be used indifferently in species' accounts.
THIGH. The feathered portion of the *tibia*.
TIBIA. Strictly, shortened form of tibiotarsus, the osteological equivalent of the shin in birds. Also used as a general term for this area of the leg, the uppermost part visible in the field in most species.
UNDERPARTS. Cumulative term for the ventral side of the body, excluding head, neck, wing and tail.
UPPERPARTS. Cumulative term for the dorsal side of the body, excluding head, neck, wing and tail.
UPPER TAIL-COVERTS. Feathers generally occurring between the preen gland and the tail-feathers; they cover the base of the *rectrices* and flex with the tail.
VANE. Also web. A rather flat structure attached to the side of the *rachis* of *pennaceous* feathers, formed by a coherent series of *barbs*.
VARIATION. Differences in any character between animals of the same species. The following broad types of variation may be recognized: individual (between individuals of the same population, sex, age, and studied at the same season), seasonal, sexual, age and geographical.
VENT. Area round the cloaca and anterior under tail-coverts. Sometimes applied to the cloaca alone; we have not used it in this sense.
VENTER. Under-surface of body.
WING-BAR. Transverse band of contrasting colour in any part of the wing.
WING-FORMULA. Configuration of tips of primaries relative to each other, expressed as distances from tip of each primary to the longest primary, on the folded wing.

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ACKNOWLEDGEMENTS

Much time and money have gone into preparing this volume, and many people have been involved. It could not have been done without the financial help and enthusiasm of Oxford University Press (Aust.) and the encouragement and advice of its staff and of D. Stone and the financial support of our sponsors (page 12).

From the start, we have had the help of many ornithologists and others with a general interest in birds in Australia, New Zealand and overseas, without whose efforts the work could not have materialized. We are particularly grateful for the unfailing support and encouragement of the RAOU through its Council and its Research and other Committees, channelled largely through its successive directors, Drs S.J.J.F. Davies and P.J. Moors. Likewise of the OSNZ, once New Zealand was included in our scope. Dr B.J. Gill acted as liaison and, with B.D. Heather, answered innumerable questions and helped us enormously in every possible way.

Museums and other official organizations

Whenever we have asked, help has been given and facilities provided by museums throughout Australia, New Zealand and overseas. The curators of birds at such museums are thanked for allowing us to study the collections in their care. We are especially grateful to Dr L. Christidis and B. Gillies at the Museum of Victoria and Dr R. Edwards, then Director of the Museum, who provided a base for the preparation of texts for plumages and related matters and of the colour illustrations and assisted with the arrangement of loans from other museums; G. Anderson, J. Bowler, J. New, L. Stephanie and A. Yen from the Museum also helped us. In NZ, J.A. Bartle, at the National Museum of New Zealand, Wellington, allowed our workers to spend long periods there and provided a base for their work in New Zealand; N. Hyde, Dr P.R. Millener and Dr T.H. Worthy also helped in many ways while our workers were at the National Museum. Curators at other museums throughout Australia and New Zealand also helped. We thank Dr B.J. Gill, Auckland Institute and Museum, Auckland; G.A. Tunnicliffe, Canterbury Museum; G. Ingram and N.W. Longmore, Queensland Museum, Brisbane; S.A. Parker and P. Horton, South Australian Museum, Adelaide; Dr R. Schodde, I.J. Mason and J. Wombey, Australian National Wildlife Collection, CSIRO Division of Wildlife and Ecology, Canberra; W.E. Boles and I. McAllan, Australian Museum, Sydney; J.T. Darby, Otago Museum, Dunedin; P. Andrews, Tasmanian Museum and Art Gallery, Hobart; R.E. Johnstone at the West Australian Museum, Perth; R.H. Green at the Queen Victoria Museum and Art Gallery, Launceston; P.R. Colston at the British Museum (Natural History), Tring.

Dr K.W. Lowe, E.B. Male and D.G. Andrew at the Australian Bird and Bat Banding Schemes helped us in many ways, especially with co-ordinating the compilation of recovery data from the ABBBS and overseas banding schemes. The following people from other co-operating banding schemes (see Movements section for codes) provided banding data that had been contributed to their schemes: R.O. Cossee (NZNBS), T.B. Oatley (SABRU), Dr H. Weimerskirch (CRBPO), D. Bystrak (BBL), M. Yoshii (BMRC), Prof. D. Torres (IAC), Dr M. Gromadzki (SOPAN), Dr P. de T.Z. Antes (CEMAVE), Dr R. Schmidt (VH). These data are the result of the efforts and contributions of a large group of dedicated banders, most of whom volunteer their time and efforts and their permission to use their data is greatly appreciated.

We also thank:
G. Hosey and D. Williams, Australian Antarctic Division; T. Irvine, CSIRO Division of Wildlife and Ecology; R. Anderson, Royal Society of Victoria, Melbourne; N. Morley and C. Surb, Sir Colin McKenzie Fauna Park, Healesville, Vic.; R.W. Dunn at Royal Melbourne Zoological Gardens, Melbourne; G. Phipps at the Taronga Zoological Park, Sydney; N. Hamilton at Perth Zoo, Perth; D. Gill at Mt Bruce Nature Reserve, New Zealand; N. Hart and L. Russell at the New Zealand Department of Conservation.

Librarians at the various institutions where we have worked or visited or to whom we have made requests have always been helpful, especially the staff of the library at the Museum of Victoria, D. Delaysee at the Arthur Rylah Institute for Environmental Research, N. Hart at Department of Conservation, Wellington, and C. Phillips, at British Antarctic Survey.

Next, we must thank those who provided special information. A number of people helped us immensely with preparation of particular sections: **Movements**. Dr K.W. Lowe and D. Purchase, through the office of the Australian Bird and Bat Banding Schemes, summarized Australian recoveries and liaised with foreign bird-banding schemes and obtained recoveries from those schemes (see above). They were also responsible for the preparation of the maps of recoveries. **Food**. Scientific names and taxonomy of items of food were checked throughout by: PLANTS: P. Lumley, Dr R. Spencer and R. Cross (Vict. Herbarium); EARTHWORMS: Prof. B. Jamieson (Univ. Qld); GASTROPODS AND BIVALVES: Dr W. Ponder (AM); CEPHALOPODS: Dr C.C. Lu (MV); CRUSTACEANS: Dr G. Poore (MV); ARACHNIDS: Dr M. Harvey (WAM); INSECTS: Dr J. Lawrence and associates (Taxonomy and General Biology Section, Divn Entomol., CSIRO); FISH: Dr M. Gomon and T. Radik (MV). **Names and nomenclature**. We thank Drs C.S. Roselaar and G.F. Mees for the list of Dutch names; V. Barter for compiling the French; the late Prof. Dr K. Immelmann for the German; Dr H. Morioka for the Japanese; Dewi Prawiradilaga and D.A. Holmes for the Malay; Dr. B.J. Gill for the Maori; Dr P. Tomkovich for the Russian. S.A. Parker and R.B. Sibson helped with the etymological derivations of scientific names and Drs P.J. Fullagar, G.F. van Tets and A.R. McEvey unearthed many curiosities in, and explanations for,

scientific names. Prof. R.M.W. Dixson of the Linguistics Department of the Australian National University advised and helped us with the Aboriginal names; M.B. Peter and J.M. Peter compiled the list of Aboriginal names from published sources. **Ectoparasites**: Drs M.D. Murray, R.L. Palma and Prof. R.L.C. Pilgrim prepared the Appendix on Ectoparasites.

Colour and black-and-white illustrations:

Many people assisted with the preparation of the colour and black-and-white illustrations by providing advice, sketches, photographs and slides and general advice, much of which was invaluable in the preparation of the accounts of field identification and plumages and related matters. S.F. Bailey, J.A. Bartle, M. de L. Brooke, R.K. Brooke, N.P. Brothers, M.A. Cameron, M.J. Carter, N.G. Cheshire, B. Chudleigh, D. Close, C.J. Corben, A.H. Corrick, Dr A.N. Cowan, Dr J.P. Croxall, D.M. Cunningham, P.J. Curry, Dr N.W. Cusa, R. Davies, N. Day, P. Disher, M. Dodkin, J. Elkin, J. Fjeldså, C. Fraser, C. & D. Frith, H. Fujimura, Dr P.J. Fullagar, Dr R.P. Gales, T. & P. Gardner, Dr S.T. Garnett, W. Green, D. Hadden, P. Harrison, B.D. Heather, N. Hermes, J. Hicks, D. Hobcroft, D. Holmes, G. Holmes, Dr D.S. Horning, J. Howes, Dr M.J. Imber, M.P. Kahl, B.R. King, T. Kloot, Dr C. Lalas, P.S. Lansley, Dr K.W. Lowe, T. Lowe, Prof. M.N. Maddock, P. Maher, S. Markham-David, A. McBride, G. McCarthy, A.R. McEvey, C. & T. McKecknie, P. McKenzie, Dr N.G. McKilligan, D. Melville, P.W. Menkhorst, D.V. Merton, Dr C.M. Miskelly, G. Moon, Dr P.J. Moors, P. Munchenberg, Dr F.I. Norman, R. Noske, Oriental Bird Club, T. Palliser, P. Peake, L. Pedler, C. Peterson, R.L. Pitman, C. Prentice, J. Purnell, Dr B.J. Reville, B. Robertson, P. Round, R. Russ, D.K. Rushton, P. Sagar, B. Schramm, B. Schreiber, D.H.C. Seton, J.C. Sinclair, K. Simpson, I. Skira, I. & K. Smith, F. Spolc, J-C. Stahl, J.R. Starks, T. Stokes, P. Stroud, Y. Tanaka, T. & K. Taylor, G. Taylor, A.J.D. Tennyson, E. Thomas, R.J. Tomkins, P. Trusler, B. van Balen, Dr G.F. van Tets, Dr J.R. Waas, C. Webster, R. Webster, E.J. Woehler, H. Yorkston, K. Zimmer.

Finally, but as importantly as all the rest, are those who have helped, voluntarily or otherwise, at RAOU Headquarters in Melbourne and elsewhere. Dr K. Fitzherbert was Assistant Editor and Co-ordinator during 1987 until P.J. Higgins took over in December of that year. Both were responsible for day-to-day correspondence with contributors and reviewers and for checking and answering the multifarious doubts and questions brought to light during editing. L. and D. Jackson regularly and unstintingly delved into records for information, without which sections of the text, particularly Distribution, would have been more sketchy. J. Zimmerman typed much of the manuscript and had the unenviable task of inserting editorial corrections; V. Gaut and D. Galea assisted earlier. P. White, RAOU Librarian, was in constant demand for references. Dr D.J. Baker-Gabb, S. Chaplin, R. Cross, K. King and B. Lepschi ferreted out references and reprints. V. Barter, K. Bartram, M.A. Cameron, B. Longmuir, J.M. Peter, J.R. Starks and E. Turnbull all helped with checking references throughout the texts. Proof-reading was done by M. Barter, M.A. Cameron, S. Clegg, M. Considine, Dr S.J.J.F. Davies, R. Dodemaide, Dr K. Fitzherbert, K. Gorringe-Smith, M.J. Hewish, Dr E. Kerr, Dr K.W. Lowe, B.A. Lane, Prof. M.N. Maddock, Dr P.W. Menkhorst, Dr P.J. Moors, A. Pecze, J.M. Peter, I. Preston, P.N. Reilly, D.I. Rogers, J.R. Starks. J. Nelson assisted with collection of material for preparation of the colour illustrations. Dr E. Kerr checked and revised scientific names for plants in Habitat and Breeding. Dr D. Hewish helped with computer problems and in transferring texts onto the RAOU machines; L. Jackson and R. Rowlands also helped with computer problems.

We are grateful to past and present officers of the Division of National Mapping, Canberra (A.G. Bomford, J. Payne, G. Parkinson) for taking much trouble to advise us regarding maps and for allowing us to use their products. We thank the editors of *The Birds of the Western Palearctic* for permission to use several order and family introductions from BWP as the base for our texts. The editors of *Auk* allowed us to reproduce a table from that journal; Dr A.J. Williams allowed us access to a computer copy of *Penguins of the World: A Bibliography* (Williams, A.J., *et al.* 1985); the New Zealand Department of Conservation gave us permission to cite from unpublished reports.

Editing, sub-editing and artwork

Credit for preparing and editing the species accounts is not easily distributed because so many changes happened during compilation. However, for some sections the matter is plain enough. M.J. Hewish prepared many and edited all the sections on **Habitat** after the planning stages, when Dr H.A. Nix gave us help and advice. Dr S.T. Garnett did so entirely for the sections on **Movements** and **Food** and had the co-operation of Dr K.W. Lowe and D. Purchase regarding banding data, and maps and recoveries in Australasia and overseas. The **Breeding** sections were edited by S. Marchant throughout. Dr P.J. Fullagar and P.J. Higgins prepared many and edited all sections on **Voice**; A. Howard prepared the sonagrams and reviewed final texts. R.M. O'Brien and D.I. Rogers prepared all sections on **Plumages and related matters**. Other sections were more the result of a joint effort. For **Field Identification**, before he had to retire, P.J. Curry compiled a number of accounts. After that D.W. Eades, Dr K. Fitzherbert, Dr C.J. Miskelly and Dr J.R. Waas provided most texts, often in impressive detail; unfortunately from the point of view of practical publication, these needed heavy editing. The section on **Distribution** was equally difficult. Dr D.E. Peters started on the task before he died tragically in 1988. The rest was finished by J.M. Peter, M.D. Bruce and S.J. Cowling. **Social Organization and Behaviour** was under the supervision of Dr G.F. van Tets throughout but Dr S.J. Ambrose compiled many texts before late 1989 and M. Considine completed the rest after he could do no more. M. Considine, M. Hewish and P.J. Higgins did much of the compiling and preliminary editing of the species accounts.

The coloured plates were all painted by J.N. Davies. The line drawings were prepared by F. Knight, N. Day and D.G. Andrew, and the diagrams of annual cycles by Dr M.J. Bamford. The distribution maps were prepared by S.J. Cowling; the base maps were drawn by J. las Gourges.

CONTRIBUTORS AND REVIEWERS

Contributions to the texts have been so multifarious that it is difficult to attribute credit in detail. Contributions have been most important in the sections on Social Organization and Behaviour, Voice and Breeding where we have tried to indicate the major contributors, both as originators and reviewers. The other sections have been compiled predominantly by our own editorial team. The following, then, have helped us and their help has ranged from chance remarks on a particular matter to full accounts of whole sections. We can say only that we are deeply in debt to them all and hope that none has been omitted inadvertently.

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ABBREVIATIONS AND CONVENTIONS

Compass directions:
N, NE, E, SE, S, SW, W, NW + standard intermediates. Note, however, when used as an adjective (e.g. northern Aust., north-eastern coast and so on) the style is lower case with a full period:
n., ne., e., se., s., sw., w., nw.

Units:
Standard SI units and their recommended abbreviations are followed throughout the text. Those used are listed below.

Statistical arrangement:
Throughout, simple statistics are presented in the form:
MEAN (STANDARD DEVIATION; RANGE; SAMPLE SIZE)
e.g. 285 g (5.23; 276–298; 14).

General:

°	degrees
A'asia	Australasia
A'asian	Australasian
ACT	Australian Capital Territory
Apr.	April
Arch.	Archipelago
asl	above sea level
Aug.	August
Aust.	Australia(n)
C.	Cape
c.	circa
Ck	Creek
cm^2	square centimetres
Dec.	December
Feb.	February
g	gram
Grp	Group
h	hour(s)
ha	hectare
I.	Island
Is	Islands
Jan.	January
July	July
June	June
kg	kilogram
km	kilometre
l	litre
L.	Lake
Ls	Lakes
m	metre
Mar.	March
May	May
MIA	Murrumbidgee Irrigation Area
min	minute(s)
ml	millilitre
Mt	Mount, Mountain
Mts	Mountains
m^2	square metres
NI	North Island, NZ
Nov.	November
NP	National Park
NSW	New South Wales
NT	Northern Territory
NZ	New Zealand
Oct.	October
Pen.	Peninsula
PNG	Papua New Guinea
Prom.	Promontory
Pt	Point
Qld	Queensland
R.	River
Ra.	Range
Ras	Ranges
Rd	Road
Rs	Rivers
s	second
SA	South Australia
Sept.	September
SI	South Island, NZ
sp./spp	species
St	Saint
Stn	Station
Str.	Strait
Tas.	Tasmania
UK	United Kingdom
USA	United States of America
USSR	United Soviet Socialist Republics
Vic.	Victoria
WA	Western Australia

Museums and official organizations

AAD	Australian Antarctic Division
ABBBS	Australian Bird and Bat Banding Scheme
AM	Australian Museum, Sydney
AMNH	American Museum Natural History, New York
ANARE	Australian National Antarctic Research Expedition
ANPWS	Australian National Parks and Wildlife Service
ANWC	Australian National Wildlife Collection, CSIRO, Canberra
ARI	Arthur Rylah Institute, Department of Conservation, Forests and Lands, Heidelberg, Vic.
AUST. NRS	RAOU Nest Record Scheme
AWMM	Auckland War Memorial Museum, Auckland
BAS	British Antarctic Survey
BMNH	British Museum Natural History
CALM	Department of Conservation and Land Management (WA)
CAMBA	China Australia Migratory Bird Agreement

CCNT	Conservation Commission of the Northern Territory
CFL	Department of Conservation, Forests and Lands (Vic.)
CM	Canterbury Museum, Christchurch
CSIRO	Commonwealth Scientific and Industrial Research Organization (Aust.)
DSIR	Department of Scientific and Industrial Research (NZ)
HLW	H.L. White Collection (housed in MV)
JAMBA	Japan Australia Migratory Bird Agreement
MM	Macleay Museum, University of Sydney
MV	Museum of Victoria, Melbourne (formerly National Museum of Victoria)
NMNZ	National Museum of New Zealand, Wellington
NPIAW	National Photographic Index of Australian Wildlife
NSW NPWS	NSW National Parks and Wildlife Service
NZ NRS	OSNZ Nest Record Scheme
OM	Otago Museum, Dunedin, formerly Otago University
OSNZ	Ornithological Society of New Zealand
PWH	Department of Parks, Wildlife and Heritage (Tas.)
QM	Queensland Museum, Brisbane
QNPWS	Queensland National Parks and Wildlife Service
QVM	Queen Victoria Museum and Art Gallery, Launceston
RAC	RAOU Records Appraisal Committee
RAOU	Royal Australasian Ornithologists Union
RBC	OSNZ Rare Birds Commitee
RFBPS	Royal Forest and Bird Protection Society (NZ)
SAM	South Australian Museum, Adelaide
SA NPWS	SA National Parks and Wildlife Service
TMAG	Tasmanian Museum and Art Gallery, Hobart
WAM	Western Australian Museum, Perth

SIMPLIFIED REFERENCES

Some references appear so regularly throughout the text that we refer to them simply as indicated below **without date and without including them in lists of references**. Personal communications, personal observations and unpublished results are indicated simply by the observer's initials and name in brackets (A.N. Other).

Aust. Atlas	Blakers, M., S.J.J.F. Davies & P.N. Reilly. 1984. *The Atlas of Australian Birds*. Melbourne: MUP.
Aust. CL	Condon, H.T. 1975. *Checklist of the Birds of Australia. Part 1. Non-Passerines*. Melbourne: RAOU.
Aust. RD	*Reader's Digest Complete Book of Australian Birds*. 1976. Sydney: Reader's Digest.
BWP	Cramp, S., & K.E.L. Simmons. 1977. *The Handbook of the Birds of Europe, Middle East and North Africa — The Birds of the Western Palearctic*. London: OUP.
Campbell	Campbell, A.J. 1900. *Nests and Eggs of Australian Birds*. Sheffield: privately.
CSN	*Notornis* Classified Summarised Notes *passim*.
HASB	Serventy, D.L., V.N. Serventy & J. Warham. 1971. *The Handbook of Australian Sea-birds*. Sydney: Reed.
Murphy	Murphy, R.C. 1936. *Oceanic Birds of South America*. New York: AMNH.
North	North, A.J. 1901–14. *Nests and Eggs of Birds found Breeding in Australia and Tasmania*. Spec. Cat. 1, Aust. Mus., Sydney.
NZ Atlas	Bull, P.C., P.D. Gage & C.J.R. Robertson. 1985. *The Atlas of Bird Distribution in New Zealand*. Wellington; OSNZ.
NZCL	Ornithological Society of New Zealand. 1970. *Annotated Checklist of New Zealand Birds*. Wellington: Reed. **Including** the 1980 supplement to the Checklist: Kinsky, F.C. 1980. *Notornis* 27 (Supplement): 1–23.
NZRD	*Reader's Digest Complete Book of New Zealand Birds*. Sydney: Reader's Digest.
Oliver	Oliver, W.R.B. 1974. *New Zealand Birds*. Wellington: Reed. (also including earlier editions of this work: 1930, 1955)
Peters	Mayr, E., & G.W. Cottrell. 1979. *Check-list of Birds of the World. Vol. 1*. Second edition. Cambridge: Harvard Museum of Comparative Zoology.
Vic. Atlas	Emison, W.B., C.M. Beardsell, F.I. Norman, R.H. Loyn & S.C. Bennett. 1987. *Atlas of Victorian Birds*. Melbourne: Dept. Cons. Forests Lands and RAOU.