

PREFACE

This *Catalogue of Tunicata in Australian Waters* revises and updates the work published on 14 May 1998 as Kott, P. (1998). Tunicata. pp. 51-259 in Wells, A. & Houston, W.W.K. (eds) *Zoological Catalogue of Australia*. Hemichordata, Tunicata, Cephalochordata. Melbourne : CSIRO Publishing, Australia Vol. 34 298 pp., and follows the general arrangement of that work.

Arrangement of Higher Level Taxa

In this work, families are treated in alphabetical order within their class and ordinal groupings as set out below.

Class: ASCIDIACEA

Order: ENTEROGONA

Suborder: APLOUSOBRANCHIA

Cionidae
Clavelinidae
Diazonidae
Didemnidae
Euherdmaniidae
Holozoidae
Polycitoridae
Polyclinidae
Protopolyclinidae
Pseudodistomidae
Pycnoclavellidae
Ritterellidae
Stomozoidae

Suborder: PHLEBOBRANCHIA

Agneziidae
Asciidiidae
Corellidae
Perophoridae
Plurellidae

Order: PLEUROGONA

Suborder: STOLIDOBRANCHIA

Hexacrobylidae
Molgulidae
Pyuridae
Styelidae
Styelinae
Botryllinae
Polyzoinae

CLASS: THALIACEA

Doliolidae
Pyrosomatidae
Pyrosomatinae
Pyrostremmatinae
Salpidae
Salpinae
Cyclosalpinae

CLASS: APPENDICULARIA

Fritillariidae
Kowalevskiidae
Oikopleuridae
Bathochordaeinae
Oikopleurinae

Geographic Scope

Distribution data in this *Catalogue* follow the format adopted by the *Zoological Catalogue of Australia* series, using political and geographic region descriptors (see Map 1), and serves as a guide to the distribution of a taxon. For details of a taxon's distribution, the reader should consult the cited references (if any) at genus and species levels.

Australia is defined as including Lord Howe Is., Norfolk Is., Cocos (Keeling) IIs, Christmas Is., Ashmore and Cartier IIs, Macquarie Is., Australian Antarctic Territory, Heard and McDonald IIs, and the waters associated with these land areas of Australian Political responsibility. Political areas include the adjacent waters. However, the Tunicata of the waters surrounding Macquarie Is., the Australian Antarctic Territory, Heard and McDonald IIs are not included in this work. Species known from these areas are treated in monographic works by Lohmann (1905, 1908), Lohmann & Buckmann (1926), Garstang (1933) Garstang & Georgeson (1935), Kott (1954, 1969, 1971), Millar (1960) Tokioka (1964), C. Monniot (1978), Monniot & Gail (1978) and Monniot & Monniot (1983).

Terrestrial geographic terms are based on the drainage systems of continental Australia, while marine terms are self explanatory except as follows: the boundary between the coastal and oceanic zones is the 200m contour; the Arafura Sea extends from Cape York to 124°E; and the boundary between the Tasman and Coral Seas is considered to be the latitude of Fraser Island, also regarded as the southern terminus of the Great Barrier Reef.

Distribution records, if any, outside of these areas are listed as extralimital. The distribution descriptors for each species are collated to genus level. Users are advised that extralimital distribution for some taxa may not be complete.

Ecological Descriptors

The following descriptors are used in this database to summarise the life history and habit of species group taxa.

Life History

oviparous: mature gametes released for fertilisation outside the parental colony or individual (as in most solitary Ascidiacea).

viviparous: fertilisation and incubation of embryos takes place in the parental colony or individual followed later by release of live larvae or juveniles (as in all colonial Ascidiacea).

Habit

planktonic: organisms suspended in and moving in water or in air, their distribution dependent on the course of currents.

pelagic: organisms moving through water independently of currents.

benthic: attached to, or crawling or walking on, or living on or in the bottom of the sea, lakes or rivers.

sessile: directly attached to the substrate or living permanently in one place (territorial).

marine: living in the sea

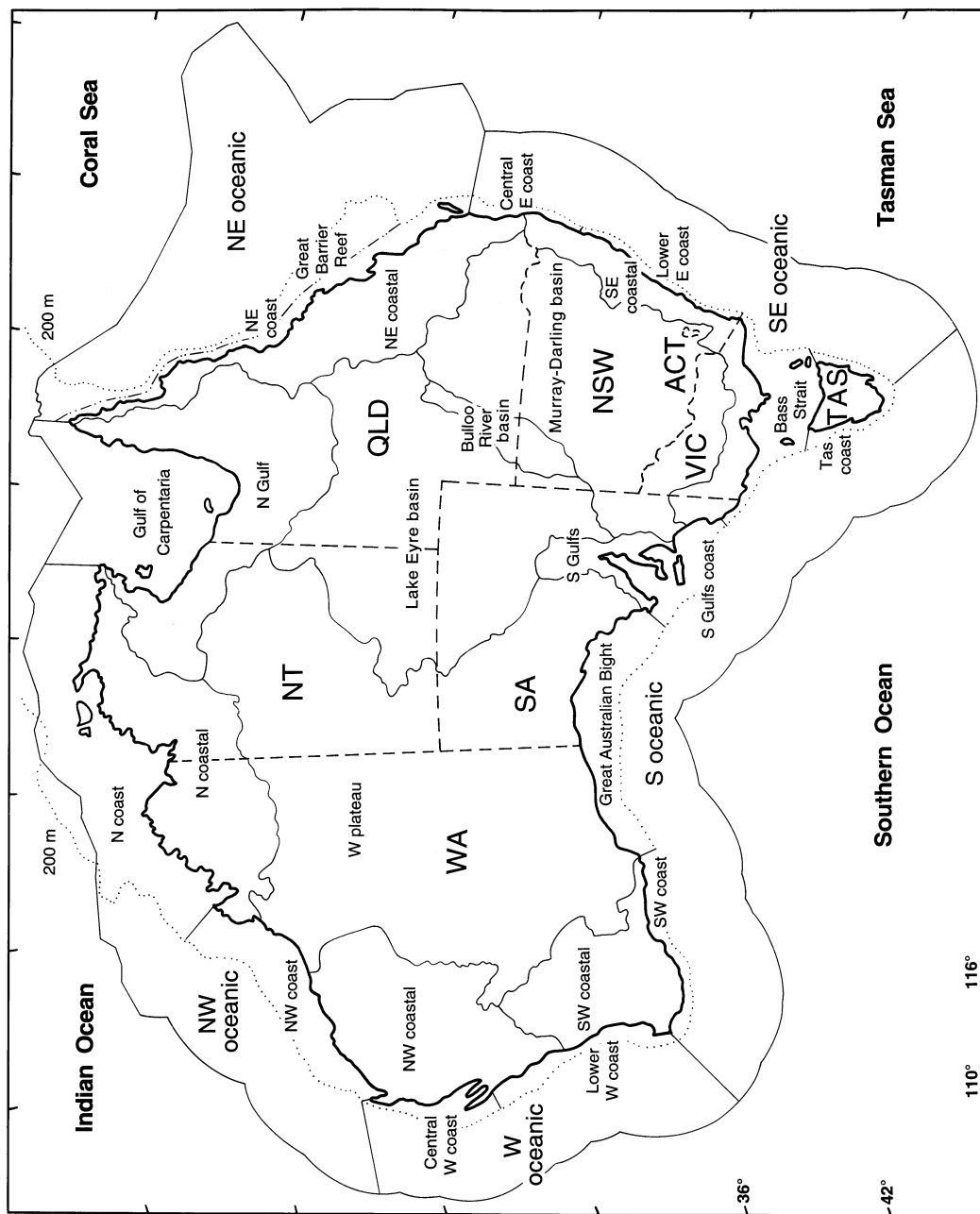
Museums

The following acronyms have been used for the institutions in which the type specimens in this taxon are held.

AM	Australian Museum, Sydney, New South Wales, Australia
AMNH	American Museum of Natural History, New York, USA
ANSP	Academy of Natural Sciences, Philadelphia, Pennsylvania, USA
BLIH	Biological Laboratory, Imperial Household of Japan, Tokyo, Japan
BMBN	Bergen Museum, Bergen, Norway
BMNH	Natural History Museum (formerly British Museum (Natural History)), London, England
BPBM	Bernice P. Bishop Museum, Honolulu, Hawaii, USA
GMNH	Muséum d'Histoire Naturelle, Genève, Switzerland
HMN	Hancock Museum, University of Newcastle, Newcastle-upon-Tyne, England
IM	Indian Museum, Calcutta, India
MAD	Madras Museum, Madras, India
MGH	Museum Godeffroy, Hamburg (now in ZMH), Germany
MNHN	Museo Nacional de Historia Natural, Santiago, Chile
MNHP	Muséum National d'Histoire Naturelle, Paris, France
MONZ	Museum of New Zealand Te Papa Tongaewa (formerly National Museum of NZ), Wellington, New Zealand
MSUMZ	Memphis State University, Tennessee, USA
NHMW	Naturhistorisches Museum, Wien, Austria
NHRM	Naturhistoriska Riksmuseet, Stockholm, Sweden
NMV	Museum Victoria, Melbourne, Victoria, Australia
NSMT	National Science Museum (Natural History), Tokyo, Japan
NTM	Museum and Art Galleries of the Northern Territory, Darwin, Northern Territory, Australia
NZOI	New Zealand Oceanographic Institute, Wellington, New Zealand
OMNH	Osaka Museum of Natural History, Osaka, Japan
OMNZ	Otago Museum, Otago, New Zealand
QM	Queensland Museum, Brisbane, Queensland, Australia
SAM	South African Museum, Cape Town, South Africa
SAMA	South Australian Museum, Adelaide, South Australia, Australia
SMBL	Museum of the Seto Marine Biological Laboratory, Sirahama, Japan
SMF	Naturmuseum und Forschungsinstitut, Senckenberg, Frankfurt am Main, Germany
TMH	Tasmanian Museum and Art Gallery, Hobart, Tasmania, Australia
USNM	National Museum of Natural History, Smithsonian Institution, Washington DC, USA
UTZM	University of Tsukuba, Zoological Museum (the Oka Collection), Okayama, Japan
VNIRO	Institute of Oceanography, Moscow, Russia
WAM	Western Australia Museum, Perth, Western Australia, Australia
YPM	Yale University, Peabody Museum, New Haven, Connecticut, USA
ZMA	Zoölogisch Museum, Universiteit van Amsterdam, Amsterdam, The Netherlands
ZMB	Museum für Naturkunde an der Universität Humboldt zu Berlin, Berlin, Germany
ZMH	Zoologisches Museum für Hamburg, Hamburg, Germany
ZMUC	Zoological Museum, University of Copenhagen, Copenhagen, Denmark

Closing Date

The closing date for entries in this section of the *Catalogue* was 30 July, 2005.



Map 1. States, standard drainage basins, coastal zones within the 200 m bathymetric contour, and the 200 nautical mile Australian fishing zones. Simple conic projection with two standard parallels. (From Rott 1988)

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The Tunicata are grouped with Hemichordata and Cephalochordata as the Protochordata. Phylogenetic relationships of the protochordate taxa are not close, but they share certain chordate characteristics and possibly an ancestry with the Chordata (Berrill 1950). Among the shared features are a perforated pharynx, and a dorsal and sometimes hollow nerve cord derived by invagination from the ectoderm. In Tunicata the larval or adult tail (when it occurs), and in Cephalochordata a rod of cells resembling the embryonic notochord of chordate animals suggest a closer affinity with Chordata than with the invertebrate phylum Hemichordata. Also, in Tunicata and Cephalochordata but not in Hemichordata a median ventral mucus-secreting groove in the pharynx is known to take up iodine like the vertebrate thyroid gland (Godeaux 1989). Tunicates differ further from Hemichordata in their unique heart and linear circulatory system, the heart reversing the direction of blood flow from time to time to ensure the even distribution of oxygen and nutrients (Heron 1973, 1975) and in having tailed (rather than ciliated) larvae. A proposal that the tunicate anterodorsal ciliated opening of the neural gland into the pharynx might be an homologue of the vertebrate anterior pituitary has been found to be invalid (see Goodbody 1974). Secretory cells are not present and the cilia create a current into the duct and to the neural gland as part of the mechanism controlling blood volume (Ruppert 1990).

The group Tunicata Lamarck, 1816 initially contained ascidians and salps. Appendicularians and doliolids were added later by Huxley (1851). Although Lamarck believed the Tunicata to be an independent class between Alcyonaria and Vermes, they were more often thought of as a class (Molluscoides) of the Mollusca (see Cuvier 1817, 1830) until Kowalevsky (1867) demonstrated the chordate characteristics evident in their embryos (see Herdman 1882). Herdman (1882) eventually divided the Tunicata into the three classes known today (see also Garstang 1896 and Fenaux 1993). These are the sessile Ascidiacea (sea squirts), and the planktonic Thaliacea (salps, doliolids and purse salps) and Appendicularia (larvaceans).

There are marked differences between the three classes of the Tunicata. The larval tail, lost on metamorphosis in the Ascidiacea and Doliolidae (Thaliacea) and suppressed altogether in other Thaliacea, persists through life in Appendicularia. In Ascidiacea and Thaliacea the ectoderm of the body wall synthesises a substance known as tunicin that is similar (chemically) to plant cellulose. It forms a test or tunic around the body composed of an acellular, proteinaceous matrix containing fibres and blood and test cells (see Goodbody 1974). Ectodermal vessels extend into it from the body wall and in colonial forms the test continues around ectodermal vessels that connect colonial zooids, or it forms a matrix in which zooids (as well as test vessels) are partially or completely embedded. Generally Appendicularia lack a tunicin covering. Instead, a balloon-like mucous house is secreted by special (oikoplast) cells in the trunk epithelium and is inflated around the whole or part of the animal by the beating of its tail. Thaliacea and Ascidiacea have an atrial cavity invaginated from the external surface (and therefore lined with ectodermal epithelium) into which the pharyngeal perforations (stigmata) open. In Ascidiacea this cavity surrounds the sides and dorsum of the perforated part of the pharynx, maintaining its connection with the exterior through the dorsal opening (atrial aperture). In Thaliacea the atrial cavity is at the posterior end of the pharynx and its aperture is at the opposite end of the animal to the mouth. In Appendicularia there is no atrial cavity and only a single pair of pharyngeal perforations open directly to the exterior.

With the exception of certain ascidians from abyssal depths that have evolved a carnivorous habit, all three classes of the Tunicata are prodigious filter feeders, straining large quantities of water passing through their mucous filters. In Ascidiacea and Thaliacea the microorganisms and organic particles from the continuous sheet of mucus secreted by the endostyle and perforated by micropores is moved up over the inner wall of the perforated pharynx by cilia and rolled into

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a mucous rod that moves along the dorsal midline into the oesophagus. The beating of the cilia lining the stigmata draws a current of water in through the mouth (incurrent aperture), through the mucous-sheet and the stigmata of the pharyngeal wall and out through the atrial cavity and the atrial (excurrent) aperture. In Appendicularia water is moved through special filters in the mucous house by the beating of the tail. Food caught in these filters is washed into the mouth by an incurrent stream of water generated by cilia lining the pharyngeal perforations (known as spiracles) and as in the two other tunicate classes, and the food, trapped in mucus secreted by the endostyle, is moved down into the gut (see Deibel 1998; Flood & Deibel 1998). With very few exceptions, tunicates are hermaphrodite, each individual having gonads of both sexes. Male and female organs mature at different times and normally they are not self-fertile (Ryland & Bishop 1993).

Recent reviews of aspects of the Ascidiacea are on physiology (Goodbody 1974), microscopic anatomy (Burighel & Cloney 1997) and biology and functional anatomy (Millar 1971; Kott 1985, 1990a, 1992a, 2001: Annotated Glossaries; Kott 1989). The biology of the Thaliacea and Appendicularia is reviewed in Bone (1998).

Ascidiacea is the most diverse class, with about 700 extant species in the Australian fauna. Thaliacea, although prolific and with a high biomass in coastal waters, are much less diverse, having less than 100 species worldwide. Appendicularia also are not diverse, with only about 60 species known worldwide. Most species of the planktonic Thaliacea and Appendicularia, carried by ocean currents, have wide geographic ranges that include most of the oceans of the world.

ACKNOWLEDGEMENTS

Much of the information on the Ascidiacea in this work is the result of the author's research on the class. However, for information on Thaliacea and Appendicularia she has relied on the work of Harold Thompson (1945); and on more recent publications and comments of Dr Robert van Soest of the Zoological Museum, University of Amsterdam (Thaliacea) and Dr Robert Fenaux of the Station Zoologique of the Université de Paris, Villefranche-sur-Mer (Appendicularia). She is especially grateful to Dr van Soest and Dr Fenaux for their advice.

In the published *Catalogue*, the illustrations used in the ascidian family introductions are reproduced from Kott (1985, 1990a, 1990b, 1992a, 1992). To maintain a consistent style, Figs 23–25 (Thaliacea) were redrawn from the original publications (as indicated) by F. Knight. Figure 26 (Appendicularia) was reproduced from Alldredge (1978), with permission.

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