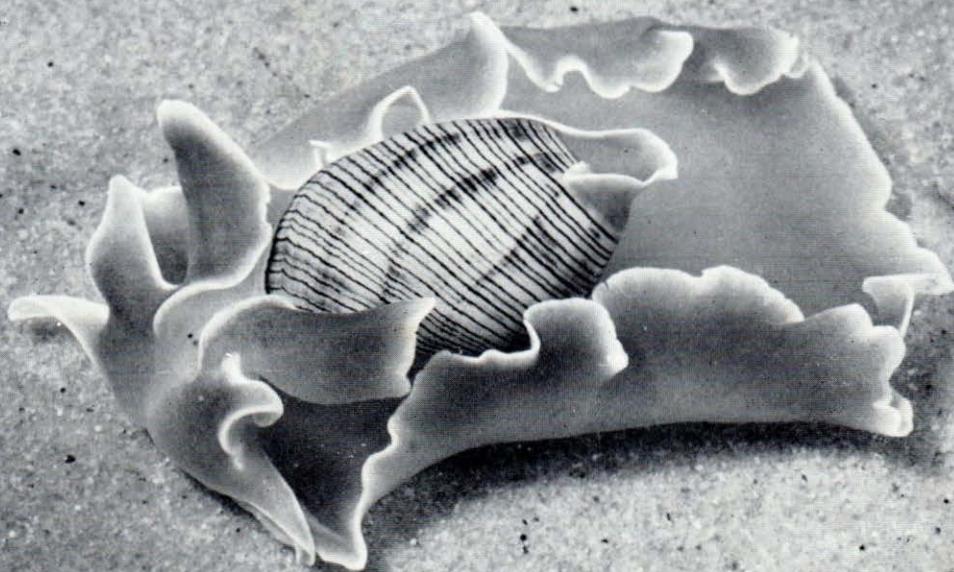


# AUSTRALIAN NATURAL HISTORY



PUBLISHED BY

**THE AUSTRALIAN MUSEUM**  
SYDNEY

Registered at the General Post Office, Sydney, for transmission by post as a periodical

DECEMBER 15, 1964

VOL. XIV, No. 12

PRICE, THREE SHILLINGS



This special issue is devoted entirely to Australian molluscs.  
It contains eight extra pages of articles and illustrations.

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● **FRONT COVER:** A living specimen of the Rose Petal Bubble Shell, *Hydatina physis*, a sea-slug. This species, one of the most colourful of the shelled opisthobranch molluscs, is widespread throughout the Indian and Pacific Ocean areas, and occurs as far south as New South Wales, where it may be found on sand flats and in rock pools. The delicate folds of its filmy mantle are red to pink with iridescent blue edges. The photo is by Howard Hughes. An article on Australian sea-slugs appears on page 396.

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*Published Quarterly by the Australian Museum* - - - *College Street, Sydney*

Editor: J. W. Evans, Sc.D.

Annual Subscription, Posted, 14/-

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## *How to Make a Shell Collection*

By DONALD F. McMICHAEL

SHELLS can be acquired in three ways. The first and most important method is to collect shells yourself—a visit to the beach or the Great Barrier Reef is often the beginning of a lifelong interest in this challenging and stimulating hobby. Practically anywhere in the world is a good place to start collecting. There are probably three or four different kinds of land snail shells to be found in your back yard if you look carefully. At the beach, concentrate on the living shells to be found in rock-pools and near low tide mark, in crevices, under stones and among seaweeds. Don't forget to leave the shore as nearly as possible as you found it, by turning back any stones which you have upended. This allows all those living creatures which may be attached to the stone to survive, and thus preserves the community of animals practically undisturbed. Don't collect more specimens that you need and remember to leave all young and immature shells, also those which are damaged or deformed. The former can grow up into good specimens for future collectors, while the latter can breed and contribute to future generations.

The second way to obtain shells is by exchanging with other collectors. Membership in a shell club (of which there are several in Australia) will soon put you in contact with collectors throughout the world who will be anxious to exchange with you for good specimens of your own local shells. Persons interested in joining a shell club may write to the Hon. Secretary, Malacological Society of Australia, the Australian Museum, College Street, Sydney, for details. In exchanging, the secret of success is, first of all, complete honesty. Always give correct locality information with each shell and make sure that the shells you send in exchange are at least the equal in number and quality of those you receive. Remember that most collectors want to have shells of scientific value, and no shell without exact information concerning the locality from which it came has any scientific value.

The third way in which shells can be acquired is by buying them. There are a number of shell dealers in Australia and many others throughout the world. Prices

for shells vary with the dealer and the rarity and popularity of the shell. The most valuable shells, such as *Conus gloriamaris*, the "Glory of the Seas", which is worth about £1000, are so rare that they seldom pass through a dealer's hands. While buying shells is one way of acquiring those rarities which come from distant parts or which you cannot collect locally, it is not as satisfying to most people as is the joy of collecting shells yourself on the beach or coral reefs. One worth-while source of shells is the fishing boats which are found in small ports almost everywhere round the Australian coast. The boats usually trawl for prawns or fish, dredge for scallops, or collect lobsters in lobster pots, and most of them pick up shells incidentally. These are often rare deep-water species and the fishermen often keep a box of shells for sale to collectors when in port.

### Cleaning And Preparing Shells

Having acquired fresh shells it is often necessary to clean them. Provided this is done soon after collecting, the animals can be removed from the shells by first placing them in cold water which should be brought slowly to the boil. After a few minutes gentle simmering the shells should be allowed to cool slowly, following which the animals can be removed with a hooked implement such as a piece of wire or a straightened fish hook. This treatment is only suitable for solid, unglazed shells; highly polished shells such as cowries may be damaged by boiling water. Bivalved shells are best treated by gentle heating, or relaxation in sea-water to which has been added some Epsom salt or menthol crystals. When the valves are gaping, a knife can be inserted and the animal removed.

An alternative method is to allow the animal to rot or macerate in water. This treatment is most successful provided good care is taken to change the water regularly—at least once or twice a day. If it is allowed to stand longer, the accumulation of decomposition products may damage the shells. During maceration, decomposing tissue can often be shaken out of the shell. The following method can be recommended for all live shells, particularly land snails: immerse them in 50 per cent alcohol (equal

parts of methylated spirits and water) for about four days to a week. This solution assists decomposition, the animal does not harden and can be extracted easily—often shaken out. If left in alcohol for no longer than a week the shells are not impaired in any way.

Shells can sometimes be cleaned by burying them in clean dry sand, aperture down, and leaving them to rot for several weeks. The products of decomposition will then run out of the aperture, but care must be taken that the sand is not too wet and that no part of the shell is exposed to light, else the colour and polish may be damaged.

When the shell has been cleaned of its contents, it should be washed in warm soapy water and thoroughly dried. Loose growths can be removed from the outside with a stout brush or knife, but care should be taken that the shell surface remains undamaged. Some shells have a horny periostracum or outer coating which may be removed or retained as the collector wishes. For scientific purposes, shells should be left in their natural state, never polished, treated with acids or lacquered.

When collecting, shells may be placed in preservative such as 75 per cent alcohol, dilute methylated spirits (three parts spirit to one part water) or neutralized 10 per cent formalin, but should never be placed in ordinary formalin (formaldehyde), which attacks the shell through the development of formic acid. After some days in preservative, they can be removed and the animal matter allowed to dry out in the open air. A precaution against unpleasant smells is to syringe the inside with preservative. The shells should then be washed in tepid soapy water and thoroughly dried. In the case of obstinate whelks and trochus shells where the apical coils of the animal remain behind, this matter can be rendered permanently innocuous by placing the shell upside-down and pouring in a fluid shellac solution. This penetrates the animal remains and solidifies, preventing subsequent decomposition.

### Naming Of Specimens

In order to complete your collection, you will probably want to name your specimens. This is where shell collecting moves from

being a healthy outdoor activity and an aesthetically satisfying hobby, to a stimulating mental exercise. For in naming your shells it is necessary to study them carefully in order to sort out the different kinds and then to delve into the literature to find the right names for them. There are a number of books available, written in popular style, which will enable the average intelligent collector to name most Australian shells. Two which can be recommended are mentioned at the end of this article, the first for new collectors, the second for collectors who have passed the beginner stage. Other books are available, dealing with the shells of individual States and with other parts of the world.

If you are unable to name your shell from books available try paying a visit to your nearest museum, where many shells will be on display in the public galleries. If you are still unable to name any particular species, most museums will provide an identification service, but only on the understanding that specimens required for the museum's collection are retained. Remember that the identification of rare or "difficult" shells may take a great deal of time, even with all the facilities available in a museum, hence it is only fair that the museum collections should benefit if the specimen is of scientific value.

### Containers For Shells

Finally you will want to keep your collection in some sort of order, where it can be safe from careless handling and yet visible to interested persons. The best way to do this is to have a suitable cabinet with shallow, dust-proof drawers in which the shells can be laid out in systematic sequence. Glass-fronted cabinets are suitable for only a few larger, showy shells, but most specimens should be kept away from light, which eventually causes fading. Each "lot" of shells (one or more specimens of a species from the same locality, collected on a particular occasion) should be kept separate, either in a glass or plastic container, a small cardboard box, or a shallow tray similar to the inner portion of a match box. Each lot should have its own label, with details of locality, date, collector's name, and scientific name of the species. It is a good idea to start a catalogue and give

each lot a consecutive number, entering the details concerning the specimens in the catalogue opposite the number, and, whenever possible, writing the number on the shell with permanent ink. In this way a specimen can always be provided with the correct locality, collector and date, should it be accidentally separated from its label.

A shell collection can be a source of great aesthetic satisfaction and both physical and mental exercise, and can be an important contribution to scientific knowledge, for many new and rare species have been discovered through the activities of amateur collectors.

BOOKS RECOMMENDED: *Shells of the Seashore*, by D. F. McMichael, revised edition, 1962; Jacaranda Press, Brisbane; price 13s. 6d. *Australian Shells*, by Joyce Allan, revised edition, 1959; Georgian House, Melbourne; price, £4 4s.

### MUSEUM FILMS

The film *White Clay and Ochre*, produced by the Australian Museum, has been very well received. Copies have been sold to film libraries and education services throughout Australia and New Zealand. A contract has been signed with the A.B.C. for Australian and international television distribution rights. The subjects of films now in process of production are frogs, lizards, Aboriginal rock engravings, Aboriginal paintings and the Australian environment.

### VISITORS FROM AMERICA

Dr. Norman D. Newell, Chairman and Curator of Fossil Invertebrates at the American Museum of Natural History, New York, recently spent 10 days at the Australian Museum examining type material of Australian Permian pelecypods. During his visit he was shown the Permian sequence of rocks in the South Coast district. Dr. George Gaylord Simpson, of the Museum of Comparative Zoology, Harvard, visited the Museum in October.

### ROCK ENGRAVINGS

Mr. Tom Harrison, Curator of the Sarawak Museum, recently visited the Australian Museum to discuss with the Curator of Anthropology, Mr. F. D. McCarthy, similarities in rock engravings and stone implements found in Borneo with those occurring in Australia.

### PREPARATORS' CONFERENCE

A conference of museum preparators was held at the National Museum of Victoria in November, and was attended by six representatives of the Australian Museum.



To seaward from Australia's north-eastern coast the Great Barrier Reef stretches for 1,200 miles. Its broad band of coral banks form a labyrinthine maze, and atop hundreds of them are to be found the low isles termed cays. Here the receding tides over thousands of square miles provide a lucrative hunting ground for the dedicated collector of sea-shells.

## *Shells of the Great Barrier Reef*

By FRANK McNEILL

OF all the natural creations of this world there are few that can compare with the sea-shells. Their exquisite texture and dainty shapes, lustrous shades and colours, have given to them a perennial appeal. Very few of those who visit an ocean foreshore can resist collecting them, and the farther from the sea people reside, the greater seems to be their attraction. As well as their educational value, sea-shells have a special appeal for their aesthetic beauty and their permanence. Among the kinds more sought after than most for their brilliance and variety are those of tropical regions, and paramount among these are the inhabitants of the south-west Pacific Ocean. In this large area of the greatest concentration of coral growths are the ideal conditions for a superabundance of molluscan life. Australia's Great Barrier Reef, off the

coastline of Queensland, is an integral part of the coral wonderland, and shares a reputation with other comparable parts further to the north for the quality and variety of its sea-shells. Numerous species to be found there among the maze of coral banks and in the adjacent waters are of rare and outstanding worth, coveted by collectors everywhere.

### **Clam Shells**

As with most tropical molluscan marine fauna, it is not the shells alone which carry beauty of design and colour. Very many of them are rivalled in the living state by the beauty and delicacy of their animal builders. This fact is one that it will be impossible to ignore in doing justice to the various kinds of Great Barrier Reef shells

forming the subject of the present account. Of especial interest in this category are the clam shells classified under the name *Tridacna*. These bivalves, with shells that lack the beauty and colour of so many other tropical molluscs, nevertheless, render themselves at once conspicuous through either their size or their colourful flesh, and their great abundance.

Most notable of all the clams is the widely distributed giant, *Tridacna gigas*, largest of the world's bivalve molluscs. It is most frequently found deep within the fastnesses of the Great Barrier Reef, resting unanchored among the coral growths, but secure against dislodgment because of the great weight of the paired shells. Many collected specimens have been as much as three feet six inches long, with a weight close to 300 lb. These are far from being the largest of their kind, for authentic records exist of examples four feet six inches long and two feet five inches broad. Such giants would to-day be found permanently immersed in comparatively deep water, where they are not infrequently seen by divers. In the living state the great shell valves of the giant clam open wide when under water to display an expansion of tough tissue (mantle) almost obscuring the housing from above, and coloured in shades of olive-green and brown.

While other much smaller clams lack the dimensions of their giant relatives, they are more attractive and arresting in appearance. They are not only abundant and dispersed in every direction over wide areas, but the

jewel-like appearance of their living flesh gives to them a brilliance unmatched in their surroundings. Two kinds of these smaller clams are readily recognized, one of them a so-called burrower, the other more of a borer. They are found tenaciously attached by their bases in cavities they somehow contrive to excavate in patches of dead honeycombed coral growths and the hard boulders of reef limestone scattered over the coral banks. Always the lips of the clam shells remain free, and never sunken below the surface level of the cavities. The larger burrower-type species, *Tridacna fossor*, is the one having a preference for its seating in the coral growths, and grows to a maximum length of about nine inches. In favourable situations the upper external halves of its valves develop leaf-like scalloped frills which enhance the appearance of an otherwise colourless shell. This burrower is mostly found submerged in water, even at low tide, and the brilliance of its mantle tissue then displayed between the gaping valves makes it the most conspicuously beautiful object seen on any part of the Great Barrier Reef. Viewed from above, the jewel-like quality of the colouring is remarkably impressive. Every conceivable shade and combination of hues appear to be present in the flesh tones of a mere dozen individuals, and no two patterns can be found anywhere exactly alike. The smaller so-called borer of the two strikingly coloured clams, *Tridacna crocea*, occupies the narrow and almost slit-like cavities sunk into the hard surfaces of the boulders, in places quite crowded and numerous. In

The Giant Spider Shell, *Lambis truncata*, grows to about a foot in length. Its curved marginal spines are shorter and thicker than those of its smaller relatives, and the sheen of its underside less colourful. Seen here projecting from the retracted animal occupant of the shell is the tip of the characteristic horny, claw-like process which is attached to an elongated process of the crawling foot.



A living Tiger Cowry, *Cypraea tigris*, showing at its base and almost completely retracted, one of the two thin, highly ornamented flaps of the animal mantle which normally envelop the shell as a protective sheath. Mottlings and spots on a porcelain-white ground vary in shade from brown to dense black in different individuals. (Natural size.)



this case the submerged expanded flesh of the mantle is of a more broadly extensive pattern, more widely undulated, and not unlike the petals of some large flower. While the colour is invariably a dark shade of blue, its velvety softness, combined with the sinuosity and symmetry of the margins, makes it a truly beautiful object.

At least one other outstanding Great Barrier Reef bivalve, in this case a swimmer, can be said to owe its arresting appearance purely to the beauty and colouration of its flesh. This is the little thin-shelled, pear-shaped Swimming Lima, no more than one and one-half inches long. Upon being disturbed at low tide in some sheltered place under a slab or boulder it puts on a brilliant display. Adorning the edges of its mantle tissue are numerous tapered, crimson tentacles which are kept continuously in motion, and remain permanently free from the shelter of the paired shells. While the little creature swims jerkily this way and that, the vigorous movement of its unusual colourful appendages is as strange as it is beautiful.

A collector intent on the permanence of beauty in any visit to Great Barrier Reef waters is normally attracted by sea-shells either striking in their pattern and colour or of delicate and artistic construction. Among these are the numerous shiny and porcelain-like cowries, volutes of unusual shape, cones, mitres, strombs and olives. While representatives of all these diverse types occur along the entire length of the coral-bound waters, they are generally found to

be more plentiful in the northern parts. They are also not necessarily confined to the coral banks, for many of them are found living on the fringing reefs which are a feature of the many high islands, and even along the shores of the mainland coast. On island beaches here and there great accumulations of untenanted shells, mostly sun-bleached, provide a gauge to the prolificacy of adjacent waters. In these places specimens may often be seen newly cast up by the waves and still retaining much of their former beauty and colour. A Black-mouthed Stromb, *Strombus aratum*, a mitre or a glistening cowry could well be the reward of the tide-line collector, but results would be far from satisfying for the dedicated enthusiast. Any real success in shell collecting requires the qualities of dogged perseverance, experience and keen observation. By such means it is soon learnt that much of the search for living specimens must be made in the caverns and crevices of the honeycombed parts of the coral banks, and on or below the undersides of movable boulders and slabs of reef limestone. Hard work and long hours of tramping and questing produce slow but worth-while results. It is not the habit of most of the sought-for quarries to lie haphazardly about in the open, and this applies particularly to sub-surface dwellers, either on the coral banks or submerged in the beach sands of tidal flats. Familiarization with the various habits and tell-tale signs are great aids to the successful collector's code. With this knowledge a particular furrow mark can be

recognized and traced to a burrower's hiding place or the surface activities of a night forager become known.

### Volute And Olive Shells

All volute and olive shells are inveterate burrowers, and here also can be included the elongate and finely tapered pencil or auger shells, *Terebra*, not previously mentioned. Of the volutes, the most prominent Great Barrier Reef inhabitants are the melon or baler shells (*Melo*)—tropical giants of their kind. They occur in a great variety of sizes, and when small many have their usual background colouring of some shade of apricot ornamented with either bands of brown or some other indefinite pattern of the same hue. The shell form, at first roughly oval, gradually assumes with growth a markedly bulbous shape, and commonly reaches a length of 14 or 15 inches. Colour and shape of the adults have given rise to the first-mentioned of the popular names. The second popular name derives from the use the shells have been put to in the past by Aborigines and native islanders as canoe balers. The finding of a large melon shell out in the open during daylight is usually considered a rare piece of luck. In their normal habitat of the gravelly, sand-like detritus flats of the coral banks, the living shells move slowly about below the surface on a great muscular grey foot and, except during darkness, prefer to remain submerged. Other volutes that have a

preference for a submerged existence are two beautiful three-to-four-inch-long kinds greatly sought after for their shape and ornamentation, both of structure and colour. One is called the Heron Island Shell, *Cymbiolacca pulchra*, because of its early discovery in the shallows at the southern coral cay that gave it its name. The other is Wiseman's Volute, *Cymbiolacca wisemani*, found much further to the north, and in this case bearing the name of its discoverer. Both shells are somewhat similar in shape—broad across the shoulder, marking the base of an extended spire ringed at regular intervals with low spiny protrusions. The first of these two shells is coloured a delicate brownish-pink, broken by innumerable small triangles of porcelain-white, and tiny blackish flecks are present in several broad, encircling bands. In the other shell a faintly pink surface carries large irregular mottlings of light-red arranged in broad bands. Though both these shells remain normally hidden in the substratum of the flooded tidal flats of coral banks, they are occasionally seen half or fully emerged on the surface on calm, still days just as an incoming tide begins to flow.

Several other kinds of colourful volutes with similar habits to the foregoing are readily accessible to keen collectors along the length of the Great Barrier Reef, but have generally smoother surfaces to their shells. Perhaps the commonest is the two-to-three-inches long *Amoria maculata*

The Giant Clam, *Tridacna gigas*, displays, when submerged, an expansion of tough mantle tissue overlapping the margins of its gaping shell valves. Many adult examples reach a length of three feet six inches, and a weight of close to 300 lb.



(formerly known as *A. caroli*), creamish in colour, with linear flecks of light-brown to purplish-brown arranged in longitudinal series. The live shells move about in the open at night, but it is the unoccupied shells which are more frequently found lying on the surfaces of tidal flats. Another larger and more robust form is the Blood-red Volute, *Aulicina rutila*, of northern parts, with a shell as bright and colourful as its popular name suggests. Still other much cherished volutes of Great Barrier Reef parts are those that frequent deeper offshore waters, and can only be collected by divers or in the trawl nets used by fishermen.

Among many personal experiences of shell collecting is one which, by chance, disclosed the habitat and hiding place of pencil and auger shells. It happened close by the shore of a tiny coral islet off the north Queensland coast. Digging with a spade at low tide on a flat near the bottom of the strand exposed a surprising number of the shells—the pencils, *Terebra muscaria*, creamish in colour with mottlings of brown, five inches long and tapered to a very pointed tip; the olives, *Oliva sericea*, shorter, more rounded, with purple markings on a yellow ground. Both were remarkable for the beauty and high gloss of their surface enamelling, a quality of all their many relatives over a wide area of the Great Barrier Reef region. The way to collect these same shells alive in the open is to wade through the shoreline shallows on a

quiet night, and, in the beam of a torchlight, search along the trails in the sand.

### Cone Shells

Cone shells have received their name for the likeness of their shape to the fruits of pine and fir trees. While so many of them do not have a glossy sheen like that of other tropical sea-shells, their variety of shape and the design and colours of their ornamentation have earned for them many admirers. Despite these attributes, the cones have also earned a sinister reputation. Among all sea-shells they are the only ones capable of inflicting a painful sting which, on a number of occasions, has caused the death of humans. As highly specialized carnivores, they show an unsuspected agility in attacking their prey. Not all kinds, it is considered, possess a venom injurious to humans, but many of those found in tropical parts, including Great Barrier Reef waters, are definitely suspect. Live cone shells are not generally very obtrusive, and are prone to shelter during low tide on the undersides of boulders and slabs of reef limestone or immerse themselves in any loose detritus sands on which these objects may rest. Often in life the colour and patterning of the shell are obscured by a slimy skin or a quite tough, horn-like covering (periostracum), but the removal of this does not present any difficulties for the initiated.

At least two proven dangerous cone shells of Great Barrier Reef waters are the Geographer Cone, *Conus geographus*, and the

The Volute Shell, *Amoria maculata*, is, in its living state, an excellent example of how, among many tropical sea-shells, the beauty and colour of the animal either match or better those of its housing. In this case the creamish ground and brown markings of the shell are repeated to provide a totally different pattern over an expansive crawling foot, feelers and siphon tube. (Slightly enlarged.)



This Stromb Shell, *Strombus gibberulus gibbosus*, clearly illustrates the greatly extended outer shell lip common to practically all of its kind: the characteristic marginal notch is also clearly defined. While it lacks the colouring normal to most other strombs, the whitish sheen of the mouth aperture is a most attractive feature. (Natural size.)



Tulip Cone, *Conus tulipa*. The former stung a man in the palm of his hand in 1935, and caused death within a few hours. Among tropical cones the shell of this killer is rather unattractive; it is comparatively thin, has a very low spire, and small blotchings and bands of a dingy brown colour cover a ground of much lighter hue. By contrast, the beautiful Textile Cone, *Conus textile*, displays an almost unrivalled brilliance, both in respect to its shell and the living occupant. The shell patterning is of a triangular motif featuring porcelain-white, yellow and shades of brown, interspersed with several broad, broken bands defined by thin, dark brown longitudinal striations. It is the most favoured of all Great Barrier Reef cones, the most often seen, and apparently the most widely distributed.

#### Molluscan Acrobats

In life, the numerous stromb shells are the acrobats of the molluscan world. To effect their dextrous movements they make use of a horny, claw-like process which is anchored at the extremity of a slender, muscular foot. With leverage gained in this way they can actually perform somersaults, and can quickly right themselves again if turned on their backs. The typical strombs have wide outer shell lips, often quite exaggerated and wing-like. Another characteristic is the almost invariable presence of a conspicuous notch in the outer lip near the narrow open end. Already mention has been made of the Black-mouthed Stromb, so frequently found as an untenanted shell along some island tide lines. Like so many

others of its kind, the richer shell tonings are found on the glistening undersurface surrounding the mouth aperture—a splash of black, merging into light and dark shades of brown. Other stromb shells with the same disposition of their richest colouring are several kinds of Spider or Scorpion Shells (*Lambis*) which carry a number of curved, tapered spines springing from the extended outer shell lip. One of them, *Lambis lambis*, is particularly abundant in scattered areas on the coral banks, and the colour of its glass-smooth underside can be a combination of several beautiful tonings, but is most commonly a rich, dark shade of purplish-red. By far the commonest and most widely spread of all Great Barrier Reef strombs is the Red-mouthed Stromb, *Strombus luhuanus*, growing to only about two inches in length. Superficially the shape resembles that of the earlier discussed cones, and the likeness tends to confuse the uninformed. The distinct notch in the outside lip of the shell is the clue to its relationship with other strombs.

Among all Great Barrier Reef shells, the strombs are unusual in their apparent preference for living permanently in the open. Despite this habit they can often escape detection through the chance camouflaging of their shells by the settlement of silt and thin investments of limy material.

#### Mitre Shells

Typical mitre shells bear a close resemblance to the well-known ecclesiastical head-dress of the same name, and a number of

them have been given technical names inspired by this likeness; examples are *Mitra papalis* and *Nebularia cardinalis*. The largest of the Great Barrier Reef kinds, *Mitra mitra*, attains a length of about six inches. It is decorated with widely spaced, irregular-shaped red markings on a white ground. Another somewhat smaller kind, often found as an untenanted shell, is the Papal Mitre, *M. papalis*, readily recognized by the prominence of the whorls on its spire and the crowded spots of red on a white to cream ground. A much smaller kind still is the Little Fox Mitre, *Vexillum vulpecula*, which is another more commonly found without any animal occupant. The features of its rather broad form are prominent whorls with widely spaced ridges, one broad band of greyish-black, and flecks of the same shade forming other bands on a silvery-white ground. The more prominent mitres are apparently rarely secured alive, and personal experience suggests that they normally live, like pencil and volute shells, submerged in the sandy detritus of their habitats.

### Cowries

The lustrous sheen of cowry shells is a quality shared with the olive shells, and for the same reason. In life, greatly enlarged, thin flaps of the animal mantle are able completely to enclose the shell housing, to act as a protective sheath. Quite apart from the structural beauty and colours of the actual shells, so many of the cowries have, in life, attracted attention for the beauty and brilliance of their animals. Collectors look upon them as the gems of the sea and, extraordinarily enough, most are easily gathered and are, as well, the best known of all Great Barrier Reef shells. Upon the receding of tidal waters it is their habit to seek temporary shelter under ledges, in the cavities below the surface of honeycombed areas of dead coral growths, and quite commonly on the undersides of any slabs or boulders. Their normally oval to globular shapes make them readily discernible for, when resting, the enveloping mantle flaps of the animal are retracted from the shell. Dozens of kinds live and thrive in the coral crowded waters and range in size from less than an inch to the comparative giant dimensions of forms like the Tiger Cowry,

*Cypraea tigris*, and the Eyed Cowry, *Cypraea argus*, both of which may attain a length of over four inches. From the plainest but most brilliant of porcelain-white, the colours of the shells are in a seemingly endless variety of patterns—bands, dots, spots, blotchings, reticulated and linear arrangements of stripes and flecks, as well as other markings. Almost any combination of the patterns listed may be found in single examples.

In concluding this article on Great Barrier Reef Shells it should be emphasized that no account could possibly cover so big a subject. It has only been possible here to include some of the limited knowledge of the author, and to touch on the highlights which were considered to have a popular appeal. If these have been stimulating enough to attract other disciples to a truly rewarding hobby, the task has not been in vain.

[Photos in this article are by Keith Gillett, except that of the Giant Clam, which is by the author.]

### AUSTRALITES

The Meteorite Expedition of 1964, of which Mr. R. O. Chalmers, Curator of Minerals at the Australian Museum, was a member, extended its area of search for australites in the Lake Torrens region with success. Further north several other localities yielded australites, such as Muloorina, Lake Eyre South and an extensive area between the Birdsville Track and the eastern shore of Lake Eyre. In Queensland the occurrence of australites at Mooraberree, about 100 miles west of Windorah, was confirmed. Specimens were also found on Currawilla, an adjoining property. Mr. M. H. Hammond, of Ingella Station, near Windorah, a grandson of the original observer of the Tenham fall of stony meteorites, through the years has collected a further 90 specimens of the Tenham on the flood plains and gibber plains near the Cooper. This collection was acquired. The entire collections have been divided between the Australian Museum, the United States National Museum and the American Museum of Natural History.

### CURATOR'S VISIT TO U.S.A.

The Curator of Crustacea and Coelenterates at the Australian Museum, Dr. J. C. Yaldwyn, spent three months at the Allan Hancock Foundation, University of Southern California, U.S.A., working on the systematics of the deep-water fauna off the southern Californian coast. He returned in October.



A wide band of the Sydney Rock Oyster, *Crassostrea commercialis*, covers intertidal rocks in coastal inlets of New South Wales. Here, near the mouth of the Hawkesbury River, 400 oysters may occur per square foot. Contrast this photo with that of the Victorian shore on the next page. [Photo: Author.]

## *Shore Molluscs of Southern Australia*

By ELIZABETH C. POPE

MOLLUSCS may be collected and studied in several ways: as the amateur who regards them as things of beauty to be acquired and kept for the pleasure of having them; as the conchologist who values them for their own intrinsic scientific interest; or they may be regarded as just one among the many animal and plant groups that help to form the fascinating mosaic of life along our shores. It is in the last sense that the author has studied the molluscs of the southern half of Australia, in the course of broad ecological surveys designed to find some general pattern of geographical distribution among coastal marine organisms.

In surveys of this type, certain interesting facts emerge. It was soon noticed that, while limpets are extremely common on temperate coasts like those of Victoria and Tasmania, both the number of species present and the populations in each of them begin to fall off on tropical coasts, till limpets become scarce or even absent. During a two-months collecting trip in New Caledonia, the author did not see a single limpet, in spite of diligent searching.

Along the tropical shores of Australia rock oysters form a prominent band, as they do along the shore of the mainland of Queensland. The oyster is *Crassostrea*



Beds of the mussel *Brachidontes rostratus* coat the rocks near Lorne, Victoria, where the substratum and degree of exposure to surf are suitable. The mussels make up for the lack of variety of species of shells, compared with tropical shores, by occurring in countless thousands. [Photo: Isobel Bennett.]

*amasa*. In the warm temperate waters of New South Wales comparable bands of oysters occur in inlets and estuaries, rather than on the open coast, and the species is the gourmet's favourite, *Crassostrea commercialis*, while in Tasmania and on most of the Victorian coast one may search in vain for a native rock oyster. Attempts are being made in these cooler seas to introduce a Japanese species that can flourish at the reigning temperatures. However, massed growths of intertidal molluscs are still a prominent feature of the intertidal zone in Victoria and Tasmania for, wherever the substratum and degree of exposure to seas are suitable, great carpets of the mussel *Brachidontes rostratus* are to be seen and, higher on the rocks, another dark band of a second smaller species of mussel, *Modiolus pulex*, occurs. Such massed groups of mussels occur from southern New South Wales round through Tasmania and Victoria and over to the southern area of Western Australia.

In addition to the prominent species mentioned above there are many kinds of periwinkles, littorinids, conniwinks and their relatives scattered in countless thousands

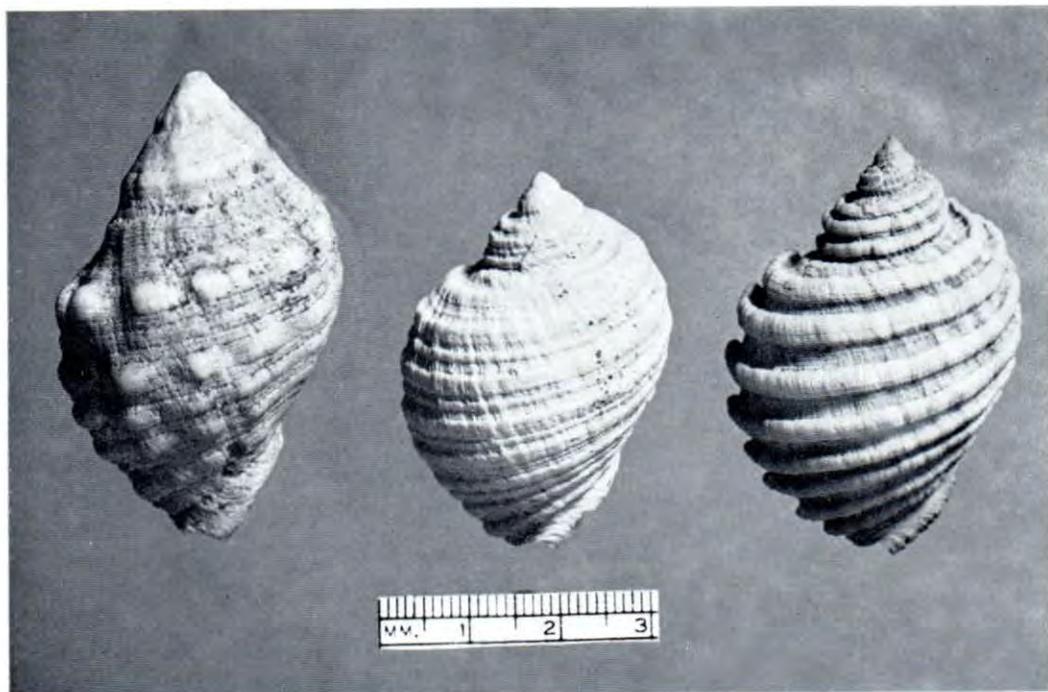
along the rock platforms of southern Australia, together with carnivorous shells like the thaliids, the oyster borers, the cominellas and so on, so there is no lack of shells on our temperate shores. However, if one can generalize, it would be true to say that, on the whole, the shells of southern Australia do tend to be rather smaller, less spectacular in colouring, less beautiful and less strongly built than their tropical counterparts. This is in all probability due to the fact that warmer sea temperatures favour the laying down of calcium salts, for calcium metabolism is speeded up by increased sea temperatures. It is in the tropics, for instance, that the colonial corals have built up massive reef-systems like our Great Barrier Reef in a way the corals from cooler seas cannot, and it is here that the heavy shells of giant clams grow. Consequently, industries and fisheries based on the gathering of shell (like trochus and pearl shells) are centred in the tropics.

However, there are successful shell fisheries in our temperate seas, but they exploit the molluscs as food. The scallop industry of Tasmania and Victoria, the rock-oyster fishery in New South Wales and the

newly developed abalone or mutton fish fishery are flourishing, while the mussels and pipis are exploited to a lesser degree. Tropical molluscs can be eaten and some are quite delicious, but there are difficulties involved in gathering enough shellfish for one good meal, so that, until our need for food becomes much greater than at present, our tropical shellfish will remain unexploited. Even the Queensland rock oyster is too difficult to open and too small to be gathered commercially.

Another striking thing that is noticed in the course of ecological surveys over thousands of miles of coast is that many shells from New South Wales shores have closely related counterparts in Western Australia but differences that are quite distinct can be recognized in their shells. Whether the soft animal parts differ has not yet been proved. A striking example of this is furnished by the thaiids. The New South Wales one is known as the Cart-rut Shell, *Dicathais orbita*, and its sculpture of prominent raised

ribs indicates how its popular name was bestowed on it. This shell is carnivorous and moves over the reefs, preying on barnacles or shellfish, retreating during low water into holes and crevices for shelter. On Western Australian reefs, near Fremantle, the shell *Dicathais aegrota* occupies exactly the same ecological niche as the New South Wales species, but, instead of having the regular cart-rut-like sculpturing, a series of bosses occur along the raised ridges so that the dominating feature of its sculpture is regular rows of raised bumps. In both this western and the eastern shell, series of regular fine lines mark the shell surface and parallel the larger raised ribs or the rows of bosses. This is shown in the accompanying photograph. However, this story of the thaiids is by no means complete because there is a third species, with its distribution centred in Victoria and Tasmania, known as *Dicathais textilosa* and characterized by sculpturing consisting of very weakly developed raised ribs so that the fine lines that

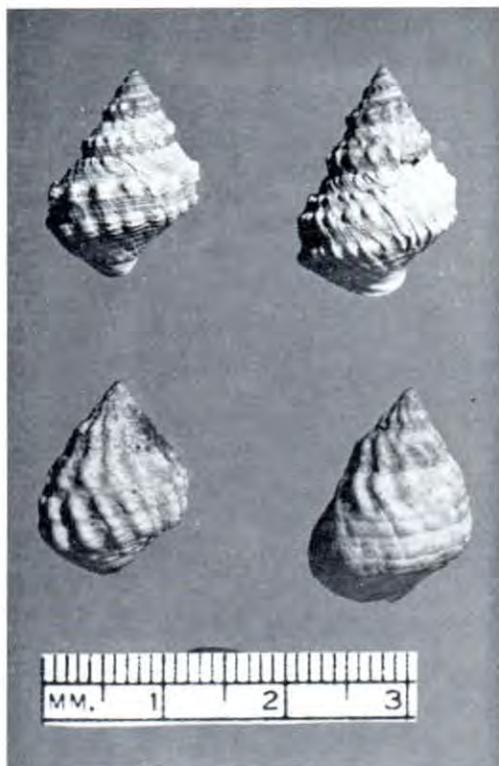


Three thaiid shells, showing differences in sculpture: left, *Dicathais aegrota* (Western Australia); centre, *Dicathais textilosa* (Victoria and Tasmania); right, *Dicathais orbita* (New South Wales). See text for explanation. [Photo: Charles Turner.]

run parallel with them are the dominating marking on the shell. This shell occupies exactly the same niche as the other two. A long series of these shells, taken between Fremantle and Twofold Bay in New South Wales, produced shells in the south-east and along the Great Australian Bight in the south-west which were intermediates so far as shell characters were concerned and a conchologist would have had a hard job to place them in one or other of the adjacent species. Moreover, many juveniles were taken in which prominent raised ribs (New South Wales form) combined with well-marked parallel fine-line sculpturing (Victorian form) and quite distinct nodules on the raised ribs (West Australian form). Such juveniles were found both in New South Wales and South Australia. The author cannot help wondering if these three species are not all one and the same and whether the differences in environmental temperatures in these three areas could not account largely for the slight differences in shell sculpture—those from the warmer waters in New South Wales and West Australia having larger and heavier shells because they would have more favourable temperatures in which to lay down calcium salts and more chance to develop heavier sculpturing than the Victorian ones. It would be interesting to transplant juvenile *Dicathais* from New South Wales to Victoria and southern Western Australia and see how they matured and how their shells would turn out. Another interesting study would be to try some experiments in cross-breeding individuals from the three areas.

Further examples of eastern and western species that show slight divergence and occupy the same niche are the chitons *Onithochiton quercinus* (east) and *Onithochiton occidentalis* (west) or the turban *Ninella torquata* (east) and *Ninella whiteleyi*, to mention only some of the more obvious species.

During our coastal surveys we were amazed to find that, where a certain ecological niche was occupied by difficult genera in the east and in the west, the two shells often seem somehow to have a superficial resemblance to one another—sometimes a likeness in colouring, sometimes in sculpturing. Examples of this are furnished by



Similarity in form and sculpture is shown in two different genera of littorinids from the supra-littoral zone of the shore. Above are two specimens of *Nodilittorina pyramidalis* from eastern Australia and, below, two of *Tectarius rugosus* from Western Australia. [Photo: Charles Turner.]

the littorinids *Nodilittorina pyramidalis* of eastern Australia and *Tectarius rugosus* in the west, which, as the illustration shows, both have rows of knobs round their whorls, or the two chitons, *Sypharochiton septentriones* (east) and *Clavarizona hirtosus* (west), which are similarly coloured when eroded and have girdles with broad dark and light stripes. One is left wondering if a certain type of shell sculpturing and certain colour patterns have survival value in the higher intertidal zone.

Unfortunately the scope of the present account will not allow even the listing of the molluscs from southern Australia that are beautiful, peculiarly shaped or zoologically interesting. Nor can we refer, if only briefly, to the species that are harmful to man or his works, like the carriers of certain stages

in the life-history of the bilharzia flatworms (cause of bathers' itch or schistosoma dermatitis), the shipworm or cobra molluscs that destroy wooden structures under water, or the octopus with a poisonous bite. Then there are the molluscs with interesting behaviour patterns like the bivalved Lima shells that build nests and swim or the tiny white gastropods that parasitize starfishes.

Such a list would be very long, for there is no end of interest to be had from the close study of the southern shells of this

continent. A great deal has already been written about some of these shells in earlier parts of the Australian Museum's magazine. For this reason an attempt has been made in this article to arouse interest in some of the commoner species and to challenge certain assumptions—in the case of the thaidis, for instance, that shell differences are necessarily indicative of specific differences. Just how important are small differences in shell sculpture? There is a great need for ecological and physiological research in this field.

## *Retirement of Mr. G. P. Whitley and Appointment of Dr. F. H. Talbot as Curator of Fishes*

With the retirement of Mr. Gilbert P. Whitley on September 8, the Australian Museum has lost the last of the old school of biologists, who, over a long period of years, rendered such good service to the Museum.

Mr. Whitley, who joined the staff of the Museum in 1922 as assistant to the then Curator of Fishes, Allan McCulloch, became Curator in Mr. McCulloch's stead following the latter's death in 1925.

During the long period he held the Curatorship, Mr. Whitley did much to enhance the Museum collections and also to benefit the Museum in many other ways.

As well as establishing a high reputation among all interested in fish and fisheries in the State, he also became well known among ichthyologists the world over as the author of very numerous papers on fish taxonomy.

He travelled widely on collecting expeditions, visited Museums in many parts of the world, and attended overseas fisheries conferences as an invited participant.

During the war he was seconded to the C.S.I.R., and took part in fisheries investigations in Tasmania and Western Australia.

As well as being active in Museum matters, Mr. Whitley has played a leading part in the affairs of many scientific societies. He has served on the Councils of the Royal Australian Historical Society, the Linnean Society of New South Wales and the Anthropological Society of New South Wales. For a period of 15 years he edited the publications of the Royal Zoological Society of New South Wales, of which he twice served as President.

Although his colleagues in other parts of the world have not always seen eye to eye with Mr.



Mr. G. P. Whitley. [Photo: T. D. Scott.]

Whitley on matters pertaining to the taxonomy and classification of fishes, all those who have known him at the Australian Museum have always held him in high regard as a kindly, courteous and respected colleague, and every good wish is extended to him on his retirement.

Mr. Whitley has been succeeded as Curator of Fishes by Dr. F. H. Talbot, formerly Assistant Director and Curator of Fishes at the South African Museum, Capetown.—*J.W.E.*



Freshwater gastropods.—Top row, from left: front and back views of *Plotiopsis balonnensis* (Conrad), from Lachlan River, N.S.W.; *Lymnaea lessoni* Deshayes, from Scone, N.S.W.; *Isidorella newcombi* (A. Adams and Angas), from near Wyalong, N.S.W.; *Physastra fusis*-Snail, *Lymnaea tomentosa* (Pfeiffer), from Tasmania. All are a little larger than life size.

## LAND AND FRESHWATER SHELLS OF AUSTRALIA

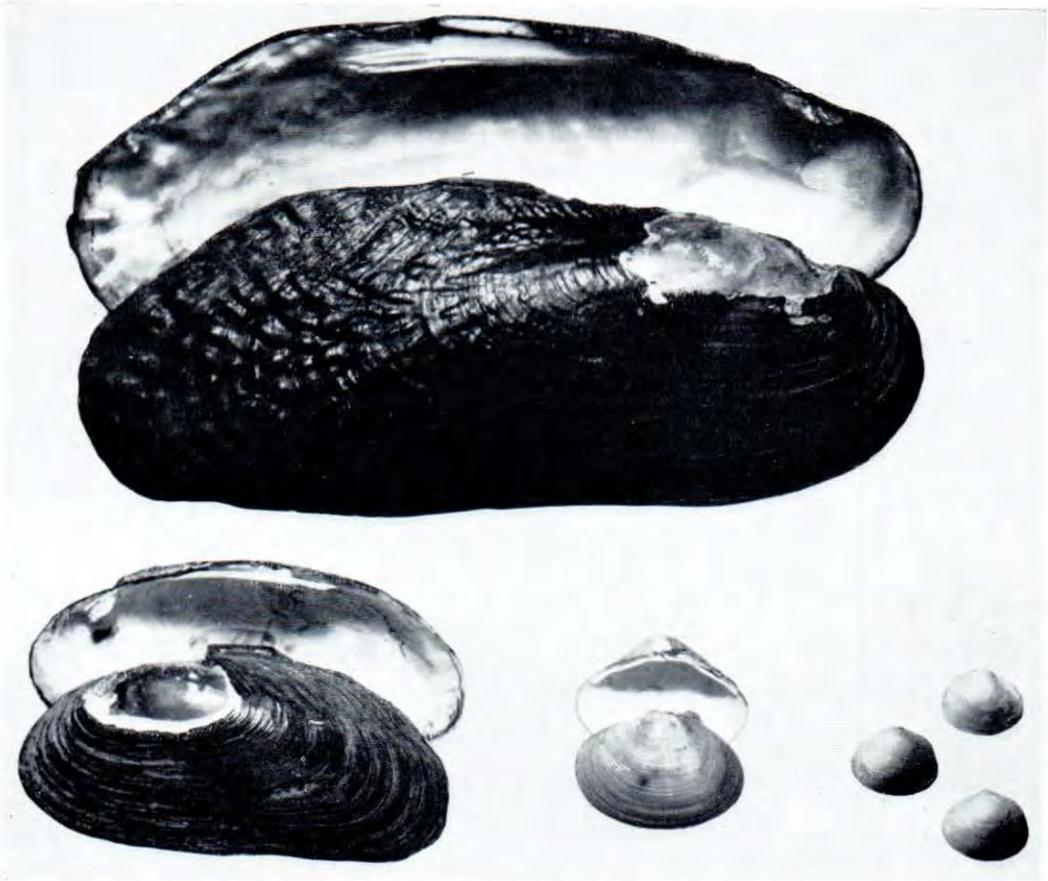
By DONALD F. McMICHAEL

MOST people think of shells as sea creatures. Curiously enough, when reminded of the common garden snail, many people still do not associate these terrestrial shelled animals with their marine relatives. Yet both the sea snails and the land snails, and indeed the freshwater snails, are all very closely related members of the Phylum Mollusca, Class Gastropoda. There have been several quite separate occasions during geological time when particular groups of snails have invaded either the land, or the freshwater rivers, from the sea. Before they could do so successfully, they would have had to evolve two important mechanisms. One of these would be an excretory system which could cope with the large quantities of fresh water which would enter their soft, permeable bodies; and in the case of most land snails, they had to evolve a lung with which they could breathe air, in place of the normal molluscan gill which only functions really efficiently under water, or in a very moist atmosphere.

As a result of these independent evolutions, there are several quite distinct groups of molluscs living in the freshwater and terrestrial environments today. We can recognize at least two major groups of snails, and beside these there are a number of kinds of bivalved molluscs or clams which have managed to adapt to life in fresh water. As yet the bivalves have not conquered the land and because of their large gills, which are important in feeding as well as respiration, it seems unlikely that they ever will become terrestrial. The other classes of molluscs (Amphineurans, Scaphopods and Cephalopods) are all strictly marine.

### Freshwater Bivalves

The freshwater bivalves include three important families. First, there are the freshwater mussels, which are large shells, ranging from about one inch to six inches or more in length, and characterized by the lustrous nacre or mother-of-pearl which lines the interior of the shell. As a matter of fact,



Freshwater bivalves from New South Wales.—Top: *Cucumerunio novaehollandiae* (Gray), from Barrington River. Bottom: left, *Hyridella depressa* (Lamarck), from Nepean River; centre, *Corbiculina australis* (Deshayes), from Lane Cove River; right, *Sphaerium* species, from the Botanic Gardens, Sydney. All are about life size.

the pearly nacre of these bivalves caused them to be used extensively for mother-of-pearl buttons in the United States about the turn of the century, but now plastics have taken over in this field. Freshwater mussels sometimes produce quite attractive pearls, and it is said that Julius Caesar first set out to conquer Britain as a result of hearing of the richness of its freshwater pearl fishery. In Australia there are about 17 different kinds of freshwater mussels, ranging from the large *Alathyria jacksoni*, which abounds in the Murray-Darling Rivers system, to the small *Hyridella naranacensis* of Victoria. They live in the sand or mud of larger rivers and creeks, and even occur in water-holes throughout the

arid central part of Australia. The larval stages are parasitic on certain species of freshwater fishes, so that if fishes are absent from a stream or lake, then freshwater mussels cannot survive long either.

Smaller freshwater bivalves are the little clams of the genus *Corbiculina*, which are about one inch or less in length, yellowish shells with white to purple interiors, and the tiny pea-shells of the family Sphaeriidae, which are only a half-inch or less in length and usually have fragile, translucent, cream to yellow shells. Both the latter groups are easily dispersed and they are among the first freshwater molluscs to be found in newly-dug ponds and dams. Farmers finding these molluscs in their dams are often amazed

and wonder how they can have reached there. However, we know that occasionally specimens are swept up in wind storms and sometimes they are accidentally transported by water birds, and even flying water beetles. As they are ovoviviparous a single adult individual may contain many young shells, so that whole colonies can be transported at once.

### Freshwater Snails

Turning to the freshwater snails, we can immediately separate them into two groups. First, those which show by their structure that they have evolved directly from marine ancestors, and second, those which have reached the fresh water by way of land-dwelling ancestors. The former are recognized because they still retain the gill, so characteristic of marine snails, and an operculum, or trapdoor which the animal uses to shut itself inside its shell when danger threatens. Among the operculate freshwater snails are a number of different families, several of which include mostly small shells only an eighth of an inch in length or less, especially common in the south-eastern part of Australia, including Tasmania. Inland areas of New South Wales and Queensland, and the coastal rivers of the tropical regions, are commonly inhabited by snails of the Family Thiaridae. These are somewhat larger, ranging from a half-inch up to several inches in length, generally high-spined shells, sometimes with spiny outgrowths encircling the whorls. One of the commonest is the genus *Plotiopsis*, species of which are found in the Murray-Darling system and in coastal rivers to the north, often surviving in water-holes which may dry up completely during droughts. On such occasions the snails have the ability to burrow deeply into the mud, and, by sealing themselves up with the operculum, they can survive until rain falls again, when they can emerge with safety. Some thiarid snails are closely related to species found in the islands to the north of Australia which are known to act as intermediate hosts for the dangerous parasites of man, Chinese Liver Fluke and Oriental Lung Fluke. However, these diseases are not known from Australia and careful quarantine will help to ensure that they are not

introduced. Another very serious disease which is transmitted by tiny freshwater snails is schistosomiasis, caused by a parasitic blood-fluke which affects some 100 million people throughout the world. Fortunately, there are no Australian snails which are closely related to those responsible for the transmission of these dangerous parasites.

The second group of freshwater snails are known as pulmonates and have a lung, which indicates that they are derived from ancestors which lived on land. They have lost the operculum like the land snails, but they seem able to survive quite well, even in the drier parts of the continent, where they too are able to live through long periods of drought, presumably by burrowing into the drying mud. As a consequence of having a lung, they still have to breathe air, and so you will often see pond snails in an aquarium coming up to the surface, where the lung opening is exposed, waste air is expelled, fresh air is taken in, and the snails move down below the surface again. There are several distinct families of pond snails in Australia, one of which, the *Lymnaeidae*, is of great importance. It is represented by two principal species, *Lymnaea lessoni* and *Lymnaea tomentosa*; the former is large and globular, while the latter is small, not much more than a half-inch in length and with a somewhat higher spire than *L. lessoni*. *Lymnaea tomentosa* lives in south-eastern Australia, Tasmania and New Zealand, and is the intermediate host for *Fasciola hepatica*, the liver fluke of sheep. Liver fluke causes a great economic loss to graziers in Australia and its control is best effected by eliminating, or at least controlling, the numbers of these freshwater snails in the sheep-raising areas. Certain chemicals are known which, when dissolved in the water, are toxic to snails but which do not hurt sheep, and in this way the snails can be kept under control.

Other freshwater pulmonates are the very widespread pond snails which have a left-handed twist to the shell. They look very much like *Lymnaea*, but a comparison of the two shells shows that whereas *Lymnaea* has its mouth opening on the right (if the shell is held with the spire up and the aperture facing the observer) the other pond

snails have the aperture on the left. For many years these snails were referred to the Family Bullinidae, but recent research has shown that they should properly be placed in the Family Planorbidae. Two genera are common in Australia, *Physastra*, which has many species and is a high-spired slender shell, and *Isidorella*, which is commoner in inland areas and has a shorter spire and more rounded whorls. Other freshwater snails are limpet-shaped (Ancylidae) and others are coiled in a flat disc (Planorbidae proper) but in both cases the shells are quite small, usually less than a half-inch across.

### Land Snails

Just as there are two major groups of freshwater snails, so there are two major groups of land snails. Some have an operculum, and breathe by means of small, but functional, gills. These are considered to have evolved only comparatively recently from marine or freshwater ancestors, and are confined to the more humid tropical parts of the world where the gill can work effectively. Operculate land snails are quite common in New Guinea, but in Australia they make up only a small percentage of the fauna, and are practically confined to the coastal fringe of northern Australia. A few species range down the Queensland coast into northern New South Wales, among them the members of the genus *Pupina*. These have small, glassy shells, solid, with complicated apertures, and often are almost impossible to pick up because of their smooth, slippery shells.

However, it is the true pulmonate land snails which predominate and which must be considered as among the most successful of terrestrial animals. Although a snail is a moist, slimy creature with a permeable skin, its shell is often quite solid, impervious to moisture, and capable of sheltering its owner and builder from intense heat and desiccation. Although the land pulmonates have lost the operculum, they have made up for it by the habit of secreting a tough mucous seal inside the mouth of the shell during dry periods. This is known as the epiphragm, and in some desert-living species of central Australia may be as much as an eighth of an inch in thickness. There are many native species of land snails in Australia, ranging from minute species



Land snails with relationships to other areas.—Top, left, *Bothriembryon rhodostomus* (Gray), from islands near Esperance, Western Australia, and, right, *Strangesta capillacea* (Ferussac), from Church Point, Sydney. Centre, *Rhynchotrochus macgillivrayi* (Forbes), from Cairns, Queensland. Bottom, *Meliobba shafferyi* Iredale, from near Mossman, Queensland. All are about life size.

scarcely visible to the naked eye, to very large shells over four inches across and weighing as much as a half-pound when alive. The common garden snails of the larger cities and towns are all introduced forms from Europe, but a few native species occur in suburban gardens from time to time. Perhaps the commonest in Sydney is the carnivorous snail, *Strangesta capillacea*, easily recognized by its flattened shiny shell. This species is known to feed on slaters and garden snails, among other things, and so should not be destroyed if found in the garden. In the tropical forests of northern New South Wales and south Queensland live several unusually interesting native snails. One of these, *Hedleyella falconeri*, is a monster by snail standards. Sometimes known as the Giant Panda Snail, it is common in the rain-forests which stretch in patches from the Barrington Tops area, just north of the Hunter River, to south Queensland, where it is replaced by a somewhat similar species, *Hedleyella maconelli*. These

shells are nocturnal creatures and may be found in numbers on a wet night in the forest. During the day they hide away under fallen logs and among leaf litter. They feed on decaying vegetation, fungi, and similar detritus, but do not as a rule worry gardeners since they are shy creatures and seldom venture from their native forests.

Related to *Hedleyella* are a number of other unusual genera occurring in wet forest areas up and down the east coast. In



Acavoid land snails.—Top, left, *Anoglypta launcestonensis* (Reeve), and right, *Caryodes dufresnii* (Leach), both from Weldborough Pass, Tasmania. Both are natural size. Centre, left, *Pygmipanda (Brazieresta) larreyi* (Brazier), from Dorrigo, N.S.W., natural size, and right, *Hedleyella falconeri* (Gray), from Dorrigo, N.S.W., one-third natural size. Bottom, left, *Pedinogyra hayii* (G. and P.), from Binjour Plateau, near Gayndah, Queensland, one-third natural size.

Tasmania the species *Caryodes dufresnii* is widespread, whereas the attractively patterned *Anoglypta launcestonensis* is confined to the wet mountain gullies of the north-east corner. *Brazieresta larreyi* is a small species with a delicate patterned shell which lives in the rain-forests around Coff's Harbour and the Dorrigo. It is a very

active little snail, apparently diurnal, whereas most forest snails are nocturnal. In south Queensland the genus *Pedinogyra* occurs, where four species live in different areas. They are all rather large, with flattened, banded, yellow, brown and olive shells, some species reaching nearly four inches in diameter. In some rain-forest patches, the Noisy Pitta bird feeds extensively on *Pedinogyra*, collecting the live shells and carrying them to a convenient stone, which it uses as an "anvil" or shell-breaker. The remains of thousands of past meals can sometimes be found scattered around some stones, but, unfortunately for collectors, mostly with the spire of the shell broken away.

The groups mentioned above are all members of the superfamily Acavoidea, which, like so many of Australia's invertebrate animals, has a "southern" distribution with representatives in South America, South Africa, Madagascar and southern India. Another group which is found only in south-western Australia, but which is closely related to South American genera, is *Bothriembryon*, a genus of high-spired shells occurring widely in both forest and desert regions from southern Western Australia across to South Australia. Some of these snails live up trees and, like so many arboreal land snails throughout the world, they are brightly coloured. Others are typical ground-dwellers, with drab-coloured shells, while still others are desert snails, and the shells are pallid white in colour.

The most colourful of Australia's land snails, however, are the members of the Family Camaenidae which live in the forests of coastal Queensland. Sometimes referred to as Hadridae or subfamily Hadrinae, these fall into several genera, including *Varohadra* and *Bentosites*, *Sphaerospira* and *Hadra*. They differ in details of size, surface sculpture, and presence or absence of the perforation in the base of the shell known as the "umbilicus". A series of typical species are illustrated in the accompanying photographs. The largest species is *Sphaerospira informis*, which is found in south to central coastal Queensland and reaches as much as four inches in maximum length. More colourful are the banded species of *Bentosites*, such as *etheridgei*, *croftoni* and *coxi*, which are found only in limited patches of

forest, sometimes on coastal islands, and which can be recognized by the fact that they do not have an umbilicus. The colours are mostly shades of brown, yellow and white, but the patterned effect is most attractive. In north Queensland, from about Cooktown up to the top of Cape York, the large shells of the genus *Hadra* are found. They are usually cream to white above the broadest part of the shell, and chocolate below, hence the specific name "*bipartita*". Some specimens are uniform creamish-yellow but are considered to be colour variations only. A group of the Camaenidae which is characteristic of New Guinea is the subfamily Papuininae, which includes a large number of colourful tree-snails. A few species of this group are found in north Queensland, with one or two penetrating down into northern New South Wales. The largest and most colourful species are *Rhynchotrochus macgillivrayi* and *Meliobba shafferyi*, the latter being a grey-green shell, tinged with violet, which is found in the forests around Mossman, north Queensland. There are numerous other kinds of Camaenids, including some which range throughout the arid centre of Australia and others which are characteristic of the Kimberleys in north Western Australia. However, identification of the various species is not easy as there is a lot of variation and much remains to be learned about them.

An unusual group of terrestrial molluscs is the Family Helicarionidae, especially the typical genus *Helicarion*, which are sometimes known as glass snails. These are rather large slug-like creatures often with brightly coloured yellow or reddish-brown bodies and carrying on their back just behind the neck a small, ear-shaped shell, which is delicate, translucent green to yellow and covered in life with large, mobile flaps of skin. The shell is so thin that the veins and organs of the pulmonary cavity can clearly be seen through it, and it is quite incapable of holding the animal when it contracts. The animals also have a short "horn" or protruberance at the top part of the tail, which is tapered from either side and cut off vertically under the horn. This is the site of a gland which exudes quantities of sticky, sometimes coloured mucus when the animal is disturbed. *Helicarion* is not uncommon in the wet eucalypt forests



Land snails with Australian affinities, from Queensland.—Top, *Hadra bipartita* (Ferussac), Chester River. Second row, left, *Varohadra rainbirdi* (Cox), Mt. Dryander, near Bowen, and right, *Varohadra oconnellensis* (Cox), Mt. Dryander. Third row, left, *Bentosites croftoni* (Cox), west of Proserpine, and right, *Bentosites gavisa* Iredale, Bowen. Bottom, left, *Xanthomelon pachystylum* (Pfeiffer), Tinaroo, near Cairns, and right, *Sphaerospira informis* (Mousson), Mt. Dryander. All are about three-quarters natural size.

of eastern Australia, living under logs and among leaf litter.

Finally mention must be made of the native slugs of Australia. Slugs are really only snails which have lost their shells during the course of evolution. The pulmonary cavity or lung is present and opens to the surface by way of a pore on the back of the slug. If you observe a living slug closely,



The Australian Native Slug, *Triboniophorus graeffei* Humbert, common in wet bushy areas of eastern Australia, and occasionally found in suburban gardens. Two-thirds life size. [Photo: Howard Hughes.]

the pulmonary opening can be seen opening and closing as air is expelled and replaced from time to time. Most of the slugs found in suburban gardens are introduced species from Europe, and they are a serious problem to gardeners and may even cause damage to agricultural crops at times. There are, however, a few native slugs which live in the forests and which are not garden pests. One of these which always attracts attention is the Red Triangle Slug, *Triboniophorus graeffii*, a species found commonly from New South Wales to north Queensland and New Guinea. It varies in body colour from pale creamish-grey to olive-green, occasionally tinted with pink, but is always recognizable by the presence of a vivid orange-red line bordering the foot, and an orange-red triangle or diamond-shaped mark surrounding the pulmonary opening. These attractive slugs sometimes wander into suburban gardens from neighbouring patches of bush, but usually they are not harmful to cultivated plants and so should not be destroyed.

There are over 600 different kinds of native land and freshwater molluscs known from Australia, and among them are many fascinating and attractive animals which are worthy of study and preservation by nature-loving Australians. Please help to conserve them by not destroying them unnecessarily, and by supporting any move to conserve natural habitats, especially forest areas, in which they can survive unmolested for future generations to study and enjoy.

[Photos in this article are by Charles Turner, except where stated otherwise.]

## Australian Museum Publications

The following Australian Museum publications are available at the Museum:—

**AUSTRALIAN MUSEUM HANDBOOK:** A comprehensive natural history handbook, as well as a guide to the Museum; 141 pages; 4/-, posted 4/6.

**THE NATURAL HISTORY OF SYDNEY:** An account of much of the land and marine fauna, topography, geology, fossils, native plants, and Aboriginal relics of the Sydney area; contains articles already published in this magazine, with two others added; sixty-four pages; 5/-, posted 5/6.

**EXPLORING BETWEEN TIDEMARKS:** An introduction to seashore ecology; forty-eight pages; 4/-, posted 4/6.

**THE FROGS OF N.S.W.:** Thirty-eight pages; 3/6, posted 4/-.

**AUSTRALIAN ABORIGINAL DECORATIVE ART:** Sixty pages; 6/-, posted 6/6.

**AUSTRALIAN ABORIGINAL ROCK ART:** Describes engravings and paintings on rock faces and in caves; seventy-two pages; 6/6, posted 7/-.

**N.S.W. ABORIGINAL PLACE NAMES AND EUPHONIOUS WORDS,** with their meanings; thirty-two pages; 1/6, posted 2/-.

**AUSTRALIAN ABORIGINES:** A booklet of special interest to school children; 6d., posted 1/-.

**THESE ARE INVERTEBRATES:** A folder, illustrated in colour, explaining how to use the Museum's unique exhibit "These Are Invertebrates"; 1/6, posted 2/-.

**LIFE THROUGH THE AGES:** A coloured, illustrated chart (34in. deep and 24in. wide), showing the progress of life from the primitive invertebrates of more than 500 million years ago to the present. The durations of the geological periods are shown and examples of the forms of life that existed in each are illustrated. Designed for hanging in schools; 6/-, posted 6/9.

**LEAFLETS** on natural-history and Aboriginal topics: Free of charge.

Also on sale: **AUSTRALIAN ABORIGINAL CULTURE**, published by the Australian National Advisory Committee for UNESCO. A handbook of the life, arts and crafts of the Aborigines; 2/6, posted 3/-.

# Locomotion, Dispersal and Distribution of Gastropod Molluscs

By A. K. O'GOWER

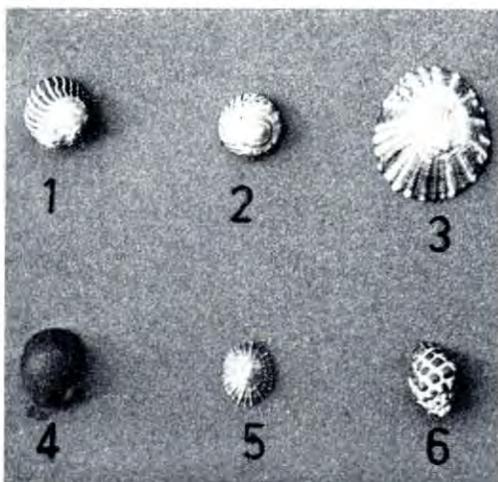
School of Biological Sciences, University of New South Wales

MANY molluscs move in a slow gliding motion across the substratum on a foot by means of continuous waves of contraction which pass along the length of the under-surface of the foot. As each wave passes over each part of the foot, that part contracts, moves forward slightly, and relaxes as the wave continues. Thus each part takes small forward "steps" and the whole foot glides slowly and smoothly forward. This motion is aided by the secretion of mucous which acts as a lubricant and as an adhesive.

The movement of molluscs from place to place is termed dispersal and it results in changes in the distribution of the animals. However, what is meant by distribution?

Distribution has at least four important meanings to biologists. The first is geological distribution, a knowledge of which is of importance in determining the past history of the animals. The second meaning is geographical distribution, which is the geographical limitations of animals by geographical barriers, such as large rivers, mountains, oceans, etc. The third meaning is ecological distribution, which is the distribution of animals in certain habitats, and this distribution is limited by various factors of the environment. At the limits of the ecological distribution of an animal population the density becomes zero, for at these limits the environment is no longer favourable for the existence of the population. The fourth meaning is pattern of distribution, and the patterns are customarily described as regular, random or clumped. If the patterns of distribution can be determined, then certain valid conclusions may be drawn from them about the relationships between the animals and their environments.

The geological and geographical distributions of molluscs in Australia have been extensively recorded in the literature, and



Six species of littoral gastropod molluscs: 1, *Austrocochlea*. 2, *Bembicium*. 3, *Cellana*. 4, *Melanerita*. 5, *Montfortula*. 6, *Morula*. [Photo: Author.]

the reader is referred to such invaluable texts as:

Allan, 1959, *Australian Shells* (Georgian House, Melbourne); Chapman, 1914, *Australasian Fossils* (George Robertson, Sydney); Macpherson and Gabriel, 1962, *Marine Molluscs of Victoria* (Melbourne University Press); Ripplingale and McMichael, 1961, *Queensland and Great Barrier Reef Shells* (Jacaranda Press, Brisbane).

Therefore, emphasis will be placed in this article on ecological distribution and patterns of distribution in molluscs with regard to dispersal behaviour.

Ecological distribution and pattern of distribution are intimately associated. Thus, if a population of animals is distributed in a certain habitat in a random pattern, then, as far as that population is concerned, the environment in the habitat is uniform. for in a non-uniform environment the animals tend

to clump at the favourable positions and to avoid the less favourable positions. If it can be shown that certain animals are clumped in one habitat but are randomly distributed in another, then it can be concluded that the two habitats are different. If certain factors of the environment are found to be different in the two habitats then it is probably these factors that determine the distribution patterns of the animals by their influence on their dispersal behaviours.

### Ecological Field Study

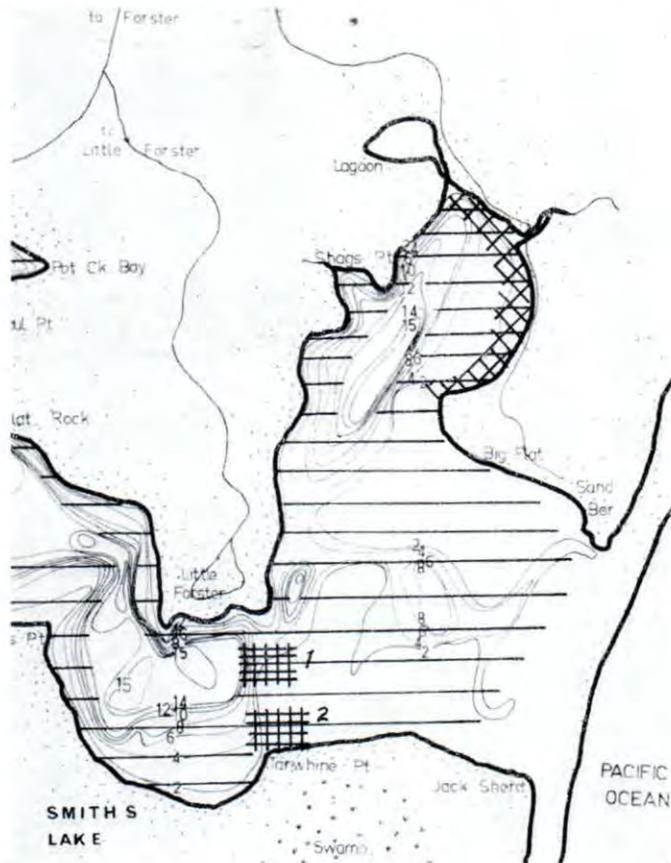
At Cape Banks, near Botany Bay, an ecological field study of the striped periwinkle *Austrocochlea constricta* (Lamarck), the coniwink *Bembicium nanum* (Lamarck), the limpet *Cellana tramoserica* (Sowerby), the black periwinkle *Melanerita melanotragus* (Smith) (= *atramentosa* (Reeve)), the false limpet *Montfortula*

*conoidea* (Reeve) and the mulberry whelk *Morula marginalba* (Blainville), showed that on a horizontal, intertidal rock platform all six species have a clumped pattern of distribution over the whole platform. However, when this platform is divided into three discrete sub-habitats, the bare rock area, the rock pool area and the "intersection" area between the bare rock and the rock pool, it is obvious that not only do the densities of the six species differ in the three areas, but, when the patterns of distribution of each of the populations are determined by statistical methods, these patterns vary with the species in three "sub-habitats", for example:—

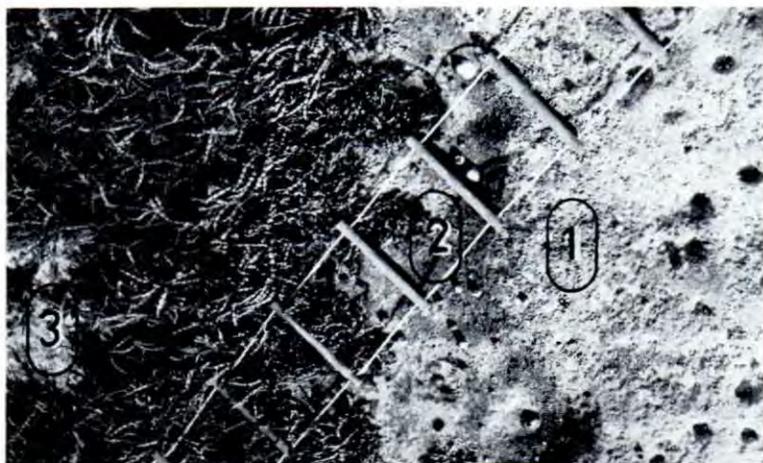
Species	Bare Rock	Rock Pool	"Intersection"
<i>Austrocochlea</i>	random	random	clumped
<i>Bembicium</i>	clumped	rare	clumped
<i>Cellana</i>	random	random	random
<i>Melanerita</i>	rare	clumped	clumped
<i>Montfortula</i>	absent	rare	random
<i>Morula</i>	rare	rare	clumped

Distribution of *Pyrazus ebeninus* and *Velacumantus australis* in the eastern portion of Smiths Lake, New South Wales.

- = young, juveniles and adults of *Velacumantus*
  - × × × = large juveniles of *Pyrazus*
  - ⊞ 1 = adults of *Pyrazus* in December, 1963
  - ⊞ 2 = adults of *Pyrazus* in May, 1964
- [Map by the author.]



Three subhabitats on the rock platform at Cape Banks: 1, bare rock area. 2, rock pool area. 3, intersection area. [Photo: Author.]



It can be seen that *Austrocochlea* is randomly distributed on the bare rock and in the rock pool, but is clumped in the "intersection" area. Hence, some unknown environmental factor within the "intersection" area is attractive to *Austrocochlea*, causing the animals to aggregate there. The determination of which factor causes such clumping depends upon the design of appropriate behaviour experiments. The clumping of *Bembicium* on the bare rock surface and in the "intersection" area, together with its low density in rock pools, probably indicates a dislike of high water temperatures in pools during mid-day low tides. Within the "intersection" area a rapid rate of evaporation from the moist rock surface and plant surface would lower the temperature of the water surface, and, on the rock surface, water in slight depression would also have a low temperature due to evaporation. Preliminary studies on the ability of this species to survive high temperatures in air and in water tend to confirm this explanation of the distribution of *Bembicium*.

The random patterns of distribution of *Cellana* in all three sub-habitats indicate this species finds the whole platform uniform in environment.

Although *Melanerita* is apparently rare on the bare rock surface in the mid-littoral zone of the platform, this species tends to be clumped in shaded and dry situations in the upper littoral zone as well as being clumped in both rock pools and in the "intersection" area. It is possible this

species has a gregarious behaviour.

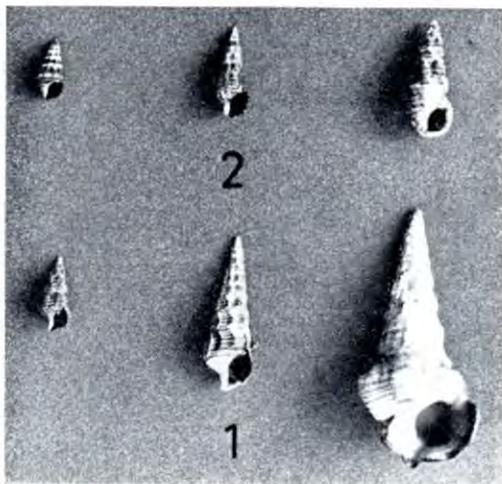
*Montfortula* is restricted in its ecological distribution to water in shaded rock pools or the shaded splash zone where *Galeolaria caespitosa* occurs, thus the random pattern of distribution of *Montfortula* in the "intersection" area might indicate a dislike of high water temperatures and an inability to survive dry conditions. Survival experiments show *Montfortula* to be very susceptible to moderately high water temperatures and to desiccation. Field observations after hot summer days with off-shore winds support this view, for heavy mortalities of this species have been recorded in supra-littoral pools, which are normally flushed with fresh sea-water from wave action during high tides.

*Morula*, like *Melanerita*, appears to have a gregarious behaviour. However, as this species is a carnivore, it seems probable that the chemical attraction of the dead prey may cause such gregariousness, but the ecological concentration of the species in the "intersection" area may be associated with some other factor of the environment.

Hence, it can be seen that a study of the patterns of distribution of animals in their habitats may more clearly define those factors of the environment which govern the ecological distributions and abundances of the species.

#### Size-categories

So far it has been assumed that the distributions of these molluscs on the rock



Mud whelks of Smiths Lake: 1, *Pyrazus*, 2, *Velacumantus*. [Photo: Author.]

platform are independent of the age of the various individuals making up the populations. However, if the populations of each species are divided into three size-categories—small, medium and large—and if the densities of each category are determined, both at the front of the platform (say the first 10 feet from the *Galeolaria* zone) and at the back of the platform (say 30 to 40 feet from the *Galeolaria* zone), then, for the species *Austrocochlea*, *Bembicium* and *Melanerita*, it is found that there are more larger animals at the front of the platform and more smaller animals at the back of the platform than would be expected by chance. For these three species wave action probably influences the distribution of different age groups on the rock platform. With *Celana* and *Montfortula* there seems to be no relationship between the sizes of the individuals and their positions on the platform, but, since both species cling strongly to the substratum, it is unlikely that wave action would influence the distributions of the different sizes. *Morula* has more smaller individuals at the front of the platform and more larger individuals at the back of the platform. As this species is a carnivore, possibly the distribution of individuals of different ages is associated with some feeding activity and not with wave action.

It can now be seen that the patterns of distribution, the distribution of various ages

and the ecological distribution of littoral gastropod molluscs all depend upon the influence of various factors of the environment, such as temperature, desiccation, light, wave action and food, on the dispersal behaviours of the molluscs.

How then can dispersal be studied? Observations of the movements of molluscs marked with paint on rock platforms have shown some limpets and chitons to have remarkable homing instincts, and the displacement of marked periwinkles above or below their normal situation on the platform has resulted in active dispersal back to their original positions, whilst animals left in their normal environment moved randomly (Moore, 1958, *Marine Ecology*, John Wiley and Sons, N.Y.). The environmental cues which direct these dispersal behaviours are unknown.

### Studies On Mud Whelks

Recent studies at coastal Smiths Lake, 200 road miles north of Sydney, on the mud whelks *Pyrazus ebeninus* (Bruguère) and *Velacumantus australis* (Quoy and Gaimard) have shown that the young of *Pyrazus* are widespread on the lake bed up to a depth of 12 feet, that the large juveniles occur only at one site on the lake in shallow water, that the fully-grown adults occur in a limited area only at another site some 1,000 yards away, and that within this area the adults have moved as a group some 300 yards within five months. With *Velacumantus*, however, all age groups occur together at all positions on the lake bed up to a depth of 12 feet (see map). The exact relationships between the distributions of these species in Smiths Lake and their dispersal behaviours may become apparent with further studies of marked individuals. But, it is obvious that in this environment, which is so very different from that of rock platforms, the distribution and abundance of the molluscs are also due to dispersal behaviours which are governed by environmental factors, but these factors are different from those governing the dispersal behaviours of the littoral rock-platform molluscs.

No doubt similar studies with pelagic and sedentary molluscs and with terrestrial molluscs would indicate an even wider range of

environmental stimuli influencing their dispersal behaviours. But, as recent studies have shown some molluscs to be able to perceive magnetic, polarized light and other stimuli which man does not perceive, it is probable that the determination of these environmental stimuli will require many detailed behaviour experiments. However, the detection of the important environmental factors may be greatly assisted by the determination of ecological distributions and the patterns of distribution within the habitats.

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## NOTES AND NEWS

### NEW MUSEUM TRUSTEES

Professor D. P. Mellor, Head of the Chemistry Department at the University of New South Wales, and Professor N. Barber, Professor of Botany at the University of New South Wales, have been elected Trustees of the Australian Museum.

### VISIT TO CORAL SEA ISLANDS

The Australian Museum's Curator of Crustacea and Coelenterates, Dr. J. C. Yaldwyn, and Curator of Molluscs, Dr. D. F. McMichael, recently visited some remote islands in the Coral Sea. They were landed on the Diamond Islets and Herald Cays by H.M.A.S. *Gascoyne*, the R.A.N.'s oceanic research frigate, and were able to spend several days in each place collecting marine specimens. Together with the collections made on the Swain Reefs expedition in 1962, and previous collections from other Coral Sea islands, these will contribute towards a better knowledge of the Coral Sea fauna, which is closely related to that of the Great Barrier Reef.

### NEW GUINEA EXPEDITION

Mr. D. A. Miles, Assistant Curator of Anthropology, and Mr. M. Cameron, Preparator, of the Australian Museum, left Sydney in September for a prolonged visit to the Sepik River and neighbouring areas of New Guinea, to collect ethnographic specimens for the Museum. This is the first expedition from the Australian Museum to visit New Guinea for the purpose of collecting this kind of material.

### HONORARY ASSOCIATE

Mr. A. D'Ombraïn was recently elected an Honorary Associate of the Australian Museum in recognition of the help he has rendered during many years.

## NEW POST FOR CURATOR OF ANTHROPOLOGY

Mr. F. D. McCarthy, Curator of Anthropology at the Australian Museum, has resigned from the staff to become Principal of the Australian Institute of Aboriginal Studies in Canberra.

Mr. McCarthy joined the Museum's staff in 1920, and became Curator of Anthropology in 1940. In 1937 he visited Indonesia and Malaya to study relationships between the prehistory of this region and Australia and to attend the Third Congress of the Prehistorians of the Far East in Singapore. He was a member of the American-Australian Scientific Expedition to Arnhem Land in 1948, spent several months in north-western Australia studying Aboriginal art on a Wenner-Gren Foundation grant in 1958, and made a similar study in central-western New South Wales on a Nuffield (Australia) Foundation grant. He has carried out field work in many parts of eastern Australia, including a study of totemic clan dances at Aurukun, Cape York, in 1961. As a result of this field work he has added many thousands of specimens and photographs to the Museum's collection.

His research has been principally in the fields of Australian Aboriginal prehistory, art and economic life, and he has also given a great deal of attention to the study of the development of Aboriginal culture, trade and contacts with neighbouring Oceanic peoples. He has excavated prehistoric sites in various parts of New South Wales and Arnhem Land. In all, he has published over 200 papers on these subjects, included in which is a wide range of scientific articles in the Museum magazine on various aspects of the life and art of the Melanesians. His writings include the book *Australia's Aborigines: Their Life and Culture*, 1957, and this Museum has published his two handbooks on Australian Aboriginal decorative and rock art, a memoir on the stone implements of Australia, and a pamphlet on place names.

Mr. McCarthy is well known for his interest in the protection and preservation of Aboriginal relics in situ, including rock engravings and paintings, stone arrangements, carved trees, etc., and in this capacity has been associated with the National Trust and the Historic Monuments Committee of the Cumberland County Council. He was a member of the Council of the Anthropological Society of New South Wales from 1932 to 1964, during which period he held every executive office; the Council of the Royal Society of New South Wales for nine years and President in 1956; President of the Anthropology Section of ANZAAS in 1957; Australian member of the Council of the Far Eastern Prehistory Association, and of the Permanent Council of the Union of Prehistoric and Protohistoric Sciences; and Corresponding Member of the Historic Monuments Committee of Unesco.



*Chromodoris splendida* (photo by A. Healy) and *Lobiger nevillei* (photo by L. Marsh).

## AUSTRALIAN SEA-SLUGS

By ROBERT BURN

Honorary Associate in Conchology, National Museum of Victoria

SEA-SLUGS are marine gastropods of the subclass Opisthobranchia; counted among their numbers are some of the most beautiful and strikingly coloured marine creatures known to man. Australia's long coastline is particularly rich in sea-slug species, although many of them are new to science or presently not recorded. Including the shell-bearing species, more than 400 species of sea-slugs are recognized among the Australian marine fauna.

Identification of sea-slugs is a rather difficult task as there is no readily available reference to either the world's or Australia's species. Persons seeking identifications of species will do best if they approach the various State museums. Another difficulty for natural history students when dealing with sea-slugs is the matter of preservation. Unfortunately, the usual preserving fluids, alcohol and formalin, have a disastrous effect on the colours and shape of the body, often destroying the colours completely and distorting the shape beyond ready recognition. Consequently, when specimens are submitted for identification some information on the colour and shape of the living sea-slugs should be included.

Vernacular names are practically non-existent among the sea-slugs. Some general group names such as "bubble shells" and "sea-hares" have been in common use for many years, but names for individual species in these groups are entirely lacking. Latin names are the easiest to use and to remember when dealing with unusual animals such as the sea-slugs.

Sea-slugs have no commercial or economic value. It is probable that they could be eaten without digestive inconvenience to man but they are rarely found in such numbers or of such size as to warrant culinary attention. No species is known to be poisonous to man, although a few do exude toxic fluids that will kill small fish, shrimps and crabs.

### Classification

The system of classification of sea-slugs is far too complicated for simple explanation. At least five main groups or orders are distinguished from one another by the presence or absence of a shell and differences in the form of the nervous and reproductive organs. One or two species from

each of these orders are briefly described below.

### Cephalaspidea

This is the order of the "bubble shells", although a few of the unusual species have no shell at all. A majority of species have a thick heavy shell into which the animal can be completely withdrawn; consequently the animals are not colourful and ornately shaped. Of the species with thin fragile shells and animals that cannot be withdrawn into the shell, *Hydatina physis* is probably the best known. Its shell is about 1½ inches long with brown bands on a yellow background; the large dark-rose coloured animal has all its edges and tentacular folds margined with blue. A less common and much smaller species is *Micromelo guamensis*. The quarter-inch-long, pure-white shell has narrow lines of black in spirals with arcs of the same colour between; the animal is nearly transparent except for some large patches of opaque white and a green and orange margin.

Some species have an internal shell. Among these is *Chelidonura fulvipunctata*, a brown species with paler spots and a white band across the head.

### Anaspidea

Most species belonging to this order are commonly known as "sea-hares". A reduced shell can be found in nearly all the species, but some are without it. About 20 species of "sea-hare" are found in Australian seas. Most of them belong to the genus *Aplysia*, which varies in length from 24 inches to 4 inches. A common furry species is *Notarchus indicus*, in which small blue ocelli or eyes are scattered over the brown-green skin.

### Sacoglossa

This order differs from all the others in that the mouth parts are specially developed for sucking the juices from the various green seaweeds upon which the species live. There are both shell-bearing and naked species in this order.

*Lobiger nevilli* is easily recognized by its green-lined shell and four elongate knobby folds projecting from under the shell. *Midorigai australis* is one of a small group known

as "bivalved gastropods" because, instead of the usual spiral shell, there is a pair of shells just like an ordinary bivalve with hinge and ligament.

The half-inch-long lettuce-green *Elysia australis* has a flap or parapodium along each side of the body; this species is fairly common living on the slender green alga *Entromorpha* in rock pools in the Sydney area. *Hermaeina nigra* is a very dark species with the parapodia developed into finger-like processes.



*Elysia australis* (top), *Cratena macphersonae* (centre) and *Berthellina punctata* (below). [Lower photo by G. Biddle, others by A. Healy.]

## Pleurobranchacea

Many large and relatively uninteresting species belong to this order. Very little is known of the Australian species. The commonest and most widely distributed species is the orange *Berthellina punctata* with its minute internal triangular shell; a long gill on the right side is the primary characteristic of the order.

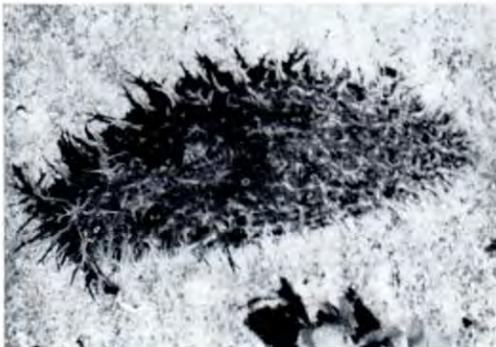
## Nudibranchia

This order, in which all species are naked, is by far the largest and also the most diverse. Four very distinct sub-orders belong to the Nudibranchia and each is well represented in Australian seas by numerous beautiful species. All the species of the order have naked gills just as the ordinal name implies. It is the various forms of gill development that distinguish the four sub-orders.

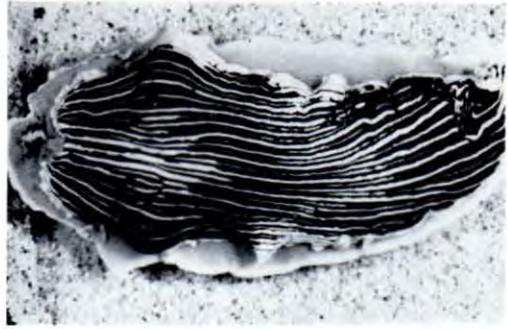
## Doridoidea

The many species of this sub-order have either a wide mantle protecting the underparts or merely fragments of the mantle forming a fringe around the body. The gills and rhinophores (organs of smell) stand upright on the mantle; in many species both organs can be fully withdrawn into sockets in the mantle.

Of the particularly brightly coloured species, *Chromodoris splendida* has a purple-brown margined chrome yellow mantle covered with a number of large purple-brown spots. *Chromodoris decora* has a palest blue mantle margined with



*Notarchus indicus*. [Photo: A. Healy.]



*Armina cygnea*; top, seen from above; below its under-side. [Photos: A. Healy.]

orange inside which is a circle of purple dots, then a circle of white and finally an elongate Y of white in the middle line. The red-speckled orange *Plocamopherus imperialis* has only fragments of a mantle but these are specially developed into bulbous light organs that glow strongly at night when the animal is disturbed or irritated. The literature on *Plocamopherus* contains colourful accounts of the nocturnal luminescence of the various species.

*Dendrodoris denisoni* has a striking pattern of brown, green and yellow with four or more electric blue ocelli or eye spots in between the blister-like pustules on the mantle. The poison-exuding species mentioned earlier belong to *Phyllidia*; *varicosa* is a common species in tropical seas, with green-blue body, orange or yellow high parts and black low parts.

## Arminoidea

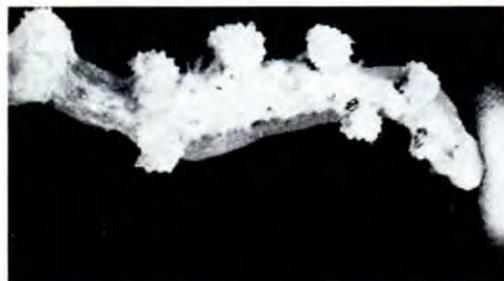
Instead of there being distinctive gills on the mantle as in the Doridoidea, this sub-order has the gills in a fringe around the

body. They either hang from the underside of the mantle or, when there is no mantle, project from the body as a thick fringe of finger-like processes.

*Armina cygnea* is a large (six inches) species found all round southern Australia, usually in deeper waters. Occasionally it is found on the seaweed beds of Botany Bay and Port Hacking, New South Wales. The velvet black mantle of this species is marked by a number of white lines, while its underparts are a beautiful rose-pink.

### Dendronotoidea

There is no mantle in this sub-order, only the fragments of one remain. But these fragments are specially developed into gills and replace the gills of the two preceding sub-orders.



*Melibe australis* (top) and *Austraeolis ornata*.  
[Photos: A. Healy.]

*Melibe australis* is a one-inch-long white species of eastern Australia. It resembles a long "trumpet", with four pairs of bulbous processes on the back. This "trumpet" is actually the head and the mouth; a fringe of filaments within the "trumpet" acts in



*Aeolidiella macleayi*. [Photo: A. Healy.]

a similar manner to the brushes of a carpet-sweeper and lifts minute marine creatures into the proper mouth. In Queensland there is a 12-inch-long species, *Melibe mirifica*.

### Eolidoidea

The species of this sub-order differ from all other sea-slugs in that along each side of the body there are finger-like processes known as cerata that are connected by ducts to the liver inside the body. These cerata have one other peculiarity of importance: within the tip of each cerata is a small receptacle called the cnidosac in which are stored nematocysts or undischarged stinging cells for defensive purposes. Nematocysts are found in sea-anemones and similar sea-life upon which these sea-slugs feed. Special processes within the digestive system allow the safe passage of the nematocysts through the body without harm to the animals.

*Austraeolis ornata* has a great number of slender cerata patterned with blue, orange, red, yellow, black, brown, green and white colour patches. This species is both very common and widely distributed along the eastern Australian coastline. *Cratena macphersonae* from the same area is very much rarer; it has a small number of bright blue cerata and a black or brown body. *Aeolidiella macleayi* has bulbous cerata along each side of the body which leave little of the pinkish-grey body visible. The pale-grey cerata have one or two yellow bands near the tip.

# VENOMOUS CONES

By R. ENDEAN

Department of Zoology, University of Queensland

HUNDREDS of species belonging to the molluscan family Conidae occur in shallow water in tropical regions of the Indian and Pacific Oceans. The bulk of these species are represented on coral reefs. More than 30 species have, for example, been found on one small reef at the southern tip of the Great Barrier Reef. Even a single coral boulder at this locality may provide shelter for representatives of different species of Conidae. However, the family is by no means restricted to coral reefs. Some species occur amidst rocks and rubble around the shores of land masses, while others have been taken by trawls and dredges from deeper waters. Nor is the family confined to the tropics, as a few species are common inhabitants of littoral regions in temperate waters.

Although the shells of some Conidae are ovoid in outline and the shells of others subcylindrical, most species possess conical shells and members of the family are known to collectors as cones or cone-shells. Great variation in size is exhibited by different species. Some are small, being less than half an inch in length, but others are amongst the largest of molluscs. *Conus millepunctatus*, for example, is reported to attain a length of eight inches and a weight of several pounds. Usually the shells of cones, which may be solid and porcellanous or thin and fragile, bear striking colour patterns. They have for long attracted the attention of shell collectors. Indeed, the shell of the Glory-of-the-Seas Cone, *Conus gloriamaris*, is perhaps the most highly prized of all shells and flawless specimens

Shells of some fish-eating cones.—Top left, the Geographer Cone, *Conus geographus* (three and a half inches long); top centre, the Tulip Cone, *Conus tulipa* (two inches long); top right, the Striated Cone, *Conus striatus* (two and a half inches long). Bottom left, the Magus Cone, *Conus magus* (one and a half inches long); centre, the Cat Cone, *Conus catus* (one and a quarter inches long); right, the Fly-spotted Cone, *Conus stercus-muscarium* (one and three-quarter inches long). The shells of *Conus tulipa*, *Conus striatus* and *Conus magus* illustrated are smaller than those possessed by average-sized adult specimens but the other shells illustrated are typical of average-sized specimens.



Harpoon (a quarter of an inch long) of *Conus striatus*. The barbed tip lies to the right.



have been sold for as much as \$2,000. Formerly, specimens of this species had been obtained only from waters near the Philippines and Indonesia but recent discoveries of specimens in waters to the east of New Guinea have stimulated interest in shell collecting in this region.

During the day, most cones occurring on coral reefs lie in crevices or depressions, or are partially buried in coral sand, often beneath boulders of dead coral. At night, they emerge to hunt their prey for, as far as is known, all species of cones are carnivorous. The majority prey on marine worms but some prey on other molluscs, including cowries, strombs and even other species of cones. A few prey on fish. It appears incredible that a slow-moving mollusc could capture an agile fish, yet, if a fish-eating cone such as *Conus catus* is placed in an aquarium with some small blennies, the cone will soon be observed in the process of stalking its prey. A tubular and mobile proboscis will be extended, often for a considerable distance from the cone and the tip of the proboscis will be observed to follow the movements of the nearest blenny. If the tip of the proboscis comes into contact with the blenny, a minute barbed harpoon, normally concealed within the tip, is thrust into the flesh of the fish. Venom is then forced through the hollow

harpoon, which serves as a hypodermic needle for the injection of venom. Almost immediately, the fish is paralysed and it is then enveloped by the distensible proboscis. Occasionally, captured fish are larger than the cone itself and, in such cases, part of the prey may protrude from the proboscis while the digestive juices of the cone are breaking down the tissues of the part within the proboscis. Essentially, the proboscis is the attenuated anterior end of the alimentary canal.

Dissection is required to expose the organs where the venom is produced and stored prior to use. A sausage-shaped venom gland lies within the upper part of the body cavity of each cone. From one end of the gland a long, greatly coiled venom duct arises and leads to the anterior end of the alimentary canal into which it opens near the base of the proboscis. Venom, consisting of microscopic venom granules carried in a viscous fluid, is produced in the hollow venom gland and in the tubular venom duct. Contraction of muscles in the wall of the venom gland forces venom along the duct, through the proboscis and thence into the tissues of prospective prey via the hollow harpoon, which possesses an opening at either end. The barbs on the tips of the harpoons ensure that prey is firmly held during injection of venom.

A Y-shaped structure also opens into the alimentary canal near the base of the proboscis. This organ, known as the radular sac, contains a large number of harpoons in various stages of formation. Each harpoon is used only once and is normally swallowed along with the impaled prey. However, a new harpoon can be quickly moved into position from the radular sac, which can be regarded as the cone's armoury.

Although the venom apparatus is normally used in the capture of food it may be used defensively. There are, unfortunately, numerous records of human injury and of several fatalities stemming from stings inflicted by cones. One fatality resulting from a sting received from *Conus geographus* occurred in Queensland waters in 1935 and several stings, some of them fatal, have occurred in New Guinea waters in recent years. General symptoms displayed by victims of cone stings may be summarized briefly as follows: initially a sharp sting is felt and the area around the puncture may quickly become numb and discoloured. Pain of varying degrees of severity and which may be excruciating usually supervenes and swelling in the region near the puncture may occur. Vision, hearing and speech are often affected

and, in severe cases, a complete paralysis of voluntary muscles ensues. Death may occur due primarily to respiratory failure.

Collectors of cones should hold them by the broad end of the shell and should avoid contact with the proboscis, which is protruded from the narrow end of the shell but is capable of reaching around towards the apex of the shell. The proboscis, a slender, usually pinkish, organ, should not be confused with a thicker tubular structure, the siphon, which is also protruded from the narrow end of the shell. The siphon serves as a channel for the intake of a current of water which bathes the respiratory organ. The danger of placing cones in a pocket of one's clothing should also be appreciated. In 1948 a woman at Hope Island on the Great Barrier Reef was stung on the thigh by a cone which she was carrying in a pocket. Fortunately, the injury was not serious.

More importantly, collectors of cones should familiarize themselves with the few species which are of potential danger to man. In the past, there has been no general agreement as to which species of cones are of danger to man and some authorities have advocated that all cones should be handled with care. While it is probable that most

A partially dissected specimen of *Conus geographus*. The shell has been removed, the body cavity opened and the venom gland with its attached venom duct displaced to the right. The proboscis with a harpoon held at its tip projects to the lower left. Immediately above the proboscis is the tubular siphon. The dark-coloured mass below the proboscis and siphon is the muscular foot upon which the animal moves.



cones, if sufficiently provoked, would attempt to sting humans, recent research in the Department of Zoology, University of Queensland, has indicated that only fish-eating cones possess venoms capable of causing serious injury to vertebrates, including man. A few worm-eating species, such as *Conus quercinus* and *Conus lividus*, possess venoms which are capable of causing such local effects in vertebrates as pain, bleeding or swelling at the site of injection but the majority are harmless. The venoms of mollusc-eating cones, such as *Conus textile*, long regarded as one of the most dangerous species, elicit no toxic symptoms at all when injected into vertebrates. On the other hand, the venoms of fish-eating cones will paralyse fish, toads, snakes, birds and mammals and they include in their number *Conus geographus*, which has been responsible for most, if not all, the fatalities attributable to cone stings. *Conus tulipa* is another fish-eating cone which has undoubtedly caused serious human injury.

The venom of *Conus geographus* is one of the most toxic of animal venoms. Only minute amounts, two to three millionths of a gram (wet weight) of venom are required to kill a mouse. Within one or two minutes the voluntary muscles of injected mice are paralysed in the relaxed state. Paralysis of the muscles of the diaphragm (the muscular partition which separates the chest cavity from the abdominal cavity and which participates in breathing movements) is responsible for the deaths of mice or rats injected with the venom. However, it has been found that rats injected with the venom of *Conus geographus* and completely paralysed could be kept alive by artificial respiration. After a variable period of time, ranging from about 20 minutes to two hours, the toxic effects produced by the venom wear off and the rats recover completely. It would appear therefore that artificial respiration may be required in the case of a person paralysed as a result of a sting inflicted by *Conus geographus*.

Pharmacological investigations made on the venom of *Conus geographus* have revealed that the venom acts directly on muscle and does not block nerve conduction or transmission of impulses from nerves to muscles. It is possible that the venom

## Film Screenings at the Museum

Screenings of natural-history films will be held at the Australian Museum at 2.30 p.m. every week-day from Monday, January 11, to Friday, January 29.

The screenings are arranged specially for children, but parents and teachers are also invited to attend. Admission is free.

Each programme will last half an hour, and subjects of the films include: the life and ceremonies of the Aborigines, the Aborigines of the sea coast, the animals and plants of the Australian bush, birds of the Great Barrier Reef, the seals of Macquarie Island, a French expedition to the Sahara Desert region, African wild-life reserves, the cat family, the lyrebird, Eskimo paintings and carvings, fossils of the Hunter Valley, ancient civilisations around the Mediterranean Sea, the building of a Bronze Age house.

could be used to bring about relaxation of muscles as required for certain surgical operations and that it may find a use in the treatment of tetanus. It is also possible that further study of the action of the venom on muscle will throw light on ill-understood aspects of muscle function. Be this as it may, it is certain that the venom apparatus possessed by cones will continue to excite the interest of future generations of naturalists.

All the known venomous species of cones are found in Queensland and north Australian waters. None of them penetrate south to New South Wales, Victoria, Tasmania or South Australia, but all those States have cone shells which are not known to be venomous.

[Photos in this article are by the author.]

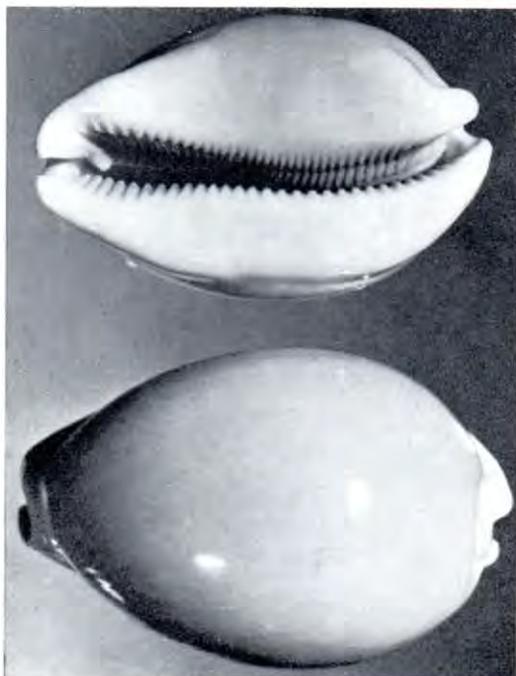
# THE GOLDEN COWRY

By DONALD F. McMICHAEL

THE Golden Cowry, or Orange Cowry as it is sometimes called, is one of the most sought after of the world's "rare" shells. Although it is not really rare (some hundreds of specimens being known) it is still not a common shell. It has quite a wide geographic range, specimens having been reported as found in the islands of the Philippines, the Marshalls and Carolines, the Fijis, the New Hebrides, the Solomons

The shell is large (reaching over 4 inches in length) and is beautifully coloured a uniform rich orange-yellow, with white extremities and a white aperture, lined with bright orange teeth. In bygone days, the Golden Cowry was worn as a badge of rank by the Fijian chiefs and specimens so used may be recognized by the hole made in one end of the shell which allowed it to be hung around the neck. The scientific name of the Golden Cowry is *Cypraea (Lyncina) aurantium* Gmelin; an incorrect synonym is *Cypraea aurora* Lamarck. Previous workers placed this species in the genus (or subgenus) *Callistocypraea* but recent research by Professor Alison Kay, of the University of Hawaii, has shown that it is more correctly placed in the subgenus *Lyncina*.

The Australian Museum collection includes eight specimens of the Golden Cowry.



The Golden Cowry. [Photo: Howard Hughes.]

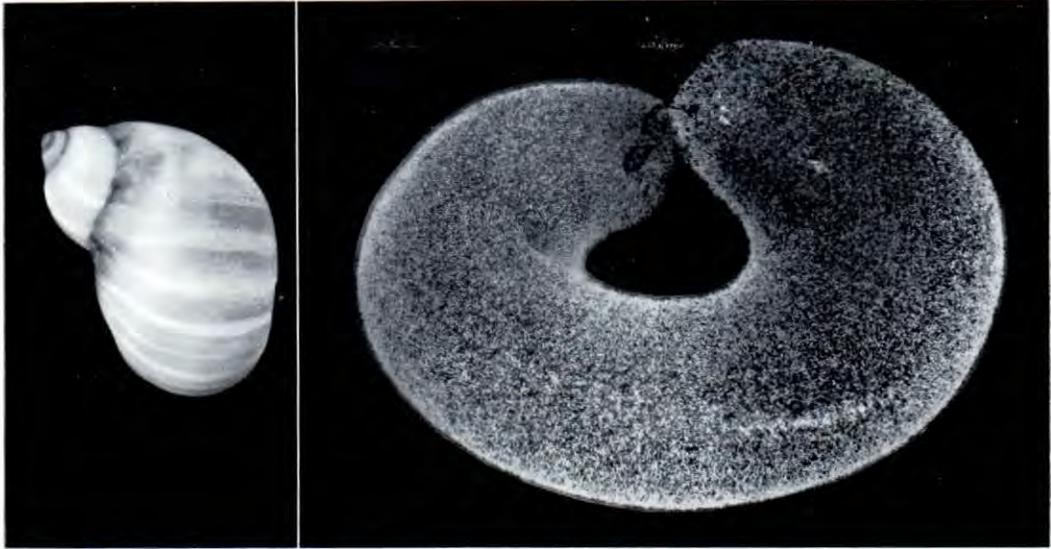
and the Bismarck Archipelago, including the Trobriand Group. The species apparently lives down over the edges of coral reefs in caves and crevices and is only rarely washed out into accessible places during heavy storms, so that it is not commonly available to collectors. Specimens can often be acquired in the markets in Fiji, and recently have fetched prices ranging from £20 to £40.

## RARE BIRD

In August and September, the Australian Museum's Curator of Birds, Mr. H. J. de S. Disney, took the opportunity offered him by the Division of Wildlife Research, C.S.I.R.O., to join Mr. W. B. Hitchcock, secretary of the C.S.I.R.O. bird-banding scheme, on a trip to Queensland. The route was through Hungerford and Mt. Isa to Karumba, on the Gulf of Carpentaria, and then across to the Atherton Tableland and down the coast. Several interesting species were collected, including the rare Chestnut-breasted Quail Thrush, *Cinclosoma castaneothorax*, from near Hungerford, with the help of Mr. A. C. Cameron and his son. This is the first specimen of this bird obtained by the Museum and only the fifth known to science. Through the hospitality and help of Queensland banders and ornithologists and the Department of Primary Industries, many interesting birds and habitats were seen.

## VISITOR FROM NIGERIA

The Australian Museum's Molluscs Department was visited by Professor Richard Reyment, formerly of the Geology Department, University of Stockholm, and now Professor of Geology at the University of Ibadan, Nigeria.



The Conical Sand Snail, *Conuber conicum* (Lamarck), and its gelatinous egg-mass, commonly known as "sausage-blubber", both life size. The thousands of minute eggs scattered throughout the jelly are visible against the dark background, giving the mass an over-all speckled appearance. [Photo: A. M. Rowlatt, C.S.I.R.O.].

## *The Spawn of Some Australian Marine Prosobranch Molluscs*

By FLORENCE V. MURRAY

OF the many thousands of species of prosobranch gastropod molluscs inhabiting the Australian littoral the spawning habits of fewer than 50 are recorded, and even for most of these information concerning their development, distribution, ecological relations, etc., is incomplete or wanting. The life-histories of our prosobranchs thus offer a rich and almost untouched field of research for naturalists and biologists, and one in which new information is comparatively easy to gain and very rewarding.

The prosobranchs, those molluscs in which the process of evolutionary torsion has brought the gill to lie anterior to the heart, include most of the familiar groups of gastropods and range from primitive herbivores through to specialized carnivores. Great variation occurs in their methods of

reproduction and the nature of the spawn produced by the species within one genus may be as diverse as that of species of unrelated families. Their eggs, when newly extruded from the ovary, mostly have a fine vitelline membrane over the ovum, a layer of albumen and an egg covering or envelope; they are usually deposited within protective jelly sheaths or in tough-walled capsules which the foot of the animal manipulates and moulds into characteristic shapes and patterns. The elaborate measures taken by certain species to provide safety for their eggs result in some of the conspicuous and strange-looking objects seen on our beaches and reefs.

In some biologically primitive types the eggs have no additional protective coverings and are shed directly into the water, where

fertilization takes place. The Pheasant Shell, *Phasianella australis*, spawns in this way and within 24 hours the minute green-coloured egg hatches as a primitive larva known as a trochophore, which soon transforms into a veliger, a type of free-swimming larva found only among molluscs and characterized by a locomotory ciliated ring, or velum.

The more highly developed prosobranchs are equipped for mating, and the eggs are fertilized internally before the protective investments are added. Not all species have a pelagic larval phase, many pass their whole development within the egg capsule. The number of eggs laid, the protection given them, the mode of development and of larval settlement and distribution are all complexly inter-related. Species with a long-lived pelagic veliger usually produce great numbers of eggs, while those whose development is direct produce many less. As a broad general rule, the more safely the eggs are protected the fewer there are in the sheath or capsule, the longer the period of incubation, and the more mature the larvae at hatching.

### Gelatinous Spawn

Most species spawn jelly masses, and one of the simplest is that of the Mud Wheelk, *Velacumantus australis*, a common mollusc on the shores of sheltered bays and estuaries. The eggs are arranged in a single series within a gelatinous tube which is

cemented to a substratum in a wavy line about two millimetres wide. More elaborately composed is that produced by the rock-platform dweller *Bembicium nanum*, in which from 100 to 200 eggs are embedded in an oval jelly sack and a series of these are attached to the under side of a rock in a closely packed layer. In both cases the eggs hatch as veligers.

The most familiar and conspicuous of the gelatinous spawns are the collar-like masses colloquially known as "sausage-blubbers", which are found stranded on sand and seaweed at low tide in bays and estuaries all round Australia. Strangely enough, until as recently as 1962 their parentage was unknown. The solution came when a specimen of the Conical Sand Snail, *Conuber conicum*, which had been isolated in a small aquarium, released just such an egg mass.

Further investigations then revealed that the Sordid Sand Snail, *C. sordidum* (= *strangei*), and the Black-mouthed Sand Snail, *C. melastoma*, also produced such gelatinous egg collars. Each is a thick gelatinous ribbon curved in such a way that the two ends either approach each other or overlap; egg capsules are scattered throughout the mass which is invested by a thin, tough, transparent membrane. *C. sordidum* produces the largest of these "sausage-blubbers", which may weigh as much as eight ounces. It may seem remarkable that so small a mollusc can suddenly create such a massive spawn, but, as might be expected,

The Common Sand Snail, *Glossaulax aulacoglossa* (Pilsbry and Vanatta), and its sand-encrusted egg-girdle. Slightly reduced. [Photo: A. M. Rowlatt.]



A spawning Cartrut Shell, *Dicathais textiliosa* (Lamarck), was disturbed when this small rock was upturned. The closely-packed egg capsules averaged about a fifth of an inch in height and were in varying stages of development. The mollusc was about one and four-fifths of an inch long and may or may not have been responsible for all the capsules. [Photo: L. Robison.]



the jelly is mostly sea-water, consisting of 96.3 per cent water and 3.7 per cent solids including chlorides expressed as common salt (NaCl).

The collar is produced beneath the sand and pushed to the surface by the snail. At first it is firm, but as it ripens it tends to soften; as hatching begins the integument sloughs off in ragged pieces, and the jelly, left in direct contact with the water, slowly dissolves away. The veligers, as they escape from the egg capsules, move through the jelly to the periphery and so into the water. As it has not so far proved possible to rear these *Conuber* veligers in aquaria we have as yet no knowledge of their life and development in the plankton, or of their metamorphosis and settlement.

### Sand Collars

The discovery that the gelatinous collars, or "sausage-blubbers", were naticid spawn came as a surprise because all members of the Family Naticidae (sand snails) were believed to spawn their eggs in characteristic sand-encrusted, collar-like structures or girdles, a well known example being that of the Common Sand Snail, *Glossaulax aulacoglossa*. It consists of a spiral sandy ribbon, about two millimetres thick, composed of a gelatinous matrix with sand grains surrounding the egg capsules, which are arranged in a single layer and contain one egg suspended in a fluid. Like the gelatinous *Conuber* collars it is formed under the

sand, but a much more complex manipulation by the foot of the snail is involved in its production. It may measure at least five inches across the basal diameter. In contrast to the free-swimming pelagic life of the *Conuber* larva, that of *G. aulacoglossa* has a much less hazardous early life-history, for it passes through the veliger phase within the sand-protected capsule and emerges as a diminutive young snail. In northern Australian waters many variations of this "typical" sand collar appear. For example, the ribbon may continue on for three or four complete spirals; also, in some cases the young hatch as veligers.



Tough-walled egg capsules of the Murex Shell, *Torvamurex territus* (Reeve), attached near the margin of a valve of a *Pinna bicolor*. Two and a half times life size. [Photo: A. M. Rowlatt.]



The embryonic shell, or protoconch, of (left) *Torvamurex territus* (Reeve), 33 times life size, which in form, is typical of many species [photomicrograph: E. Matthaei], and (right) that of *Syrinx* (formerly *Megalotractus*) *aruanus* Linné, twice life size. [Photo: A. M. Rowlatt.]

Not many prosobranch egg masses are cast free; usually they are fixed to rocks, seaweed, other shells, etc., or implanted within other marine forms, such as sponges or tunicates. In some instances they are given "brood protection" by the maternal parent; this is typical of the cowry family, Cypraeidae, and the much-prized Black Cowrie, *C. thersites*, from southern Australia, has been found with its foot extended over the edges of the lower valve of a Queen Scallop shell containing its egg-mass.

All the highly-specialized carnivorous prosobranchs lay their eggs in tough-walled capsules deposited singly or in groups. Many of these may be found on the underside of rocks, an interesting example being those of the common Tulip Shell, *Pleuroploca australasia*. The individual capsules may be 25 mm. high and are cream-coloured, wine-glass-shaped and attached by their bases in closely packed clusters. Each contains between 4,000 and 5,000 eggs, most of which serve as food for the half dozen young buccinids which finally rasp their way out of the capsule. No such "nurse eggs" are provided by *Torvamurex territus*, a muricid recently found depositing capsules on the exposed margins of the valves of live Razor Shells, *Pinna bicolor*, partly buried in the sand. Up to 25 eggs are contained within a capsule: all develop and the young crawl out through an exit hole in the unattached end

which becomes unplugged when hatching is due.

A more complex arrangement of capsules is achieved by Spengler's Triton, *Cabestana spengleri* (also known as *Cymatilesta spengleri*), whose completed spawn is a pale-orange, cup-shaped mass glued to a rock by a flat base; it consists of a spiral of horny, transparent capsules each containing several hundred eggs. The outer surface of the mass is made up of a series of thin, horny, overlapping plates to which the capsules are attached on the inner surface. The eggs hatch as veligers.

The largest and most spectacular of the capsular-type spawns are those of the Baler Shells, *Melo* species, and the False Trumpet Shell, *Syrinx aruanus*, and they are somewhat similarly constructed. Each cements large horny capsules one to the other around a central core, forming an elongated mass reaching up to a foot in length. The young of *Melo* hatch, one from each capsule, as well developed miniatures of the parent, but those of *Syrinx* are distinctive in that the large body whorl is preceded by a series of small calcareous ones.

The shell of the gastropod embryo, or protoconch, forms the apex of the adult, and from a study of this it is possible to deduce the mode of larval life of the shell concerned. Protoconchs are also important in the classification of species.

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