JUNE 15, 1956.

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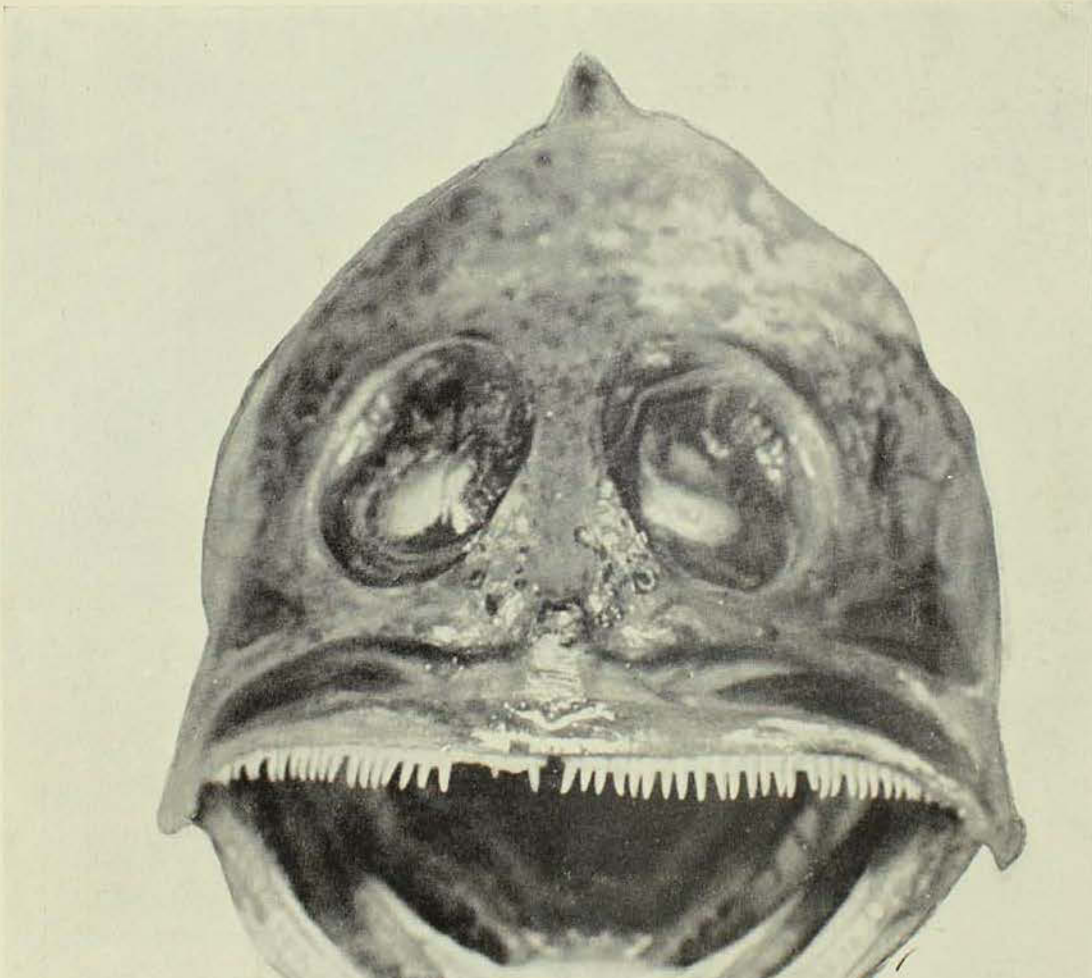

This "fine, open countenance" belongs to the Smiler, or Jawfish.

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THE AUSTRALIAN MUSEUM

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THE AUSTRALIAN MUSEUM MAGAZINE

(*Photography, unless otherwise stated, is by Howard Hughes, A.R.P.S.*)

● OUR FRONT COVER: Even the steel nerves of a spearfisherman might rust a little if he were confronted by this face looming from the floor of the sea, and he might well wonder if he had encountered the "missing link". The head illustrated belongs to a fish called the Smiler, also known as Jawfish, Harlequin or Pug (*Tandya latitabunda*), 10½ inches long, from Queensland. There are six Australian species of the family (Opisthognathidae), mostly brightly coloured and patterned so that no two specimens seem exactly alike. Some wear a livery of gold and blue, others a uniform of brown; the one illustrated was marked with yellow and black on a white ground. Readers of Ion Idriess's *Forty Fathoms Deep* will recognize his Monkey Fish as one of them. Pearl-divers note that they scoop and bite out holes and burrows in sand near rough coral or rocky bottoms, sally forth to gobble up their finny prey, then retire tail-first to their lurking places to digest their meal. Smilers are edible but are very rarely caught and more specimens are required by museums. Nothing is known of their breeding habits.

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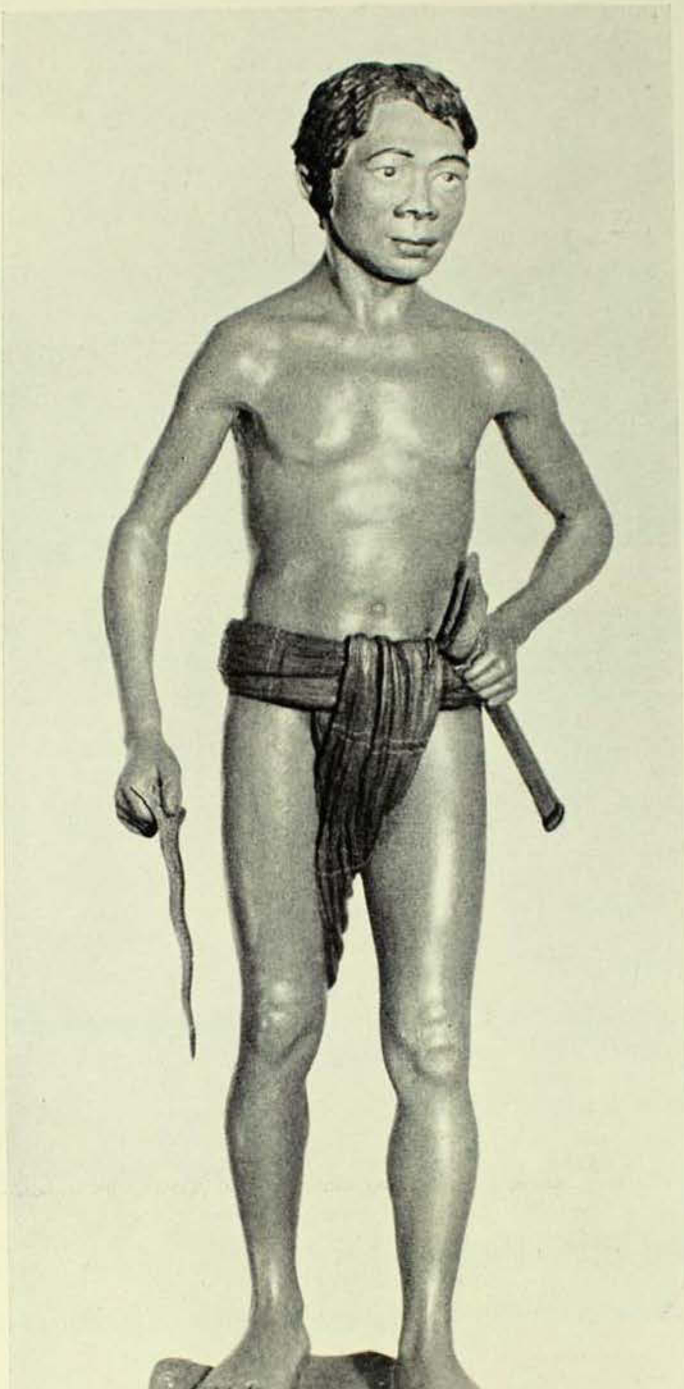

Figure of a Javanese man in the Australian Museum's exhibit on the Races of Man in Oceania. In his right hand he holds a kris, a special form of dagger, which he has withdrawn from its scabbard (left hand). The loin-cloth is the type adopted for everyday wear in the fields. (See article, page 54.)

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Ancient Armoured Fishes Discovered at Canowindra, N.S.W.

By H. O. FLETCHER

THE first vertebrate remains to be found in the geological record were those of the armoured fishes. These primitive creatures, known as the ostracoderms, were largely covered with a series of hardened plates which formed an armour or protection against their predaceous contemporaries.

The ostracoderms inhabited freshwater lakes and inland seas of the Ordovician geological period, approximately 500 million years ago. In the following Silurian period they had become widely distributed and were flourishing in all parts of the world including Australia. Many forms became extinct at the close of that period, but some species continued into Devonian times so that the group had a life span of about 150 million years.

At the end of the Silurian period there appeared certain other interesting fish types known as the placoderms. These were far more advanced in their structure than the ostracoderms as they possessed jaws which, although of a very primitive type, materially assisted them to undertake a more adventurous and active life. The ostracoderms, on the other hand, did not possess jaws of any description and food must have been secured by the trapping of small organisms as these passed through the gill system which took up a great deal of the space in the large head region. Means of progression were not well developed and as a result the ostracoderms spent most of their time on the sea-floor.

Although armoured fishes were essentially inhabitants of freshwater there can be little doubt that towards the end of their existence some forms had become dwellers of the open sea.

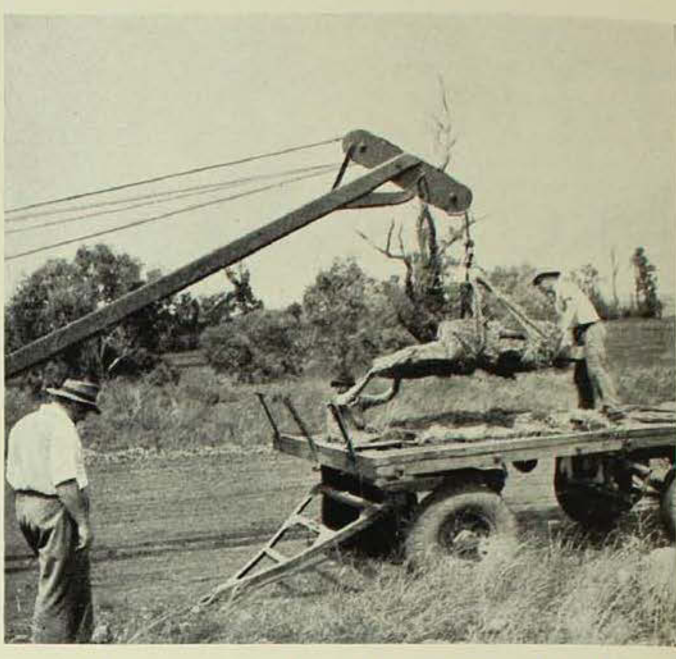
The remains of armoured fishes are known from Silurian and Devonian rocks in Australia. Most of the groups are represented by fragmentary material consisting mainly of isolated plates of the head and body armour. In New South Wales specimens have been found at various localities including Harvey's Range, near Parkes; Jemalong Gap, near Forbes, and the Murrumbidgee area near Yass. All are of Upper Devonian age with the exception of those collected from the Murrumbidgee area where the rocks are of Middle Devonian age.

Several months ago, during blasting operations on the Canowindra-Goolagong Road, there was exposed a large number of exceptionally well preserved armoured fishes in a hard quartzite rock. The occurrence was brought to the notice of the Australian Museum by Mr. W. A. Simpson, of Holmwood. The fossils proved to be of great importance and the Museum authorities are most appreciative of having been notified of their presence.

The area was visited by the author, who is Curator of Fossils at the Australian Museum; Mr. E. O. Rayner, Geologist of the Geological Survey of New South Wales; and Mr. K. Mayfield, a Preparator at the Australian Museum. The fossil armoured fishes were found to be beautifully preserved and are more complete than any others so far found in Australia. The specimens appear to be more representative of the antiarch fishes than of other groups of the placoderms. A primitive crossopterygian type of fish is represented by a complete specimen. The head is covered by a complete shield of dermal plates while the body is protected with rows of hardened scales. This fish shows relationships with a genus known as *Osteolepis* already recognised from Australian rocks by fragmentary remains. It has a world-wide distribution.

Investigations proved that the fossil fish were restricted to a very narrow zone of limited extent on the Goolagong Road. The zone of fossils was literally crowded with armoured fish remains and it would appear that some local catastrophe must have occurred to kill so many individuals at the one time. This could have been brought about by nearby volcanic action fouling the water with tuffaceous material. The quartzite rock shows traces of foreign material and a microscopic examination is being made to determine the exact rock constituents. Another explanation could be the drying-up of a trapped inlet or estuary of the sea, causing an influx of fish to a limited area before they finally perished.

In Devonian times the sea encroached over a large area of eastern New South Wales and the whole of the country where Parkes, Canowindra, Forbes and Cowra are now situated was part of the Devonian seafloor. In this sea flourished the armoured fishes and a host of early invertebrate life including the sea-scorpions or eurypterids, some of which attained a length of 11 feet.



Fossil fish are contained in this quartzite slab which is being loaded for removal to the Museum.
Photo.—"Canowindra Star."

These were large voracious creatures which reached the peak of their development in Silurian times, but continued on into the Devonian seas. It is thought that the armour plating of the primitive fishes was a defence against the sea-scorpions. Throughout geological history it has been found that certain creatures, usually defenceless, gradually developed some protection against their natural enemies. In this age-long "struggle for existence" many animals over-organised their defensive armour to such a degree that they were over-specialised and were thus headed for extinction. The eurypterids became extinct during Devonian times while the armoured fishes themselves did not continue for long afterwards and became extinct well before the close of the Palaeozoic.

It was decided to remove some of the large slabs of quartzite with the contained fossil fish from the Goolagong Road to the Australian Museum. Assistance was given by Messrs. Ross and Neville Bowd, of Canowindra, who, with the aid of a large mobile crane, loaded the heavy quartzite slabs on to our vehicles. One large slab, on which most of the perfect specimens were preserved, weighed about 12 cwt.

Museum preparators are now carefully and methodically removing the covering matrix on some of the specimens and many interesting features are being exposed. At this stage it is difficult to make any definite determinations regarding the generic and specific names of the armoured fishes, but it is almost certain that species of *Bothriolepis*, or closely allied genera, are represented. This fish has a world-wide distribution and belongs to the antiarch group of the placoderms.

Of the armoured fishes the ostracoderms are the most primitive. They did not possess jaws and lacked paired fins, although in some cases an elongated spine was developed and this projected from both sides of the body behind the head. A single nostril is found in most ostracoderms on top of the head.

The placoderm fishes which were most abundant in all parts of the world during Devonian times are divided into three groups consisting of the acanthodians, the arthrodires and the antiarchs.

The acanthodians, or "spiny sharks", were only shark-like in general appearance. The entire body was covered with well-developed scales rather similar to those found in some of the more highly developed bony fishes. The acanthodians were more or less normal looking fishes with a range extending from the Silurian through Devonian and Carboniferous times into the Permian, in which period they became extinct.

The odd-looking and rather grotesque armoured fishes belong to two main groups, the arthrodires and the antiarchs, and representatives of both have been found in Australian rocks. In these groups the head and body were covered with an armour made up of symmetrically arranged bony plates. The head shield is movably articulated by joints with the body shield. It is suggested that the development of the movable head was a means of altering level while swimming as these fish received little assistance in this regard from their poorly

An almost complete Upper Devonian fish preserved in quartzite from the Goolagong Road, near Canowindra, N.S.W. The other remains are the armoured heads and bodies of antiarch fishes.

developed fins. In most cases the arthrodires did not possess fins but these were represented by a pair of large hollow spines which projected on both sides from the region of the shoulder. Small bony plates served as jaws and teeth in the arthrodires.

The antiarch fishes had two sets of armour very similar to the arthrodires. They had small heads, tiny bony plates used as jaws, and for fins possessed a pair of jointed paddle-like appendages covered with dermal plates. Two eyes, close together, were set in the middle of the head.

The discovery of the fossil armoured fishes in Upper Devonian rocks on the Goolagong-Canowindra Road is a most important and interesting find. These specimens represent some of the first jawed vertebrates, an experiment of nature which was not a great success as the group became extinct. Over-specialisation in defence was also a factor in hastening their extinction.

Introducing Frogs and Toads

By J. R. KINGHORN

FROGS and Toads are amphibians and amphibians are a very ancient group. Fossil remains of the oldest representatives have been found in the Carboniferous and Permian rocks of North America and Europe, which means that the group has existed for approximately 250 million years. Naturally these early forms, which belonged to a class known as the Labyrinthodonta, were not the same as the present-day types. Their very name suggests some complexity. It refers to the structure of the teeth: Labyrinth (a place full of intricate passageways), and donta (teeth); a cross-section of a tooth of one of these early amphibians shows a labyrinthine arrangement of the dentine. Labyrinthodonts were somewhat closely related to fish, and they survived for a very long period of time. They held a position between fish and the higher vertebrates. Present-day amphibians are distributed almost all over the world except in polar regions and on high, snowy mountain peaks. Though a few types are to be found in very dry, almost desert places, amphibians generally are most abundant in tropical and sub-tropical regions.

In most instances amphibians spend their early lives in water and at first breathe by means of gills; later they metamorphose into lung-breathing animals. The group contains tailed amphibians such as newts and salamanders, which are absent from Australia, and frogs and toads, of which about sixty species occur here.

The differences between frogs and toads are mainly of a skeletal nature and too technical to describe in this Magazine, but in brief it can be said that the structure of the shoulder girdle and the presence or absence of teeth are involved. In Australia we have some peculiar types that can be regarded as near frogs, near toads, and this sometimes makes identification difficult. It is commonly stated that toads have warty skins and frogs smooth skins, but this does not get us very far because of the near-frog-toad types. A character which can be safely used as a guide in Australia is that our frogs all have teeth in the upper jaw, whilst our toads lack teeth.

Having no true ribs, chest, or diaphragm, a frog breathes differently from other vertebrates. It generally keeps its mouth tightly closed, and by successively raising and lowering the floor of the mouth, and perhaps relaxing and contracting the muscles at the sides of the flanks, draws air into the lungs. This seems a rather primitive method but it is quite effective. Whilst we can breathe with mouth open, a frog, except for an occasional gulp, would suffocate if its mouth were forceably kept open.

Most frogs and toads have a voice, and strangely enough some of the smaller species have the louder and more piercing voices. The sound-producing organ is the cartilaginous larynx situated just below the pharyngeal cavity, almost at the very entrance to the lungs. The vocal cords can be likened to elastic bands extending across the larynx. In many frogs there are vocal sacs—a kind of air-supply-cum-soundbox—and croaking is merely a matter of pumping air from the lungs past the elastic bands.

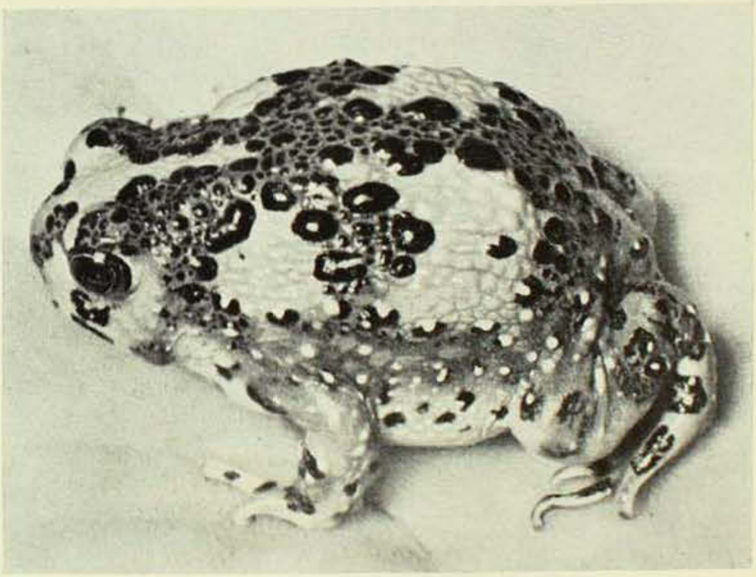
A tongue is not present in all types of frogs and those that lack them are classified into a special group known as the Aglossa = a, without; glossa, tongue. In other frogs the tongue is fixed in front and free behind, which makes for greater speed and accuracy in catching insects. A frog, having got within range of its prey, throws its tongue forward by a sudden contraction of muscles; this flicks the tongue over, hinging on the anterior muscles only.

A frog's sight is very keen but is restricted in definition to a few yards, and the slightest movement near singing frogs will bring about a sudden silence. This of course may also be aided by an acute sense of hearing and the two combined senses are correlated for helping in the securing of food.

The power of regeneration of lost parts is not so great among certain amphibia (for example, the tadpole stage of newts and salamanders) as is generally supposed and only the tail can be replaced. In adult frogs and toads, regeneration of lost parts is unknown.

Frogs and toads do not drink like other animals but mostly absorb moisture through the skin. Experiments have shown that a frog kept in a very dry place for about twenty-four hours may lose between 10 and 15 per cent. in weight, depending on its physical condition, but it will regain this loss within forty-eight hours if replaced in water. Hot water will kill a frog, whilst cold water merely slows down its activities. By hot water is meant water that, even in waterholes, may be heated by the sun to 110 or 120 degrees. Frogs have been kept alive for several days in water ranging from 0° to 13° C., and many that have been placed in freezing water have completely recovered when removed to more temperate conditions.

The Golden Swamp Frog (*Hyla aurea*), common in most swamps throughout Australia, has golden stripes and spots on its back and sides. Normally it is green above but may be brown, merging to green on the flanks.
Photo.—R. D. Mackay.



The Cross-bearing Toad (*Notaden bennetti*) is an inland species found from slopes and plains. It is a burrowing toad measuring 1½ inches long when adult. The young are bright yellow, the adults vivid green; each with raised, large black spots and minute red or yellow ones.

The locomotion of frogs and toads may be by swimming, walking and jumping. In the tadpole stage all swim by means of the tail, but after reaching the adult stage all take to hopping. Some of the tiny toadlets, and for that matter larger toads, generally either walk on their toes or heave themselves along by short, clumsy hops. On the other hand all true frogs are good hoppers or jumpers, and most of them are excellent swimmers. The leap of a frog may be a mere six or eight inches or up to eight feet for some of the long-legged members belonging to such genera as *Rana*, *Limnodynastes*, *Mixophyes* or *Hyla*.

In some countries frog-hopping contests are regular events, often run in a series of heats, with a final championship. It is a very popular sport in several of the States of America, and generally the test is the total distance of three hops from scratch. As there is a time limit, it might be regarded in the light of a race, and furthermore it is permissible to give the frog a slight poke to start it off. Frogs are most unpredictable creatures. Sometimes known "long hoppers" have taken three tiny hops aggregating a mere 8 or 10 inches; others have started immediately and have covered up to 20 feet in three hops. One champion, competing in the 1953 "all American," in California, sat glum and blinking whilst lesser lights covered the required course. Immediately the race was over the champion gave a record exhibition in the wrong direction. In this particular championship some Australian Great Barred River Frogs from New South Wales competed, and whilst one covered the greatest distance, said to be 11 feet in its first hop, it refused to move further.

In cold climates or even temperate ones frogs hibernate, or lie dormant for several months during the winter. Often they bury themselves in mud at the bottom of a pool. Sometimes they curl up under large stones or logs in damp places. With the change of temperature from warm to cold their vital activities slow down, until practically no energy is required to maintain life. No food is required, respiration is reduced to a minimum and is mainly through the skin.

Hibernation gives rise to stories such as "frogs found in solid stone", which of course is impossible. Sometimes during blasting operations in a rock quarry a frog is found curled up in a pocket and in a dormant state in a piece of blasted rock. There does not appear to be any opening into the pocket and people, seeing this, jump to the conclusion that the frog has been found in solid stone. Now a frog could not live in a "pocket" if there were no opening, however small, whereby water and air could enter. Secondly, the rock in which such frogs have been found may be millions of years older than the frog. The fact is that at some time—even a year or two before a frog is so found—an adult, or perhaps a very young frog, will have crawled or been washed into a crack. This had either filled up or a slight earth movement almost closed it, thereby imprisoning the frog. Air and water kept the frog alive in the pocket. Experiments in which twelve frogs were artificially sealed up in solid sandstone for two years showed that all perished, whilst of twelve others sealed in twelve pockets in more porous limestone, eight were found alive. After a further period of twelve months' imprisonment the remaining frogs also died.

A frog's intelligence is very low. Frogs learn by means of trial and error, but learning is slow and the lesson learned is not permanently retained in their memory. Often frogs will grasp almost any small moving object under the impression that it is food, and because the sense of taste is limited they have been known to try to push a moving pencil into their mouths.

In those countries that have extremes in climate, from sunny summers to snow-and-ice winters—countries in which the seasons are clearly marked—the breeding habits of frogs, as with other animals of these places, are regular, and dependent on the season.

In Australia the breeding periods are irregular; normally frogs breed in summertime but in the dry interior spawning may take place whenever the rainfall coincides with suitably warm weather. Some species of burrowing frogs, in particular the Water-holding Frog of the Centre, fill themselves with water on the approach of dry weather and burrow deep into the mud. Whilst the surface of the one-time waterhole is a sunbaked clay pan the frogs remain 15 to 20 inches deep in a hard ball of clay which retains a wet centre, in addition to the water within the body of the frog. This frog may remain below for many months; only when copious rain fills the clay pan does it come to the surface and look for a mate; and within a few days there may be thousands of tadpoles swimming around. The metamorphosis is fairly rapid with these frogs and the tadpoles are seldom caught and eliminated by the drying up of their pond.

The breeding habits and metamorphosis of our frogs and toads vary a little from species to species but the general scheme is approximately like this: the eggs are minute, jelly-like, and about the size of boiled tapioca. They vary in number from fifty in some toadlets to many hundreds in some of the larger water frogs and tree frogs. Under favourable conditions the eggs hatch in a few days and the newly-hatched tadpoles resemble mosquito larvae. They have several tiny external gills and breathe under water like fish. Later the gills disappear, and lungs develop; so the tadpoles have to make frequent visits to the surface to breathe. As they grow the hind legs appear, and later the arms, but the tadpole sucker mouth is retained. During this time the tail is still well developed. Then the true frog mouth commences to develop and as the tadpole cannot eat at this time it survives on its accumulated fats, and particularly the tail, which is absorbed. Eventually the little tadpole grows into a small frog and spends as much time out of water as in it.

In regard to the eggs and breeding habits of some of our toads: as a rule the eggs are laid in clumps, or strings like a necklace, in very damp places at the base of a clump of grass or under stones, and some of the early stages of the tadpole's life are spent within the egg. Development is rapid once the eggs hatch but they may remain under the stones awaiting rain before this takes place.

Most toads and, to a lesser degree some frogs, secrete a fluid from the parotid glands that is more or less poisonous. It is curari-like and neurotoxic in its action. If you have ever rubbed your eyes after handling the Common Green Tree Frog you must have experienced a burning or stinging sensation. The toxin is more powerful and more neurotoxic in some species than in others. A cat or dog, having once taken a toad in its mouth, receives a stinging sensation that gives it a good and lasting lesson. The gland secretion of some toads is so great that small dogs have died after taking a toad into their mouths.

A neurotoxic poison is one that affects the nerve centres, often causing death through paralysis of the nerves controlling breathing, and so the victim suffocates.

POPULAR SCIENCE LECTURES—1956 SERIES.

Popular science lectures will be given in the Australian Museum lecture hall twice monthly, up to and including October. No charge is made for admission. The lectures, which begin at 8 p.m. (doors, 7.30 p.m.), are usually illustrated by films or lantern slides.

Subject and Lecturer.

June 20—"Fungal Flora of Our Bushland"—N. H. White, D.Sc.

July 4—"Australian Reptiles"—J. R. Kinghorn, C.M.Z.S.

July 18—"Australian Frogs"—A. N. Colefax, B.Sc.

August 8—"Molluscs of Medical Importance"—D. F. McMichael, Ph.D.

August 22—"The Grand Canyon of Arizona"—F. W. Booker, M.Sc., Ph.D., F.G.S.

September 12—"The World's Finest Cave Paintings"—F. D. McCarthy, Dip.Anthrop.

September 26—"Deterioration and Preservation of Structures"—R. A. Johnson, M.I.E.

October 10—"Insect Flight"—D. K. McAlpine, B.Sc.

October 24—"Research Among an Almost Untouched Population in the Western Highlands of New Guinea"—N. W. G. Macintosh, M.B., B.S., Dip.Anthrop.

Exploring Between Tidemarks

II. Adaptations of Seashore Animals

By ELIZABETH C. POPE and PATRICIA M. McDONALD

ON the seashore, between low and high water marks, one is struck very forcibly by the fact that each species living there successfully has become specially adapted to cope with its particular environmental conditions. In fact as Maurice Burton has said in his stimulating book *The Margins of the Seas*, it is here we can "see in concentrated form, and in miniature, the struggle for existence and the evolution of special habits or structures to overcome the environmental difficulties. Nowhere else in the world is there such a variety of habitats in so small an area, or

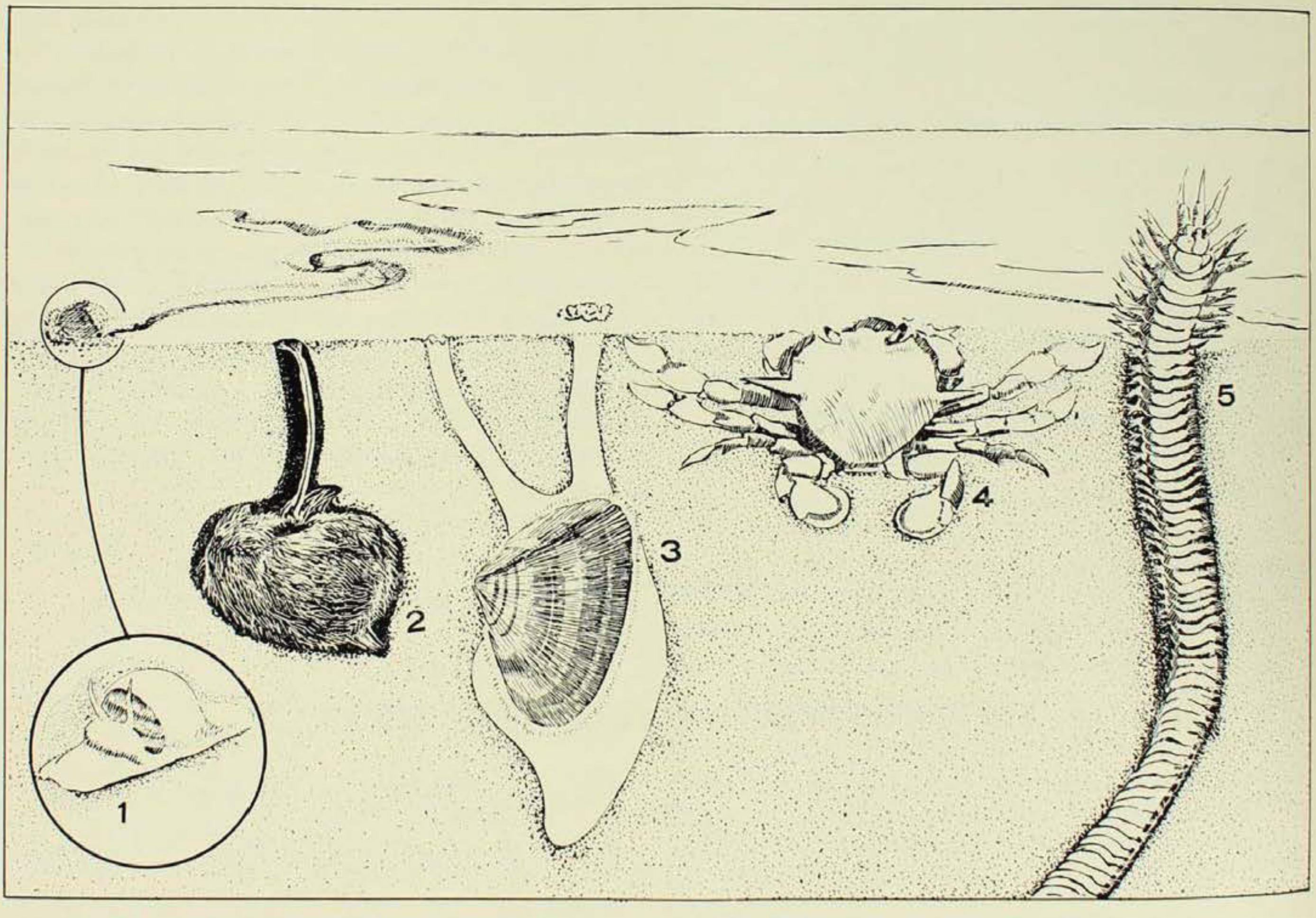


Fig. 1.—*Animals adapted to life on surf beaches*: 1. The Moon Snail (*Uber incei*) ploughs distinct furrows on the surface with its large foot. (Inset: Snail washed clear of sand.) 2. A Heart Urchin (*Echinocardium*) burrows in the sand, which is eaten for contained detritus. Special tube-feet keep contact with the surface. 3. The Pipi (*Plebidonax deltoides*) has an inlet-tube (right) guarded by complex papillae which strain off sand grains and trap food particles. Its outlet-tube is simple; the wedge-shaped shell is thick and strong. 4. The Sand Crab (*Matuta lunaris*) has a flattened body and limbs like spades for digging-in rapidly. 5. The Giant Beach Worm (*Onuphis teres*) with head projecting to catch food. View is of lower surface to show mouth, tentacles, and enlarged digging-feet (parapodia) at the front end. Figs. 1 and 2 are diagrammatic and not to scale.

—F. J. Beeman del.

[a place] where the conditions vary so much from hour to hour, day to day, season to season and from one year to another."

The observation of these adaptations can become a fascinating pastime for the dabbler in natural history or it can be the subject of a lifetime study for the serious student of ecology. In another place we have mentioned how intertidal organisms tend to be arranged in horizontal bands or zones, according to their abilities to withstand increasing amounts of exposure to desiccation. Here it is intended to discuss more particularly the adaptations of some of the individual species to the rigorous conditions in which they live and to try to appreciate how they are fitted for the particular niche they occupy.

A most obvious and broad difference is at once apparent between the animals living on (or as they most generally do "in") a sandy, wave-beaten surf beach and those inhabiting a neighbouring rocky shore. Both are subjected to the same pounding by waves and the same tidal effects but the two groups of animals have solved the

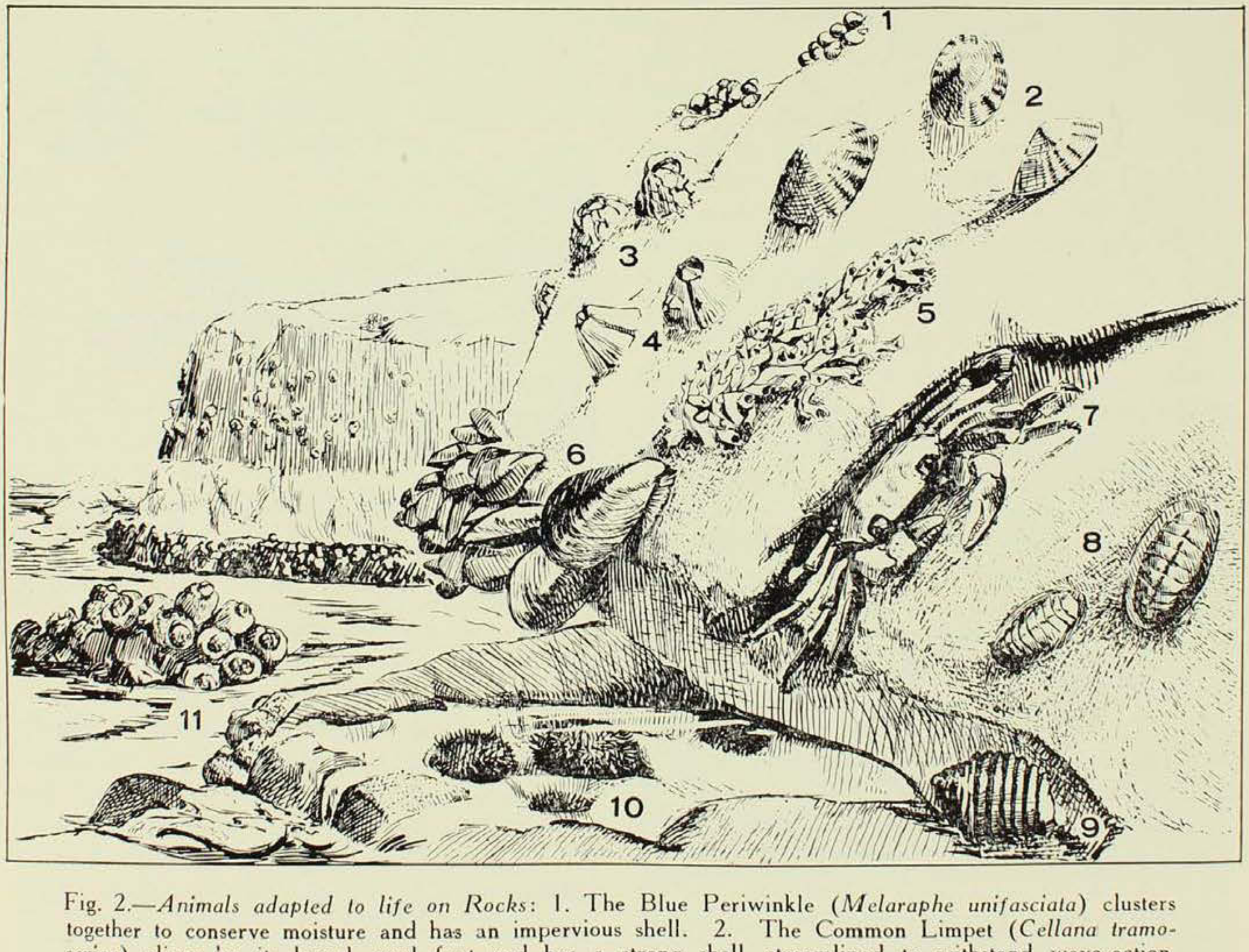


Fig. 2.—*Animals adapted to life on Rocks*: 1. The Blue Periwinkle (*Melaraphe unifasciata*) clusters together to conserve moisture and has an impervious shell. 2. The Common Limpet (*Cellana tramoserica*) clings by its broad, oval foot and has a strong shell, streamlined to withstand wave-action. The Surf Barnacles 3. (*Catophragmus polymerus*) and 4. (*Tetraclita rosea*), with trapdoors closed, are cemented to the rocks. They also have conical, streamlined shells. 5. Limy tubes of *Galeolaria* worms cemented to the rock. 6. Mussels (*Mytilus obscurus*) are anchored by byssal threads and have a shape adapted to cleave through rushing water. 7. Swift-footed Crab (*Leptograpsus variegatus*) can wedge itself in crevices. 8. Smooth-girdled Chiton (*Onithochiton quercinus*) clings like the limpets and has its 8-plated shell similarly streamlined. 9. The Cart-rut Shell (*Dicathais orbita*), a roving carnivore, has a strongly corrugated, protective shell. 10. Common Sea Urchins (*Heliocidaris erythrogramma*) wedged in holes mined in the rock. 11. Cunjevoi (*Pyura stolonifera*) with its tough coat of tunicin is cemented to the rocks.

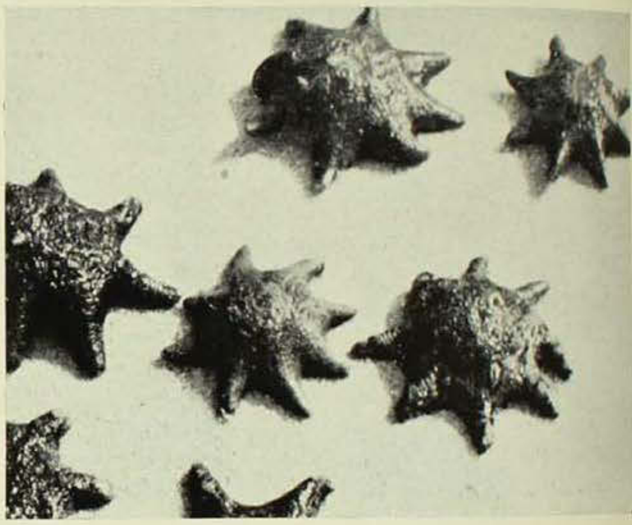
—F. J. Beeman del.

problems of survival in different ways. A quick comparison of the commoner species of animals from these two habitats may be made by referring to Figs. 1 and 2.

TWO HABITATS CONTRASTED, AND THEIR FAUNAS.

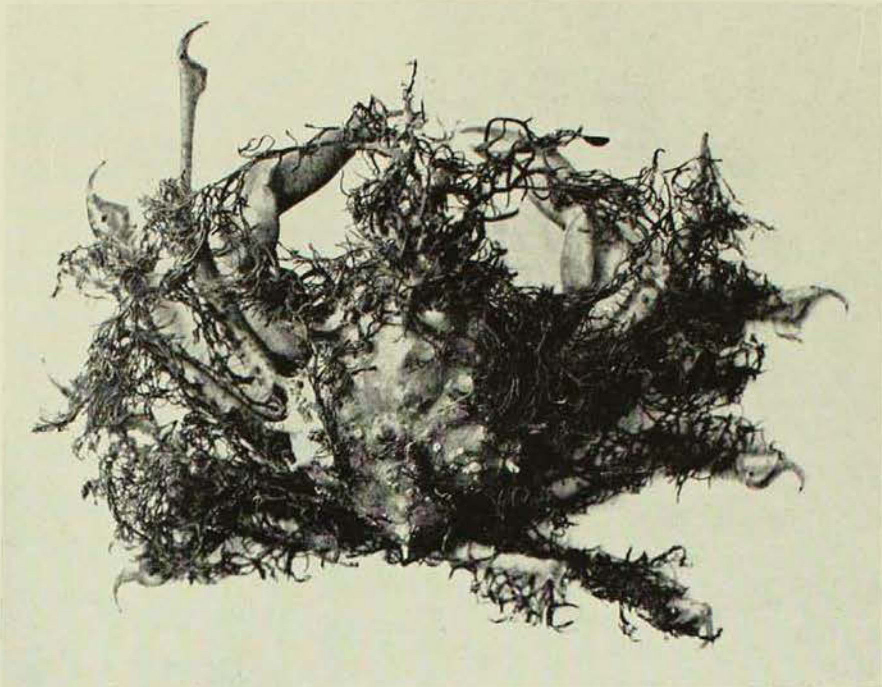
The most obvious difference in the two environments under discussion lies in the nature of the bottom or substratum. Sand shifts and may be swirled about by the surf, whereas rocks are generally stable and remain firm when exposed to wave action. So in the sand we find burrowing, wedge-shaped pipi shells, giant sand worms (*Onuphis teres*) with well-developed digging organs, and heart-shaped sea urchins with special "snorkel" breathing tube feet reaching up to the surface of the sand, where life-giving oxygen is available. The crab *Matuta lunaris* spends much of its life entrenched in sand with only the front of the body projecting above the surface and the Moon Snail (*Uber incei*) has a huge foot like a ploughshare which helps it crawl over and plough through the shifting sand. Half buried in its furrow, the snail is prevented from being bowled about by all but larger waves.

On the rocks clinging and encrusting animals predominate. Here are found the chiton, the limpet and its relatives, proverbial for their powers of clinging. Cemented to the rocks are hosts of barnacles with their hard protective shells, and the tough-coated Cunjevoi sea squirts which quilt the rocks. Some sea urchins actually mine their own holes in the rocks, wedging themselves in by means of their spines and anchoring themselves by their tube feet to avoid being washed away. (See illustration page 49.) Because of the firmness of the rocky substratum, true algae (seaweeds) of many kinds can find a foothold on the intertidal reefs whereas the shifting sands of an ocean beach prevent the growth of any large plants between tidemarks. Only on the sheltered shores of inlets or estuaries are the sands and muds firm enough to allow plants to establish themselves—not algae but higher forms of plant life such as the familiar Eel-grass (*Zostera*) and the Strap-weed (*Posidonia*), both of which have true roots.



Protective coloration.—Though brightly coloured the 8-rayed seastar, *Patiriella calcar*, is well camouflaged on rocks. Similar colouring in a sand-dweller would be conspicuous. The same series of seastars was used in both photographs but one group was placed on rocks and the other on sand.

The algae on the rocks provide both food and shelter to numerous animals of widely different kinds such as browsing molluscs, worms, sponges, sea mats (*Bryozoa*), sea urchins and hosts of small *Crustacea*. These are necessarily absent from the sandy habitat because of the lack of algae. As a consequence more varied forms of life are to be found on rocky shores than on the sands. The prevalence of the carnivorous habit, or of feeding on detritus, among the sandy shore animals is a consequence of the lack of plant food growing in the area. On the rocks browsing animals and creatures that filter plankton from the sea are in the ascendant and only a comparative few



Camouflage by garnishing.—Dwelling among the seaweeds on the rocks, the Weed-masking Crab, *Naxia spinosa*, deliberately transplants snippets of algae on to the spines of its shell—an efficient camouflage. The first picture shows how the shape of the whole crab is masked. The enlargement gives details of the knobs and spines on the carapace to which algae are attached. The algae grow in this position.
Photos.—The late G. C. Clutton.

are carnivores or detritus feeders (eaters of organic débris). More will be said of this later.*

During low tides, the animals of the sandy beaches are never subjected to the same degree of desiccation as are those of the upper sides of rocks. The sand always retains a fair amount of water and so any animal buried therein does not have to be adapted to withstand the effects of drying. On the other hand those on the rocks tend to have thick impervious shells or tough outer coats to retain moisture, for fine flying spray is often their only source of water when the tide recedes and sun and wind cause rapid evaporation. In the illustration on page 49, some of these rock-dwellers are shown in their natural habitat. Against this, the rock dwellers enjoy a plentiful supply of oxygen whereas those buried in the sand have to be adapted to sustain life on the limited amount of this essential gas at their disposal. To ensure the proper supply of this life-giving gas we find them equipped with special organs such as long breathing tubes or siphons which reach up to the sand surface, or with specially efficient gill systems, and such aids to oxygen absorption as blood pigments (like haemoglobin). Of course sand grains have to be excluded from delicate structures such as gills and siphons or they would soon become clogged. Adaptations like fringes of hairs (seen in crabs round the openings leading to the gills), or the complex sieve-like arrangement of papillae that guards the entrance to the intake siphon of the bivalve pipi, are developed.

*The feeding of intertidal animals will be dealt with more fully in the September issue of this Magazine.

One other striking difference between the animal communities of the sand and of the rocks should be mentioned—colour. On the whole the rock dwellers are far more vividly coloured than are their relatives in the sand. The drab colour of the heart urchin (*Echinocardium*) contrasts markedly with the bright reds and pinks and greens of any of the rock sea urchins, and the sand worms, shells and crabs are generally paler than their rocky counterparts—protective coloration would be of little use when the greater part of the animal's life is spent hidden in the sand! It is among the rocky shore animals that we find colour adaptations and camouflage developed to a very high degree. For instance the Weed Masking Crab, *Naxia spinosa*, and the colourful eight-armed seastar, *Patiriella calcar*, are two very common examples. In fact the novice shore collector will probably miss hundreds of cryptically coloured animals, so perfect is their deception and likeness to their surroundings.

Perhaps the easiest way to appreciate the degree of efficiency in adaptation to environment achieved by marine animals is to consider one by one some of the better known shore animals and to try and determine how their structures and their behaviour fit them for life in the rigorous climate of the shore.

The Barnacle—A Well-adapted Rock Dweller.

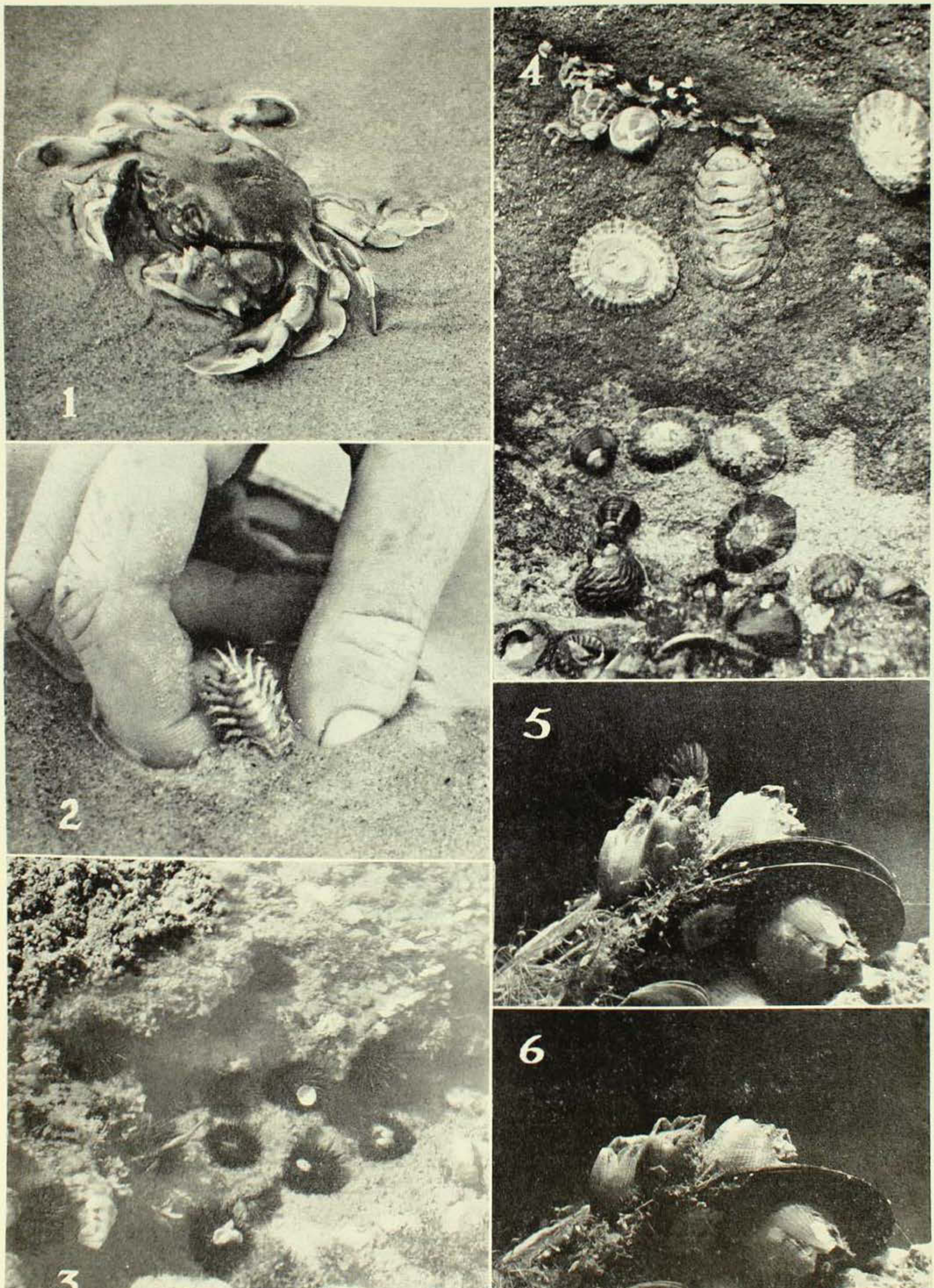
Judging from their numbers and their wide distribution over the tidelands of the world, the acorn or rock barnacles are the most successful colonisers of rocky shores. On the New South Wales coast they may be found from below low water mark right up to areas above the level of the ordinary spring tides on the ocean headlands. Barnacles can live far up estuaries and can attach themselves to rocks, boats, buoys, cement walls, wharves, and even other animals like molluscs; in fact any solid substratum will serve. Actually a number of different species of barnacles is found on any shore—one favouring rough wave-beaten areas, another liking calmer waters and so on. However, all agree in having the same general shape and in feeding and breeding in the same way.

What makes the rock barnacles so successful? Firstly their hard protective shells, firmly cemented to the rocks with the softer body and organs inside, adapt them to withstand the bashing force of waves and the currents which might wash them from their perches. Often the shell is bell-tent shaped and therefore efficiently streamlined to cut down water resistance. The hole in the top of the limy shell can be closed by means of two pairs of "trap-doors" (opercular valves), thus excluding many preying animals and also helping to prevent desiccation by retaining moisture inside the shell when the tide is out. (See lower right-hand illustration on page 49.) So much for the barnacle during low tide when life activities are at a minimum.

When flooded by high tides each barnacle can open its operculum and protrude its very efficient system of paired fishing feet (the cirri), covered with fine hair-like spines, to trap minute organisms from the plankton which floats by in the sea. The six pairs of cirri are worked all together like a scoop net when actively "fishing". Just how efficient this method of food catching is may be judged by observing how quickly the rock barnacles grow and how rapidly they mature and breed. A feeding barnacle is illustrated on page 49.

In breeding habits rock barnacles also show adaptations to their fixed existence on the rocks. The problem of colonising new areas and avoiding overcrowding in their

Illustrated opposite.—1. The Sand Crab, *Matuta lunaris*. 2. Head of Giant Beach Worm, *Onuphis teres*; dorsal view. The reinforced areas on the digging feet appear as black dots. 3. Sea Urchins, *Heliocidaris erythrogramma*, in self-excavated holes. (Seen through two feet of water. Weedmat projects above water surface in top left-hand corner. Photo: E. C. Pope.) 4. Group of common rock-dwelling molluscs from mid-tide level. Most prominent is the Scaley-girdled Chiton, *Sypharochiton septentriones*, with its eight central plates. On either side are limpets, *Cellana tramoserica* (three smaller ones below). The striped periwinkles, *Austrocochlea obtusa*, show a variety of patterns, some with broad stripes and some with narrow. 5. Barnacles on a mussel shell—two with extended fishing feet (cirri) are actively feeding. 6. The same barnacles as above closed up on exposure to air; note that the mussel has also closed.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own vicinity is overcome by having swimming larvae. These larvae drift and swim about in the sea, temporarily forming part of the plankton. The numbers of larvae produced by the rock barnacles are astronomical but this is offset by huge losses due to predators and by misadventures leading to settlement in unsuitable places and subsequent extinction from a variety of causes —chiefly unsuitable factors in the microclimate of their environment.

During this period of free-swimming, the young barnacles change by a series of moults from the simple nauplius type of larva with three pairs of swimming legs to the cypris type which has six pairs of legs and which, in addition, has developed a protective bivalved shell and a pair of antennae capable of attaching their owner firmly to the substratum. After a time the cypris larvae are ready to settle down and undergo further metamorphoses which will alter them to the fixed adult stage, surrounded by a hard protective ring of shell cemented firmly to the substratum. Meanwhile tides and currents will have carried the young barnacles some distance from their parents and they settle down in a different area of the shore.

Many other intertidal animals use this indiscriminate broadcasting method for ensuring the spread of their kind and pure chance determines whether or not their young survive to recolonise a suitable shore. Other dwellers on the rocky shores go to the opposite extreme from the barnacles. They have few young but allow them to develop inside the body or shell of the parents until they are ready to set up independent existences of their own.

The beautiful deep red Waratah Anemone, *Actinia tenebrosa*, (or "Bloodsucker" to small children), is adapted in this way and to ensure that its progeny will find suitable rocks on which to settle the young anemones develop inside the body cavity until they are perfect miniatures of the parent, about one-quarter of an inch in diameter. They then emerge or are forced through the mouth during a period when high tide covers the reefs where the parent is attached. The young *Actinia* now stands a chance of attaching itself to nearby rocks. The naturalist is rarely able to stay on the rocky reefs during periods of high water to witness "the birth" of these young anemones but it is possible, in the breeding season, to "pop" the young anemones out through the mouths of their parents while exploring at low tide, and thus verify this phenomenon for oneself.

Adaptations in Other Rock Dwellers.

Like the barnacle the various species of limpets are also streamlined to a high degree and are thus also adapted to stand the shock of waves and currents, their strong thick shells protecting them also from both enemies and desiccation. The foot, by which the limpet clings to the rock, is large in comparison to the size of the rest of the body and one South Australian worker found that it required a pull of 30 lb. weight to detach our common *Cellana* from the rock.

Two further exponents of the "cementing method" of attachment to rocks are the Cunjevoi and the colonies of Galeolaria Worms. Although differing widely in structure, both of them use basically the same method of protection from desiccation and battering; the Ascidian has a tough leathery outer coat of tunicin and the Galeolaria Worm a rigidly constructed limy tube. In addition the Galeolaria Worm can close the mouth of its tube by a plug-like operculum reminiscent of the structure of the same name seen in many gastropod molluscs.

Many such gastropod snails with opercula may be seen on rocky shores, for instance the Turban Shells, Cart-rut Shell, Mulberry Shells and the many kinds of periwinkles. From their appearance it can be appreciated at once that the molluscs from the lower levels of the rocks are better adapted to withstand the bashing of waves for they have to put up with the rough treatment for a far longer period than those from higher levels. Some, like the Cart-rut Shell (*Dicathais orbita*) and Turban Shell (*Ninella torquata*), have shells strengthened by heavy corrugations while the same purpose is served in the Mulberry Shell (*Morula marginalba*) by a series of large knobby structures.

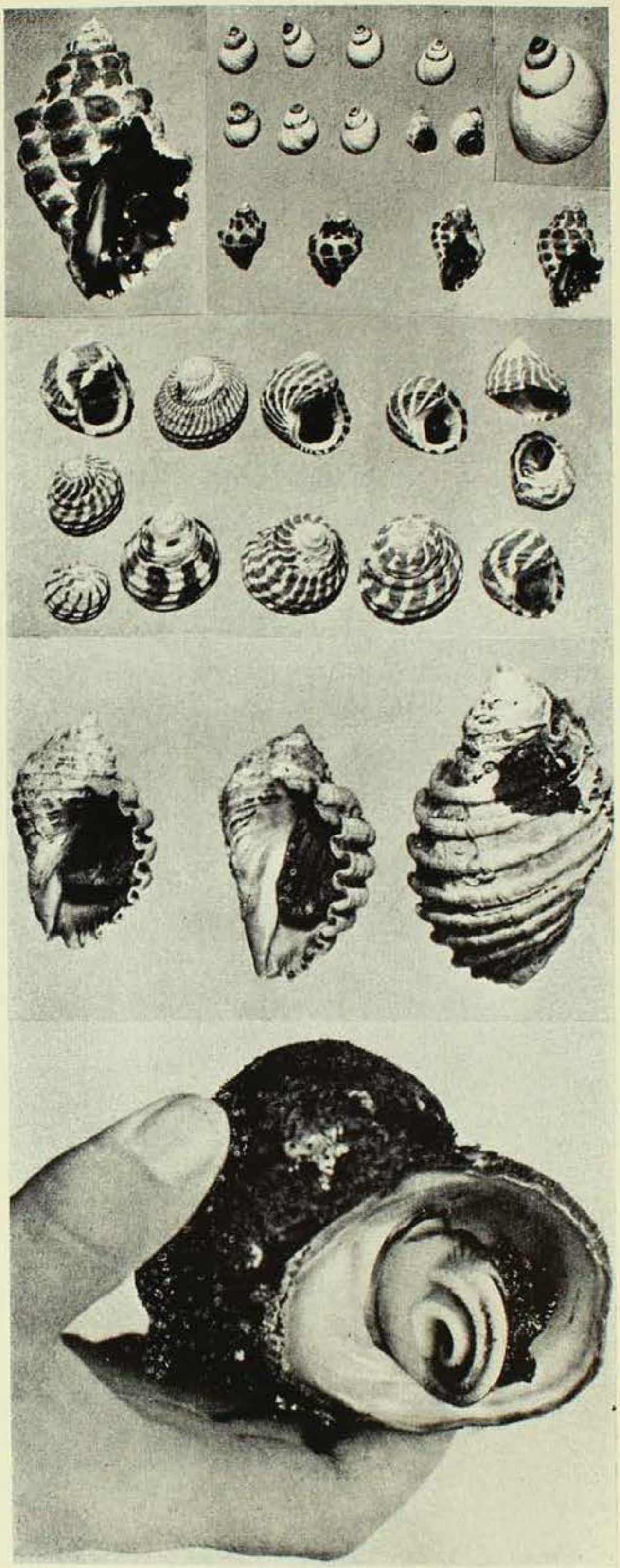
Mussels are one of the few types of bivalve molluscs which have adapted themselves to life on the rocks. They do this partly by anchoring themselves by means of a series of strong threads called the byssus, and partly by having a shape well adapted to cleaving and diverting the sea water that flows over them. Even so, mussels can only flourish in comparatively sheltered places on the ocean coast.

Probably the most numerous bivalve on the rocks is one that is rarely seen, *Lasaea australis*, for this tiny, split-pea sized mollusc has adapted itself to life on the wave-beaten shore by hiding from heavy surf in any available nook or cranny. Thus it is found in the spaces between Galeolaria tubes; between the Cunjevoi; amongst the byssal threads of mussels or imprisoned in amongst the fronds and holdfasts of the short, crunchy weedmats of coralline algae on the outer edges of rock platforms.

These weedmats are also adapted for life on the exposed coast. The short coralline forms just mentioned are strengthened to resist battering by deposits of lime in their tissues, while many of the large green and brown seaweeds adopt the method of passive resistance. Securely fastened to the rocks by their holdfasts, the tough but flexible stalks and fronds bow before the onslaught of the seas, recovering unharmed when the waves have washed over and through them.

ADAPTATIONS IN SAND DWELLERS.

Turning now to the inhabitants of the sand, the habit of digging-in is found to be the most notable adaptation common to their behaviour. The strong wedge-shaped shell of the pipi is the best possible one for being drawn through the resistant sand by the working of the large and efficient muscular foot. This is reflected in the speed with which pipis can up-end themselves and disappear into the sand if accidentally exposed in the wash of a wave. An even faster digger than the pipi is the Giant Beach Worm (*Onuphis teres*), which can burrow through the sand faster than most people can dig with a spade, as bait gatherers know to their sorrow. It is able to dig so fast by reason of its specially



Shell Adaptations in Gastropod Snails (shells approximately half natural size).—From the bottom: Large Turban Shell—a thick heavy shell; note the thickness of the complex operculum plugging the opening. Three Cart-rut Shells, carnivores from low tide level—very rugged shells. Group of Striped Periwinkles, thick shell to withstand battering. Mulberry Shells (enlargement left) traverse wide areas in search of prey—a strong shell. Blue Periwinkles (enlargement right)—smooth, thin shelled, least battered by waves.

adapted digging feet. Throughout its tremendous length (up to 8 ft.) the worm is more or less the same width except for the head end which is slightly broader, thus enabling the hinder end to slip along easily. The head bears from four to six pairs of specialized larger parapodia adapted for digging. (See illustration, page 49.) As may be seen, these are stouter than the other parapodia and bear small, dark-coloured plates which shield the softer parts while digging is in progress.

The Heart Urchin (*Echinocardium*) is another accomplished digger. Some of the spines of the lower surface have flattened tips like small spatulas or oars and are used to "row" the urchin into the sand. Here it excavates a small chamber, just a little larger than itself, and keeps the sand grains of the walls in place by secreting a mucus-like cement. As already explained, contact with the outside world is maintained by specially adapted, long tube feet which can be retracted when danger threatens (Fig. 1).

Like most sand crabs the local species (*Matuta lunaris*), digs itself in backwards. Its walking legs are specially well adapted for this purpose by being flattened and having greatly enlarged blades at their tips for shovelling the sand. *Matuta* should not be confused with the small hermit crabs (*Diogenes custos*) which are frequently seen in summertime being bowled about on the edge of the surf. The latter are merely seasonal visitors, coming up into the intertidal zone to breed. The presence of *Matuta* is generally detected when it emerges from the sand to grasp the bait of the unwary fisherman.

An Unending Interest.

From this short account it will readily be appreciated how marvellously the animals—whether from the sandy beaches or from the rocks—are adapted to cope with their environment. The same difficult living conditions may be met and overcome in many different ways, all apparently effective. The problem of breaking surf, for instance, may be overcome by adopting methods reminiscent of Stonewall Jackson (Cunjevoi, barnacles, limpets and the like); or by seeming to give way completely to the force of the waves (seaweeds like the kelp *Ecklonia*); or by living in positions sheltered from the breakers (the tiny bivalve *Lasaea* and all the digging species of the sandy surf beach).

Equally ingenious methods have been established by the shore animals to counteract other difficulties that are met with in the intertidal environment. Each visit to the shore reveals more and more of these wonderful adaptations. The more one learns, the more one sees. There is no end to the fascination of exploring between tidemarks.

Next issue: Shore Animals and Their Feeding.

A "Barking" Crayfish

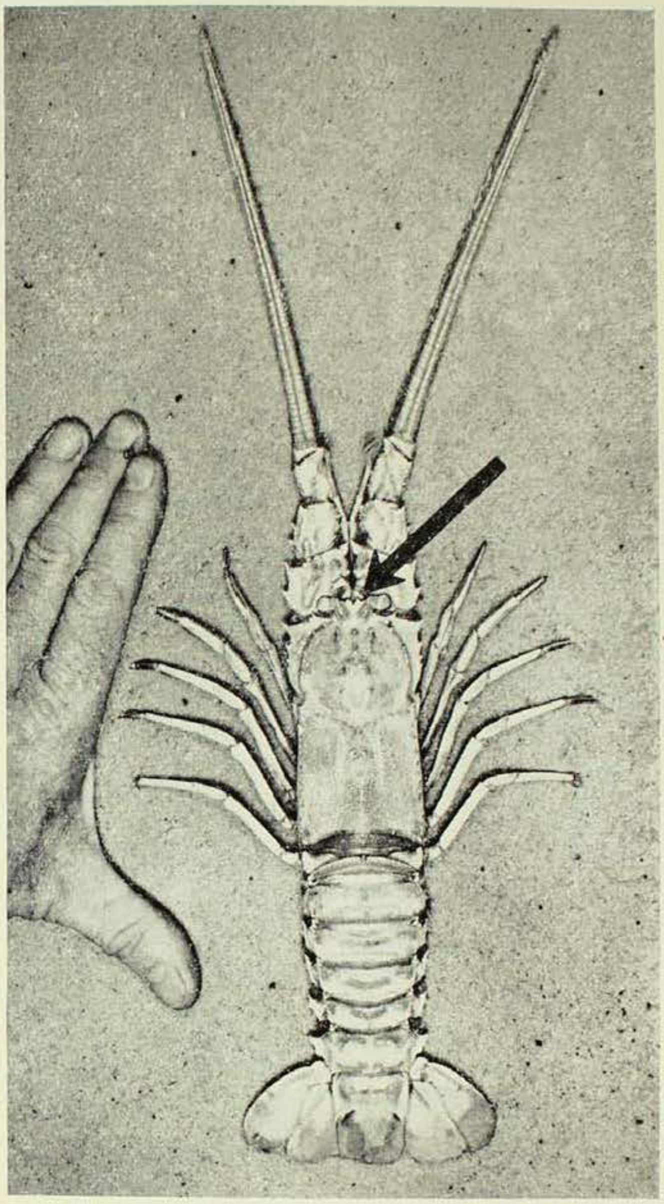
By FRANK McNEILL

It was hard to believe that a crayfish could bark. However, Athol D'Ombrain's voice was emphatic on this point. He had telephoned the Museum late one afternoon near the end of January. "It's an unusual kind," he said, "and a stranger to the fishermen here in Newcastle. They've never seen anything like it and are anxious to have your opinion." Then followed a recital of the locality—16 to 18 miles east of Newcastle; seine netted in 50 fathoms of water. These were intriguing details though they did not quell the doubt about the "barking" claim, an assertion which could not be ignored. Athol D'Ombrain knows the commercial fishing fraternity very well. In the Newcastle district he has quite a reputation as a sportsman and big game fisherman. As a keen naturalist he has gathered much data on local game fish and has directed a number of specimens of these and other examples of unusual marine life to the Australian Museum.

The cray, it was learned, was still alive and arrangements were made for it to be brought to Sydney next morning, enclosed in specially dampened wrapping. Eventually the still living specimen was examined at the Museum and it did prove to be the rarity claimed. Only one other example of its species (*Linuparus trigonus*)* had ever been recognised from anywhere around the Australian coastline and that specimen was also collected in seas adjoining the temperate eastern quarter of the continent and as recently as 1949. Both occurrences are surprise distributions of a cray which strictly belongs to the Japanese seas, from whence it was originally described in scientific literature. The only other record from so far flung a spot concerns a single specimen trawled off Portuguese East Africa, in 180 fathoms of water.

The crayfish was still very much alive. A startling reminder of this came with a sudden body contortion as the cray flexed its tail and threw its pair of heavy antennae backwards over its head. The movement was accompanied by quite a loud harsh grating sound—the "bark" claimed by Athol D'Ombrain. The crayfish reproduced this note again and again while it survived. The strange noise made by representatives of this species has probably passed unnoticed until now. Certainly no related crayfish, including our local marine commercial kinds, can produce sound of any kind. Certain sand crabs (*Ocypode*) make faint rasping sounds by rubbing one row of beaded tubercles across another. The tubercles are on the inner surface of the larger of the two nipper limbs and are brought together when the hand of the nipper is folded in against the rest of the limb; they are called stridulating organs and are thought to be warning or mating aids.

*See this Magazine ix (10), p. 337, where a specimen is recorded from 65 fms. off Botany Bay, N.S.W., taken by a steam fishing trawler. Unfortunately the incorrect name of *Puerulus carinatus* was used in that instance.



A "Barking" Crayfish (*Linuparus trigonus*), measuring 16 inches overall. Arrow indicates the site of one of the two polished bosses which help to produce the strange "barking" sound. Specimen from off Botany Bay, N.S.W.; trawled in 65 fathoms of water.

The purpose of the loud harsh note from the deep water cray remains a mystery. Even its source was not located for some time after the Newcastle specimen died. Finally it was traced to the inner angles of the heavy basal joints of the stubby antennae, just in front of the eyes. Here there are two smooth-lined cavities which enclose and bear upon a pair of highly polished bosses when the antennae assemblage is thrown backwards over the head. Even after death a semblance of this friction-produced sound could readily be achieved by hand manipulation.

A Semang pygmy of Perak, northern Malay Peninsula, using a blowpipe. Poisoned darts are blown through the long bamboo tubes to kill birds and mammals in the dense jungle where spear and arrow would be difficult to use.

Photo.—Author.

The Races of Man in Oceania

(*Continued from page* 20.)

By FREDERICK D. McCARTHY

The Metal Working Rice Growers.

IN Indonesia the Mongoloid race has become dominant, although physically the people vary considerably, a variation heightened to the casual observer by the amazing array of colourful dress to be seen in this region.

The Meningkabau, Achinese and Batak of Sumatra, the Dyak and Klamantans of Borneo, Buginese and Toradja of Celebes, Sundanese, Javanese and Madurese of Java, and the Balinese are among the well-known ethnic groups of Indonesia. On the whole, the Indonesians are a small but graceful people. Two important physical types among them are the Nesiot (or proto-Malay) and the Malay. The former has a medium to long head, wavy hair, and a stouter stature, straighter eyes, longer and narrower nose than the Malay type which is lightly built, broad-headed with prominent cheek bones, wide nose, coarse straight black hair, and bulbous Mongoloid eyes. The Malay type has spread through the archipelago from Sumatra since the 12th century A.D., and is found along the coasts of many of the islands. The Malay peninsula and archipelago formed a corridor of migration for the earlier Oceanic peoples, remnants of whom survive in a few places and their strains are present in some of the Indonesian groups.

Culturally, the Indonesians are the most advanced of the Oceanic peoples. Their life is centred on the growing of rice, the key element in a complex of which the water-buffalo, terrace cultivation, permanent villages, and a feudal system of organisation are other traits. It is the only mode of life which could support such a vast and dense population in these islands. Many crops other than rice are grown, tropical fruits are abundant, pigs and other animals are kept. The coastal communities use a wide variety of canoes and boats for fishing and trading. The Indonesians are skilful craftsmen and artists, producing beautiful work in silver, gold, and other metals, often ornamented with precious stones. Their music and dances are highly developed. Houses, of considerable architectural interest, are in some areas lavishly decorated with plastic and complex decorative art. Hindu priests established the Brahman religion as the dominant one in Sumatra and Java between the 4th and 16th centuries A.D., and it survives in Bali to-day. Since then Mohammedanism, introduced by Indian and Arabian traders, has been adopted in most of the Indonesian islands. In social life, religion, architecture, agriculture, household and factory crafts, the primitive and modern exist side by side in this land of contrast between the old and the new.

CULTURE VARIATION.

The peoples of Oceania secure their living in many ways, which include the nomadic and semi-nomadic habits of the pygmy Negritos, Tasmanians and Australian Aborigines, the shifting cultivation of the Melanesians and some Indonesian groups, the artificial pit gardens of the atolls of Micronesia and Polynesia, and the terraced cultivation of the Indonesians and some of the Melanesians. The symmetrical fields of raised and rounded or squared plots of sweet potatoes separated by drainage ditches (a method of cultivation which supports a comparatively large population) are a feature of the landscape in the great valleys of the mountain ranges in central New Guinea. Along the coasts, lakes and streams, communities may adopt a pure fishing economy (obtaining plant foods by barter), a mixed hunting-fishing or gardening-fishing mode of life. Thus in the search for food and economic stability the nomadic peoples are still at the mercy of their environment, a stage of culture abandoned by man in the Middle East some 7,000 to 8,000 years ago. It is only among the gardening and rice-growing peoples in Oceania that the settled communities have a control of their environment that is sufficient to ensure their food supply.

A Polynesian of Hawaii about to throw his casting net into the water. This sea-loving people depended largely upon fish for their food.
—"Mid-Pacific Magazine," xxxiii (1), p. 58.

The art of the Pacific peoples expresses a variety of religious beliefs, magical practices, social institutions and aesthetic feelings. The Australian Aborigines and the Melanesians use yellow, red, white and black in striking combinations of line and mass to highlight the high and low reliefs of their decorated surfaces and to emphasize the sculptural qualities of their plastic art. In Polynesia and Micronesia plain polished surfaces add a craftsman's touch to beautifully fashioned wooden objects (bowls, clubs and sculptures of

Aboriginal hunters in the Oenpelli district of western Arnhem Land returning to camp with a kangaroo. Their bodies are smeared with clay as a disguise and to suppress the smell of perspiration.

Photo.—Author.

human and other figures), and the Maori has developed a bold and massive decorative art based chiefly on the human figure. In Indonesia art flourishes in many forms and techniques, particularly on domestic articles and houses, and craftsmanship at its best is seen in the working of metals and in the use of gemstones. The art of Oceania in general is original and stimulating in conception; it offers an absorbing field of study to the anthropologist and a profitable source of application to the designer.

Culture in Oceania is a dynamic process, ever-expanding, but progressing much more slowly than in Asia, its primary source. To the customs and technological knowledge brought by the ancestors of the Oceanic peoples to their present habitats, and during the whole period of their occupation of these islands, have been added numerous new ideas and skills in many aspects of their cultures. These additions have diffused from Asia through Indonesia, and also Micronesia to a lesser extent, some spreading into Australia but few penetrating as far as the remote islands of eastern Polynesia. Thus the latest Oceanic peoples, the Indonesians, not only brought with them a higher culture but, because of their geographical situation, they receive the more advanced ideas from Asia before the earlier peoples. The varied cultures of Melanesia, the neighbouring cultural region to Indonesia, have been considerably enriched in this way. The use of tobacco, for example, introduced into Amboyna, in the Philippines, by the Portuguese or Spanish at the end of the 16th century, spread throughout Indonesia and Melanesia, and into northern Australia, in less than four hundred years, and the same process has been taking place with art motives, religious beliefs, manual techniques, and other traits.

The Migrations of Oceanic Peoples.

It is generally believed that a short Melanesian (negroid or negrito) type, or the Australian Aborigines, were the first people to migrate into Oceania, but the southward movement of both these peoples differed little in time and could well have been made during the same period. These people came during the last glacial phase of the Pleistocene period, when migration was much easier because of the existence

A rice field in Bali, almost ready to harvest.

Photo.—Author.

of Banda Land (which joined Asia to the northern and western islands of Indonesia), and Sahul Land (which connected Australia and New Guinea with the southern islands of Indonesia). A complete land bridge did not exist between Asia and Australia to assist man's penetration of Oceania, and the early migrants had to cross sea channels up to thirty miles wide to pass through Indonesia. The evolution of the Australian Aborigines and the early negroids from extinct types of man like *Pithecanthropus erectus* and others in south-east Asia and Indonesia would give them a high antiquity physically, but they could not have migrated until they acquired rafts or bark canoes—no longer than 20,000 years ago, although estimates for the antiquity of the Aborigines range from 6,000 to 150,000 years ago.*

As the snows melted after the last glacial phase of the Pleistocene period, the water thus released caused a rise in sea-level which covered the low parts of Banda and Sahul Lands, leaving the high areas and mountain ranges as islands. Thus the later Melanesians (or Austronesians), the Polynesians and Indonesians, had to travel by sea-going watercraft from island to island in their migrations from Asia. The main routes were down (1) the western islands from the Malay Peninsula through Sumatra, Java, the Timor chain, New Guinea and the Melanesians groups; (2) through Formosa to the Philippines and thence through (*a*) the Micronesian islands or (*b*) through Borneo, Celebes, Moluccas, New Guinea and the Melanesian islands, and (*c*) through the Moluccas to New Guinea and the Pacific islands. Waves of Melanesians migrated into this region during the past ten or fifteen thousand years as the spread of the Mongoloids (with their rice culture from Asia) into the Indonesian archipelago forced them further eastward. The principal migrations of the Polynesians took place between the 5th (or a little earlier) and 10th centuries A.D. The ancestors of the present Maoris reached New Zealand in 1350 A.D., in the great canoe migration from the Cook Islands. The traditionally accepted theory is that the Polynesians came from Asia through Indonesia and Micronesia, and some possibly through Melanesia, but the Pan-American theory of Heyerdahl, demonstrated so vividly by the *Kon Tiki* raft's voyage, would bring them from the Peru area of South America.

As yet archaeological work has not been carried out on a sufficiently wide scale to throw much light on the migrations of man

* See article on "The Antiquity of Man in Australia", this Magazine, vol. IX (6), 1947, pp. 184-89, and (7), 1948, pp. 220-26.

in Oceania, but it is a line of inquiry that is now being gradually developed. During the past thirty years serological research, aimed at discovering the blood groups of the various peoples of Oceania, has provided important information. Dr. J. Graydon has pointed out that serological differences all support the hypothesis of a relationship between the Polynesians and the American Indians, who as a group are sharply distinguished in this respect from both Melanesians and Micronesians. He believes that if the Polynesians came from south-east Asia they must have left a long time before their arrival in central Polynesia. There is no evidence, he says, to indicate long stays by them in either Melanesia or Micronesia, nor of their having migrated through either region; rather the evidence supports the long landless ocean journey from Peru. There is, too, a major gulf between the blood groups of the African negroes and the Melanesians (who are often called Oceanic Negroids). The number of races and mixed peoples living in this Oceanic region makes it extremely difficult to elucidate the time factor for their respective migrations, and to establish the racial types and ethnic groups which formed separate migration units.

A Balinese silversmith using a hammer and punch to emboss a design on a bowl. He is wearing batik skirts on which elaborate patterns are printed by a complicated wax and dyeing process.

—From "Netherlands Indies," December, 1936.

At this stage in Oceania's history it is well to consider the present day situation and the future of these various peoples. One, the Tasmanian, became extinct in 1879, and another, the pygmy Negrito, has continued to survive in small communities in the interior of some islands. In all, there are probably no more than fifteen or twenty thousand Negritos in the whole region. The Australian Aborigines have dwindled from about a quarter of a million to between fifty and sixty thousand full bloods. They are increasing in some localities and decreasing in others, and the proportion of hybrid or mixed to full bloods has been rising fairly rapidly. The Melanesians, of whom there are between two and three millions, have decreased sadly in some islands but a great deal is now being done by various governments, by Unesco and the South Pacific Commission, to improve their economic and social situation, their health, housing and education, to assist them to adapt themselves more ably to the changing commercial and political environment of to-day and to arrest depopulation causes. The Micronesians number about 100,000, and they too are being assisted in every way to fit into the new life imposed upon them during and since World War II. The Polynesians have adapted themselves well to modern conditions and their future seems assured. None of these people enjoys an economic life which could support a population like that of the Indonesians who number in the vicinity of eighty millions, and who, with self government, have become a modern nation with immense numbers in striking contrast to the populations of the other Oceanic peoples. There is an additional sixteen million Mongoloid people, like the Indonesians, in the Philippines.

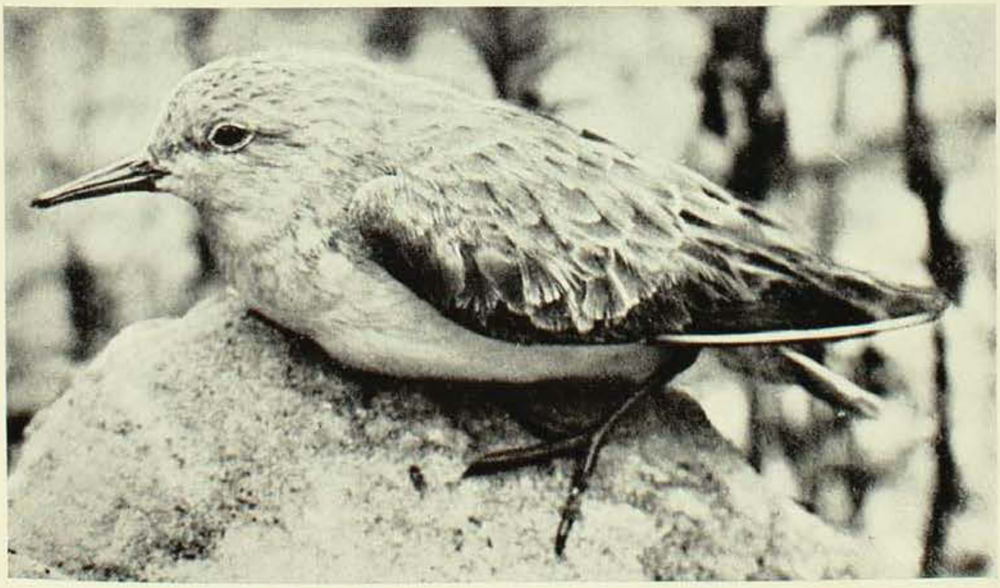
Black-faced Cuckoo-shrike. This Australian bird moves north during winter, some individuals reaching New Guinea, New Britain and other northern islands.
Photo.—Norman Chaffer.

Migration in Australian Birds

By ALLEN KEAST

BIRD migration has excited the imagination of man since earliest times. Our ancestors, like primitive people to-day, speculated about the seasonal comings and goings of the birds. They wondered at the restlessness that suddenly overcame the friendly storks and swallows, sent them dashing or spiralling into the air until, with the building up of the flocks, they disappeared. They must have felt melancholy when the northern woods became silent, a sure sign that autumn tints would shortly pass and the trees become stark and bare. But what happened to the birds; where did they go?

Only in modern times has a full insight into migration been gained and especially since the introduction of that remarkable idea, leg ringing. Every year in the Northern Hemisphere, by means of systematic trapping, millions of birds are banded. Only a small proportion is ever seen again—but it provides remarkable information as to the movements of the birds. Storks banded during the European summer have been recovered in South Africa. Arctic Terns, banded at their nesting colonies in the north Atlantic, have been found a few



The Little Stint breeds in Siberia and Alaska; migrates to Australasia.
Photo.—A. R. McGill.

months later in the south Atlantic. Yes, knowledge has come a long way since the days when people believed that swallows passed the winter at the bottom of ponds, cuckoos turned into hawks until the spring and that some birds wintered on the moon.

What is migration? Migration is one of the kinds of seasonal movement undertaken by animals. These journeys reach an extreme, both in extent and impressiveness, in birds. They are regular, occurring at the same time from year to year, typically follow the same route, and end in the same place. This point is emphasised to contrast it with the more common type of seasonal movement in Australian birds, irregular wanderings of no fixed duration or extent that serve to bring the individual to where conditions are best and food plentiful. To this the term nomadism can be applied.

Why do birds migrate? This is not precisely known but food is probably the major factor, with the obtaining of equable conditions for adult or young also important. The billions of birds that leave Europe, Canada, and the northern United States before winter must do so because the ground then becomes covered with snow and insects and seeds are no longer available. It is a case of get out or starve. Also, small birds rapidly freeze to death. But, one would imagine, the forest migrants of southern Australia are hardly likely to be imperilled by the relatively small drop in temperature occurring there. Is it food shortage that causes them to leave? Possibly, for there is no doubt that insects, berries, and nectar, are scarce in winter. One point should be noted, however. The Australian forest migrants are typically birds of tropical origin. This suggests that they may, in fact, dislike the winter temperatures of the south.

If migrants do leave at the same time from year to year what starts them off? There has been a great deal of research into this. The obvious answer, that the birds detect the first cold winds or find the food supply getting short, is apparently not the right one for many species leave not far past the peak of summer, well before climate and food have taken a turn for the worse. It has been experimentally shown that the stimulus is the gradual change in

The nesting colony of Gannets on Cat Island, Bass Strait. Most of those seen are young birds. It is not known where members of this particular colony go after the breeding season for no banding has been undertaken. First-year New Zealand birds, indistinguishable from those of Cat Island, have been known to move across to eastern Australia.

Photo.—A. Keast.

day-length of autumn and spring, a change that birds have a remarkable ability to detect. Each species apparently has a threshold day-length that acts as a trigger, all members of the population getting the migratory urge simultaneously. Moreover, this ensures that the group gets an early "go on" and the chance of it being "caught" by an early cold snap is reduced.

How fast do migrants travel, do they always follow the same route, and how do they find their way? Flight speed has been found to vary greatly for different species. Moreover, the movement from winter grounds to summer grounds, and *vice versa*, is usually not continuous, groups "resting up" for days or weeks on the way. H. Southern has found that the spread of the swallow over the main part of Europe is accomplished in seventy-nine days, at a steady rate averaging 25 miles per day. F. C. Lincoln records that the American Blackpoll Warbler, returning north in the spring, averages 30 to 35 miles per day from the Gulf of Mexico to Minnesota, then speeds up to some 200 miles per day over the last part of the journey from Minnesota to Alaska. The Canada Goose advances very slowly, keeping pace with the 35 deg. F. isotherm, taking two and a half months to travel the 1,300 to 1,400 miles from the Missouri to Hudson's Bay.

Migrants may advance on a broad front or concentrate along "flyway paths". How do they navigate? This is one of the most exciting aspects of all. As a result largely of the work of Gustav Kramer, whose laboratory in Wilhelmshaven I had the privilege of visiting last year, it is now known that birds have the ability to find their way by the sun. Since much migration is carried out at night it seems possible they can also navigate by the moon and stars. Much of the travelling, however, is known to be along physical features of the landscape—river valleys, mountain ranges, and the sea coast. Suffice it to say that to-day the more spectacular theories of navigation, such as the utilization of the earth's magnetic field, Coriolis force, and the like, have been discarded on technical grounds.

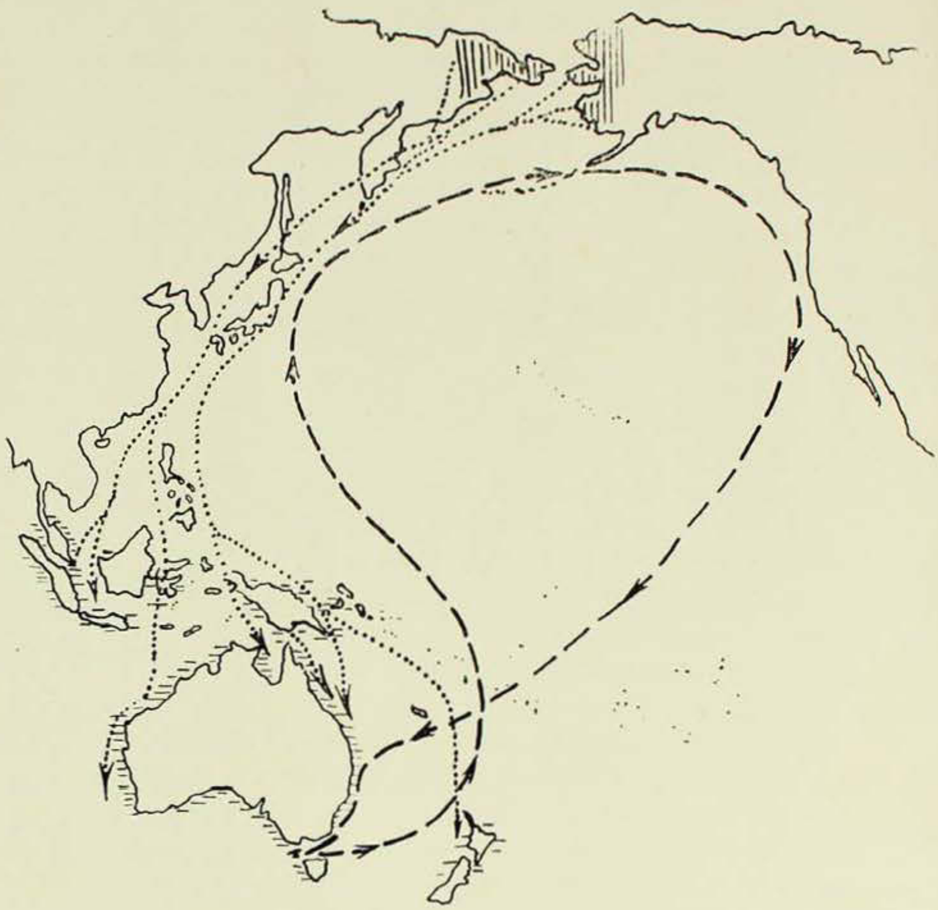
How much is known of migratory routes in Australia? As with speed of migration one can answer "virtually nothing". It may be noted, however, that most migrants are inhabitants of the rich coastal forests and, so far as the south and east are concerned, all they need do is follow the main mountain range or coastline north. Birds leaving the other well forested area, the south-west corner, also have a coastline stretching away to the north. Notwithstanding this, there is some evidence that shorebirds, Arctic-bound, may cross the centre of the Continent. Some nomadic species of the drier inland do have a northward movement at the end of summer. Their problem, however, is not to reach any particular place but to find country where the seasonal conditions are good. This must be a special problem in itself.

Types of Migration in Australian Birds.

Australia has just about every conceivable kind of migratory pattern. The main ones are:—

(1) *Inter-continental Migration.*—(a) *Visitors to Australia from the Northern Hemisphere.* Some thirty species of shore birds (plovers, sandpipers, dotterels, godwits) that breed in the tundras of Siberia and the Arctic Circle, come south to winter (*i.e.*, spend the Australian summer) in the estuaries and marshes of Australia and the islands of the south Pacific. In addition, two swifts and one cuckoo, the former breeding in caves off the coast of China and Japan, visit us during our summer.

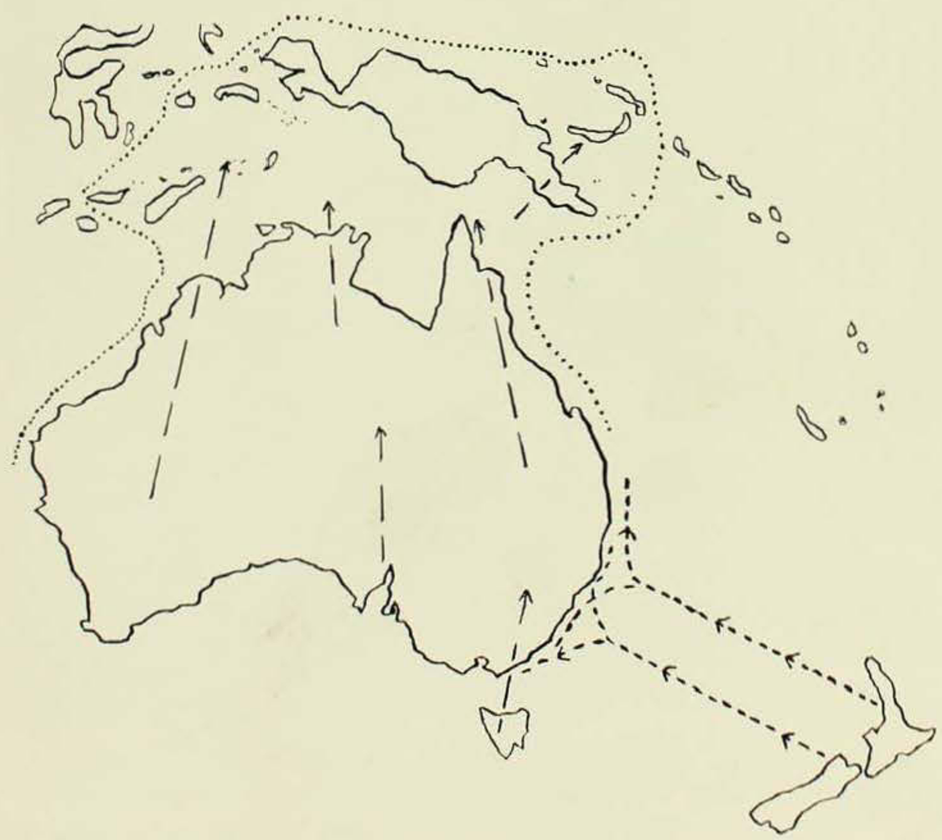
(b) *Australian visitors to the Northern Hemisphere.* There is apparently only one Australian species behaving in this way and that a sea bird, the Short-tailed Shearwater, or Muttonbird. This species, which breeds in millions on the Bass Strait islands, has been the subject of an intense study by Dr. D. L. Serventy, of C.S.I.R.O., for it is of economic importance, the canning of the young birds being a staple industry. The birds leave Australian waters towards the end of April and, as Dr. Serventy has noted, are numerous off Japan in June, Alaska in July, and British Columbia in August. In October muttonbirds appear



Map 1 (right).

Dashes show the "figure of eight" trans-Pacific migratory route of the muttonbird or Short-tailed Shearwater. It only breeds in one area—the islands of Bass Strait—but does so in countless millions.

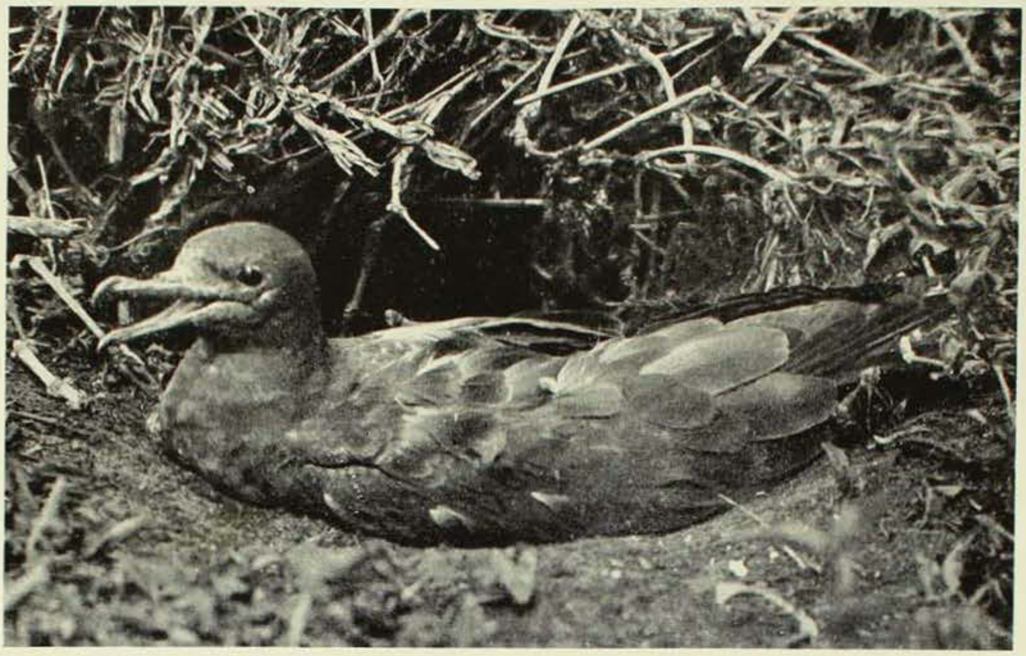
Dots indicate the general path of the Little Stint, a tiny wading bird (5 inches long) that breeds in eastern Siberia and western Alaska and spends the rest of the year (our summer) on the estuaries and mud-flats of Malaysia and Australasia.



Map 2 (left).

The east-west migratory route of the New Zealand Gannet, White-fronted Tern, etc., is shown by dashes. These birds breed in New Zealand and winter along our south-eastern and southern coasts. Dots suggest the manner of dispersal of the Black-faced Cuckoo-shrikes. Individuals from southern Australia being found in the north of the Continent and as far afield as New Britain, New Guinea and the islands to the north-west. As a complication, however, not all individuals migrate. A few are to be seen in Tasmania all winter, whilst along the Murray River and about Sydney they are not uncommon.

Although the extent of the migrations of the birds shown is well-known, the routes must not be taken too literally. They are probably as suggested but proof must await widespread leg-ringing.



Muttonbird or Shearwater. The Short-tailed Shearwater of Bass Strait, a chocolate-coloured bird about the size of a pigeon but with long powerful wings, has one of the longest migrations known. The bird shown in the picture is the Wedge-tailed Shearwater that breeds off the New South Wales coast. Only an expert, however, could distinguish the two kinds.

Photo.—A. Keast.

in vast numbers off Queensland. Thereafter, for weeks on end, they move south in a continuous stream, until the ancestral breeding grounds are reached once more. The migration, one of the longest known, is thus in the form of a giant "figure of eight" superimposed on the map of the Pacific.

Although the migratory route of the muttonbird has long been known in general terms Dr. Serventy, by banding thousands of young birds on the Bass Strait islands, has sought to prove it. After several years, however, the only banded birds seen had been in Australian waters. Quite recently press despatches announced that a banded bird had been caught by fishermen off Japan—a most exciting piece of news for it means that the first link in the chain of proof has now been forged.

(2) *Inter-island Migration*.—(a) *West-east Migration: New Zealand Birds that winter in Australia.* These are: Fluttering Shearwater, White-fronted Tern (sea birds), and the Double-banded Dotterel (shorebird). As a result of banding work carried out in New Zealand an addition may now be made to this group—the Gannet. In recent years young gannets, banded as chicks at the nesting colony, have occurred in numbers on the eastern coast of Australia.

(b) *Australian forest birds that winter in the islands to the north.* Some migrants in this group reach the Solomons, Bismarks, and the East Indies, whilst others extend no further afield than New Guinea. Examples are: Shining Starling, White-tailed Kingfisher, Sacred Kingfisher, Koel Cuckoo, Dollarbird, Rainbowbird and Pratincole. It should be noted that, in the case of most, not all individuals leave Australia, many wintering in the north.

It would be indeed interesting to know how the wintering ground varies with the area from which the migrant came, with the age of the individual, and so on.

(3) *Intra-continental Migration.*—This grades into category 2 (*b*). Included in it are many species which are partial migrants, *i.e.*, migrants in some areas only. In these cases it is typically the populations of Tasmania and the south-east that are the migrants, examples being: Rufous Whistler, White-throated Warbler. Again, the more southern populations of some of the large fruit pigeons (Wompoo, Topknot,

White-headed Pigeons) have a northward migration, and probably some of the little honey parrots fit into this category.

(4) *Altitudinal Migration*.—This involves a movement from mountain to lowlands. A few species behave this way in the east, notably the little Scarlet and Flame Robins.

(5) *Nomadism*.—It is not proposed at present to enter into a detailed discussion of nomadism in Australian birds beyond noting a few things about it. Firstly, in the case of many species it is "splitting hairs" somewhat to try to classify their movements as either nomadism or migration for they are really a combination of both. An example is the Crimson Chat, an inland bird that, in addition to being a nomad, has a definite north-south trend. Nomadism is very widespread in Australian birds and takes many different forms. This is obviously the result of the "peculiar" qualities of the Australian climate: large areas of uncertain rainfall, great tracts of desert that bloom at irregular intervals, and so on. In fact, Australia favours the development of nomadism just as the Northern Hemisphere, with its extreme winters, necessitates that most species be migrants. The Australian nomad moves to wherever conditions are best but, as they are frequently good at certain places at the same time each year, the bird movements may gain the semblance of regularity. Included in these are coastwise movements of many inland waterbirds at the end of summer, and the northward movement of certain small inland birds(*e.g.*, Chat) for the summer monsoon there ensures good autumn and winter conditions. Mention might also be made of "blossom nomadism", or the movements of many nectar-feeding birds in search of blossoming trees. There are many of these: honeyeaters, honey parrots, and some of the "sweet-toothed" wood swallows.

How Are We Learning about the Movements of Australian Birds?

The bulk of our knowledge of migration has been gained by the simple process of elimination, noting that when a species is absent from one area it is common in another. Observation can, however, provide only generalized information, especially since our birds move about somewhat surreptitiously and not in the great flights typical of the Northern Hemisphere.

A more exact knowledge has been obtained in the case of some species by taxonomies, the study of geographic variation in the colouring and dimensions of animals. Birds, like humans, vary in appearance from place to place, readily forming races. When I was in America recently I had the opportunity of working through the wonderful collections of Australian birds (by far the most comprehensive in the world) stored in the American Museum of Natural History, New York. In several species it was seen that individuals breeding in different areas varied in small, but quite recognisable, ways. This enabled birds collected during autumn and winter to be associated with their true home or, stated differently, the wintering grounds of the different populations were revealed.

The best example of this proved to be the Black-faced Cuckoo-shrike. Birds of this species breeding in Tasmania have conspicuously short bills, those from Melbourne longer ones, Sydney birds longer still, and so through to the north of the Continent. By this means it was found that Tasmanian birds wintered right up the coast and through to New Guinea and that, interspersed through them, were Melbourne, Sydney, and Brisbane inhabitants, and so on.

The third way of studying migration, and easily the best, is leg banding. Though only recently commenced in Australia this has already produced interesting results. But that is another story.

Bird migration in the Australian continent can best be seen in perspective by comparing it with that on other continents. If we exclude seabirds, shorebirds, and waterbirds and restrict ourselves to true land dwellers we find that there are some thirty species with fairly extensive migrations. To these might be added about fifteen partial migrants making a total of forty-five. However, to be on the safe side, perhaps we could add another twenty to thirty to represent nomads whose movements tend to be repetitive or to have a south-north direction. The breeding land birds of Australia are in the region of four hundred to four hundred and twenty species. That is to say, only about twenty per cent. of Australian birds are migrants. If we consult a modern book on European birds, such as that of Roger Tory Peterson, we find that there are some two hundred and thirty to two hundred and forty land birds out of which one hundred and thirty to one hundred and forty are partial or true migrants. That is to say, more than half the land birds are migrants.

Only a small proportion of Australian birds are migrants compared to those of Europe (and North America). The great migratory flights of the Northern Hemisphere are unknown to us. But our birds have evolved just as efficient a method of grappling with their environment—nomadism that leads them to where the countryside is greenest.

Nature's Contrasting Moods West of the Darling

By R. O. CHALMERS

AFTER good rain both the rate and extent of recovery of vegetation has always amazed visitors to the normally semi-arid West Darling District of New South Wales. The 1955 rainfall was among the highest ever recorded for this region. Broken Hill, Milparinka and Tibooburra had falls far in excess of their usual meagre averages. Usually the district, while it always has a fascination of its own, for the most part appears somewhat bare, with little cover excepting shrubs and trees. Last year the Museum party on the Morley Johnson Field Trip[1] had the good fortune to see the district in a condition described by many local residents as "the best within living memory". From the grazier's point of view the most important thing was the profuse growth of grasses to supplement the salt-bush as stock fodder. Salt-bush, that most important stand-by for stock in poorer times benefited too by the rains. However, it was the wonderful display of wild flowers that gave us our outstanding impression of the West Darling country. Each of us had our specialized tasks to perform but the frequent sight of large areas up to an acre in extent massed with brilliant red, blue and purple blooms will remain an indelible memory of the visit, even to such hardened creatures as geologists, zoologists and anthropologists.

No full census of all species seen could possibly be given and what follows is a sketchy record of the most notable. Probably the most striking example was the blue flowering plant introduced from the Mediterranean region to the Albury district about 1880 by a thoughtless gentleman named Paterson. In southern districts this has so relentlessly choked out large tracts of pasture land that it is called Paterson's Curse and is often declared a noxious weed. It is not harmful to stock and when young is a fodder. It seems as though its nature may be more benign in the West because there they call it Salvation Jane. We saw some magnificent colour combinations of this and the brilliant red fruited dock (*Rumex vesicarius* L.) a naturalized Mediterranean native that has appeared in the Broken Hill district only in recent years. Both of these plants were much bigger than usual, standing three to four feet high. Near Rockwell a dense carpet of these red and blue blooms extended for hundreds of feet. Another extensive display of dark, brilliant red dock was seen clothing hills and paddocks a little to the south of Euriowie on the Tibooburra road. Both plants were commonly seen in extensive

[1] Chalmers, R. O. This MAGAZINE, xii (1) 1956, p. 3.

Poole's Grave.

Photo.—R. D. Mackay.

patches between Wilcannia and Broken Hill, and in the Broken Hill district generally. A third showy Mediterranean invader was the purple Gilgai or Broughton Pea (*Swainsonia procumbens* F. Muell.) which is poisonous to stock and which probably accounted for a number of bloated sheep carcases we saw. Massed displays of Gilgai Pea were seen but not so frequently as Dock and Salvation Jane.

The pride of the west, Sturt's Desert Pea, was not so common but none the less was seen in its splendour in a number of places, notably on the way from Dolo to Mootwingee and near Huonville station.

It is interesting to note that Sturt, in 1844, mentioned having seen the desert pea near Mt. Gipps, to the north of Broken Hill. This confirms one's impressions that by far the most extreme drought conditions were encountered by him not in the Broken Hill district, despite popular belief, but much further north, although in his journal he does state that it was growing amongst "barrenness and decay". It is regrettable that according to the strict rules of scientific nomenclature its name has been changed from *Clianthus Dampieri* to *Clianthus formosus*. It was one of the first plants ever to come from the Australian mainland, having been collected by Dampier in 1699. His specimens are still in existence. Cassias in bloom were also abundant, particularly in the fenced-in regeneration areas surrounding Broken Hill. Of the many species of Acacia seen in the whole north-west of the State only one group of large Mulga-like trees (species unknown) was seen in bloom, on the way from Broken Hill to Huonville.

As our party went northward from Broken Hill towards Tibooburra, the general condition of pastures, shrubs and trees was still excellent but massed displays of wild flowers were absent. We journeyed from Mootwingee to Fowler's Gap, passing through Turlta and Marapinna. Near Marapinna there were a number of sizeable sand-ridges thickly covered with vegetation, including native pines. Sturt, in 1844, described similar pine covered ridges near Flood's Creek, to the north-west of Fowler's Gap. Travelling north towards

The same scene on Onepar Road, 20 miles north of Tibooburra, in 1945 and 1955, showing the difference which good rains make in the vegetation. The cracked, rounded objects are calcareous concretions.

Photo.—H. O. Fletcher.

Photo.—O. le M. Knight.

Milparinka one's mind turned very often towards Sturt and his party whose path in 1844 lay not very far to the west of the present Broken Hill-Tibooburra road.

A short trip was made eight miles to the north-west of Milparinka to see Sturt's Depot Glen, which lay on Preservation Creek about a quarter of a mile east of the present day Mount Poole station. Here Sturt's party was forced to spend six months in 1845 because of pitiless heat and lack of water on all sides, excepting for this life-giving creek with its fringe of river red gums. This is where Sturt made his well-known observations about human hair and sheep's wool ceasing to grow, the horn handles of instruments splitting into fine laminae, and the lead dropping out of their pencils due to the mean temperature not having fallen below 101 degrees for three months. Despite all this it is clear that the greatest burden the party bore was that the three leaders were stricken with scurvy. An interesting fact is that the rest of the party was not attacked. Sturt had taken a flock of 200 sheep with him to supply fresh meat and the men ate mainly this, which would supply a sufficiency of vitamin C. The leaders, however, were away from their depots so much on reconnaissance trips, even during the enforced six months' delay, that they fed mainly on bacon. Poole, the second in charge, was worst affected, and a dug-out was made near the bank to offer him protection, first from the heat and then from cold and rain as July approached. The onset of rain gave Sturt the opportunity to send Poole back with a south-bound party while he, with the remaining men, intended to strike north-west in quest of the long imagined inland sea. Poole, however, died when the party was barely under way and was buried beneath a beefwood tree close to the dug-out. The tree is still alive and bears clearly the mark "J.P. 1845". A monument was erected alongside the tree in later years. It was impressive to stand on this historic spot. Three and a half miles away Mount Poole itself could be seen with the 18 feet high cairn on top, erected by the party during their long wait at Depot Glen. Sturt wrote in his journal: "I little thought when I was engaged in that work that I was erecting Mr. Poole's monument, but so it was; that rude structure looks over his lonely grave and will stand for ages as a record of all we suffered in the dreary region to which we were so long confined."

Impressed by the pleasant surroundings of Depot Glen we were nevertheless reminded that Sturt, after Poole had died, pushed on north-west for another 400 miles, finally returning after having crossed Sturt's Stony Desert and having entered the eastern fringe of what is now known as the Simpson Desert.

Notes and News

New Glow-worm Record.

In February this year a member of the Museum staff (D. K. McAlpine) was camping at Mount Royal in the Upper Hunter District of New South Wales. Specimens of a luminous insect were found and collected on several nights and by torch light were seen to be the larvae of a beetle. None of these could be bred to the adult stage but some were preserved in spirit.

The luminous insects previously known from Australia are of two types: Fire-flies, which are adult beetles of the family Lampyridae (which also includes non-luminous species), and Glow-worms, which are larvae of certain members of the Fungus Gnat family (Mycetophilidae), most notably those of *Arachnocampa*, which is unknown outside Australasia. The caves at Bundanoon, New South Wales, and Waitomo Caves in New Zealand, are famous for the displays produced by large colonies of these glow-worms.

The well known glow-worms of Europe and other regions are the grub-like, wingless, mature females of lampyrid beetles and sometimes also their larvae. It is to this last category that the recently found specimens belong. It is interesting that two of these were found feeding on snails as recorded for the larval European glow-worm.

The "new" glow-worm resembles the European glow-worm in its broad flattened body and well developed legs. The colour is dark brown. By contrast the Gnat-larvae glow-worm is a slender, whitish, legless maggot producing much less light. The beetle larvae were found on grass in moist, leech-infested mountain forest at an elevation of over 3,000 feet. The Gnat larvae are found only in sheltered caves or under ledges on creek banks.

Studying Crustacea.

Miss Joan Steinberg, a science graduate of the University of California, has worked in the Crustacea Department and in the Museum Library since she came to Sydney as a Fulbright scholar. Miss Steinberg's principal interest lies in crustacea belonging to the family Caprellidae, of which the Museum has an extensive collection, but she has also had discussions with the conchologists concerning Opisthobranchia.

First Eggs of the Ribbon-tailed Bird of Paradise.

Thanks to the generosity of Sir Edward Hallstrom, President of Taronga Zoological Park Trust, the Australian Museum recently obtained two eggs of the Ribbon-tailed Bird of Paradise, the first known to science. The bird itself was only discovered in 1938—by Messrs. J. L. Taylor and J. R. Black, patrol officers, when pushing into the then unknown Mount Hagen area of central New Guinea. Three skins were obtained and presented to the Museum by the Administrator of New Guinea, Sir Walter McNicoll.

The ribbon-tail is one of the world's most remarkable birds. It is about the size of a pigeon, a symphony in iridescent greens and purples, and with a remarkable long, predominantly white tail which is some four times the length of the bird. One can imagine the excitement of the patrol officers when they encountered the bird in dense mountain forests some 8,000 feet above sea level. They noted that its call-note was a clicking or hammering sound something like a pneumatic riveter at work. The bird was, as would be expected, much impeded by its tail and the flight was slow and jerky, the bird never flying more than a short distance.

With the passage of time the Mount Hagen area became much better known (even opened up to the extent that a sheep farm has been established by the Sydney philanthropist, Sir Edward Hallstrom, for the benefit of the natives in the fertile Wahgi Valley) and many museums now have specimens of the Ribbon-tailed Bird of Paradise. The nest of the bird has never been found but quite an event occurred recently in the Taronga Park Bird of Paradise avaries—one of the captive ribbon-tails laid a couple of eggs, so that at long last it is known what the bird's eggs are like and another of nature's secrets is revealed.

Because of the great interest of these eggs the Australian Museum has arranged a special exhibit in the front hall. This shows the newly discovered eggs, a study skin such as those made when a bird is shot in the field, and a copy of the scientific paper (that of Mr. J. R. Kinghorn in 1939) containing the original scientific description of the new species.

Remarkable Fishes from New South Wales.

The State of New South Wales is generally considered to be well known ichthyologically, yet the early months of this year ushered into the Australian Museum several kinds of fishes which have not hitherto been noticed from this State. Some of them were quite big fish, too. Thus the trawlers obtained not far from Sydney an Oil Fish (*Ruvettus tydemani*), 4 ft. 4½ in long, weighing 35 lb., and by no means fully grown. This fish is well known over a wide Polynesian range and was dealt with in detail in this Magazine (Vol. ix, No. 8, Sept. 1948, p. 256).

Mr. George Guy caught and presented a fine Morwong, 30 in. long and 15½ lb. in weight, from Moruya, South Coast, belonging to a coldwater species known in Western Australia as Queenfish (*Nemadactylus valenciennesi*); this was a record for size as well as locality.

Messrs. J. C. Woore and E. Bolton continued to bring in any strange fishes which appeared in the Sydney Fish Markets and so we received a Lizard Fish (*Newtonscottia houlti*) from the New South Wales coastline. Previously this species was known only from Queensland, Lord Howe Island and Elizabeth Reef. This, too, although only 10 inches long, was of record size for its kind.

When three such interesting fishes appear on one's doorstep, as it were, in a month or two, one wonders if all the fishes of Australia will ever be fully understood.

Cave Paintings Reproduced.

Mrs. Agnes Schultze, an artist from the Frobenius Institute, Frankfort-am-Main, Germany, spent a week in Sydney recently. The Institute has built up a reference library of full-size copies of cave paintings, and rubbings of rock engravings, together with photographs, from sites in Europe, Africa and Asia, to the comparative study of which its founder, Dr. Frobenius, devoted much of his time.

During 1938 and 1939 some of the Institute's staff studied the cave paintings of the Kimberleys, and during the past year Mrs. Schultze and others have been painting reproductions of the remarkable Wandjina and other cave paintings in this area for the Institute. A well illustrated paper by Mrs. Schultze on these paintings was published recently in *Memoirs of the National Museum of Victoria*. Mrs. Schultze also worked at Oenpelli, in western Arnhem Land, making copies of the unusual X-ray and other cave paintings of that area. While in Sydney she traced some of the rock engravings nearby, and studied aboriginal art designs on specimens in the Museum's collection.

Research on Muscle Tissues.

Professor A. H. Ennor, Department of Biochemistry, National University, Canberra, visited Sydney early this year in company with Dr. J. F. Morrison and Mr. D. Griffiths, a visiting research chemist from Wales. Trips were made to various points of the local coastline under the expert guidance of Miss E. Pope, Assistant Curator of the Museum's Department of Invertebrates. The object was to secure special bulk material of certain inter-tidal marine invertebrates which, after being frozen and stored, would be the basis of research on the chemistry of muscle tissues.