# The AUSTRALIAN MUSEUM MAGAZINE

VOL. XIII, No. 2 Price—TWO SHILLINGS.

The 9 ft.-long jaws of *Kronosaurus queenslandicus*, a sea reptile which lived about 130 million years ago, dwarf Miss Nelda Wright, research assistant at the Museum of Comparative Zoology, Harvard University, U.S.A. These jaws are part of a *Kronosaurus* skeleton which was found in north Queensland in 1931 and sent to Harvard. (See Article on page 47.)

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# THE AUSTRALIAN MUSEUM

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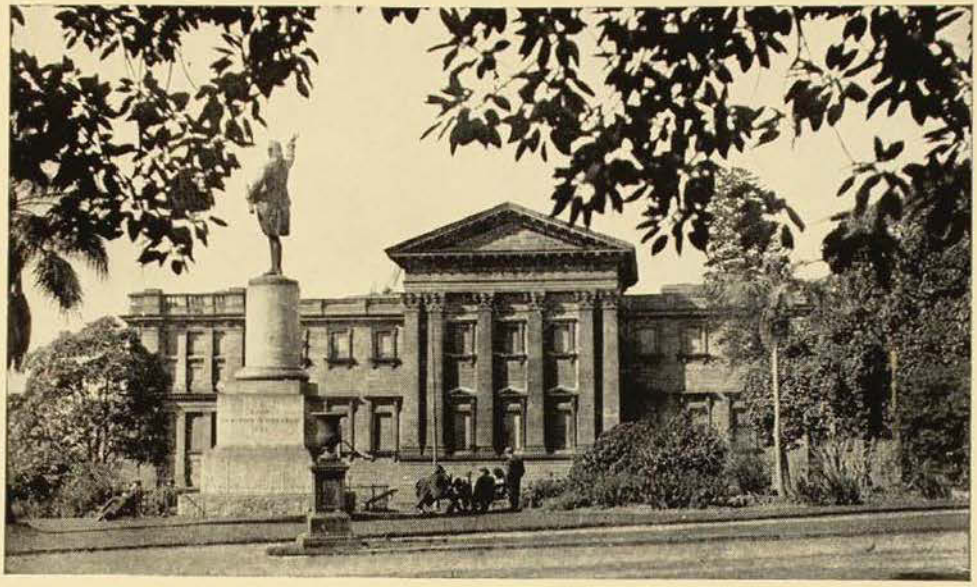

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OUR FRONT COVER: This photo was supplied by the Harvard University (U.S.A.) News Office for the article "A Giant Marine Reptile From the Cretaceous Rocks of Queensland," by H. O. Fletcher, on Page 47. The skeleton of *Kronosaurus queenslandicus* is displayed in a room of its own at Harvard, posed against a sea-blue background.

VOLUME XIII, NUMBER 2. JUNE 15, 1959

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

Editor: J. W. Evans, Sc.D. Annual Subscription, Posted, 9/-

VOL. XIII, No. 2 JUNE 15, 1959


# *SEA-SNAKES*

By HAROLD G. COGGER

SEA-SNAKES are a highly-specialised group of reptiles found throughout the tropical and sub-tropical waters of the Indo-Pacific region, including Australia. They are venomous, the venom of most forms being extremely potent, and a few species are deadly to humans. Observations have indicated that, on a drop-for-drop basis, the venoms of many sea-snakes are among the deadliest known.

Fortunately, for humans, however, most sea-snakes have relatively short fangs, and their biting mechanism is not as efficient as that of many of the larger-fanged land snakes, the venoms of which may be much less potent.

Nevertheless, many deaths from sea-snakes' bites have been recorded, particularly of native fishermen in the Indo-Malayan Archipelago, where medical treatment is seldom available. No deaths have been recorded in Australia, though some of the species in our waters are capable of inflicting a fatal bite.

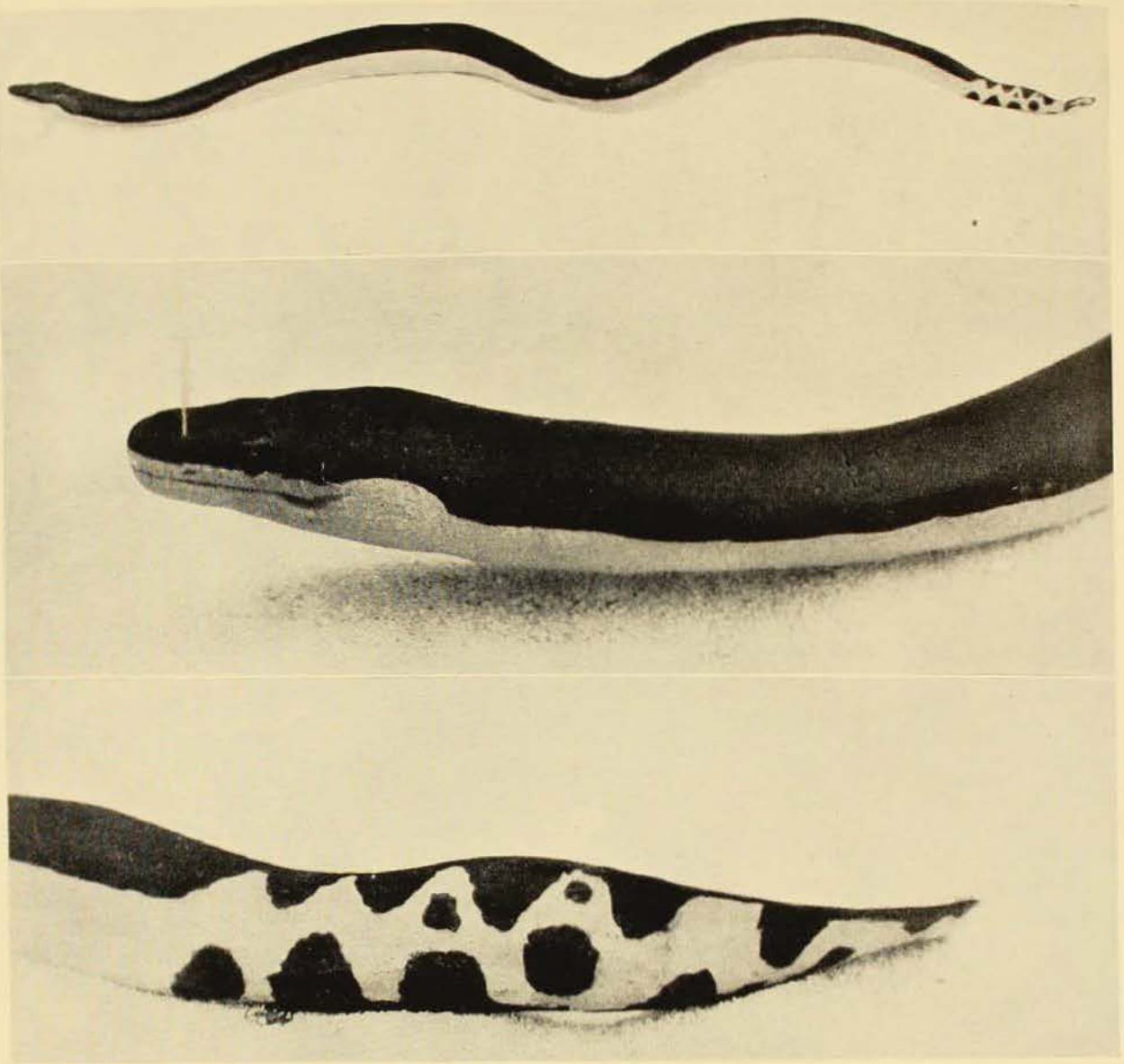
Sea-snakes are perhaps the least known of all the families of snakes, for, with few exceptions, they are difficult to obtain and, because of the nature of their environment, observations on their habits are generally restricted to brief glimpses.

There is little doubt that the sea-snakes (Family Hydrophiidae) arose fairly late in reptilian evolution, and that they were derived from a venomous terrestrial form. Various features have been modified to enable these snakes to survive the vastly different conditions of an aquatic life, and these adaptations to their environment are evident in nearly every aspect of the biology of sea-snakes.

**Valved Nostrils**

As in the case of their land-dwelling cousins, sea-snakes breathe atmospheric oxygen, and therefore must return to the surface periodically to replenish their air supply. The nostrils are situated on the top of the head and are equipped with valves in the form of small flaps of skin. Once the snake has taken a breath the valves close and the reptile can thus submerge without any chance of water entering the respiratory passages. Sea-snakes are probably able to remain beneath the surface for up to an hour or more.

Another feature which aids in keeping water out is the complete closure of the mouth. Terrestrial snakes have a small opening at the tip of the upper jaw through which the tongue is protruded. Most sea-snakes, however, lack this opening, and a scale on the tip of the snout fits into a notch



The Yellow-bellied Sea-snake (*Pelamis platurus*), the most common species off the New South Wales coast. The upper half of its body is black, the lower bright yellow. Like most other sea-snakes, it has a paddle-shaped tail, which aids in swimming. The bite of this species can be fatal to humans.

Photo.—Author.

in the lower jaw, helping to keep the mouth rigidly closed. Those forms which retain an opening for the tongue can close it with a small flap of skin.

Most sea-snakes have the tail flattened into the form of a paddle, which greatly assists in swimming. As a further aid to swimming, the body itself is often flattened. The swimming movement consists of a series of horizontal undulations passing from the front to the rear of the body, and is quite different to the locomotion of terrestrial snakes. In the latter, the ribs are principally involved in movement and are attached by muscles to the broad belly shields. These shields, together with the outward curves of the snake's body, move the snake forward by pushing against irregularities in the surface of the ground. For this reason most land snakes, when on a very smooth surface, make little progress and are more or less unable to control the direction of their movement.

As most sea-snakes rarely come on to land their belly shields are little used in locomotion and are therefore greatly reduced in size. Exceptions to this are some members of the genus *Laticauda*, which are often found on land as well as in the sea, and which are efficient climbers.

Nearly all sea-snakes feed on fish; some species feed exclusively on eels. It has been recorded that when fishes with sharp spines are eaten the spines actually pass out of the sea-snake's body through the intestinal and body walls. Specimens have been seen with the spines protruding from the body walls. In such cases the spines seem to cause no inconvenience to the sea-snakes.

The extreme potency of the venom of most forms of sea-snakes is probably the result of the need to kill quickly and efficiently such active prey as fish. In experiments with pigeons, Rogers found that the venom of one species of *Enhydrina* is up to 10 times more potent than that of the cobra.

**Sea-snakes Found On Beaches**

Views differ as to the temperament of sea-snakes. Some people contend that they will attack only under extreme provocation, but others maintain that they are extremely savage. Of the few seen by the author most have supported the first contention, and it is most unlikely that a sea-snake would attack a bather unless provoked.

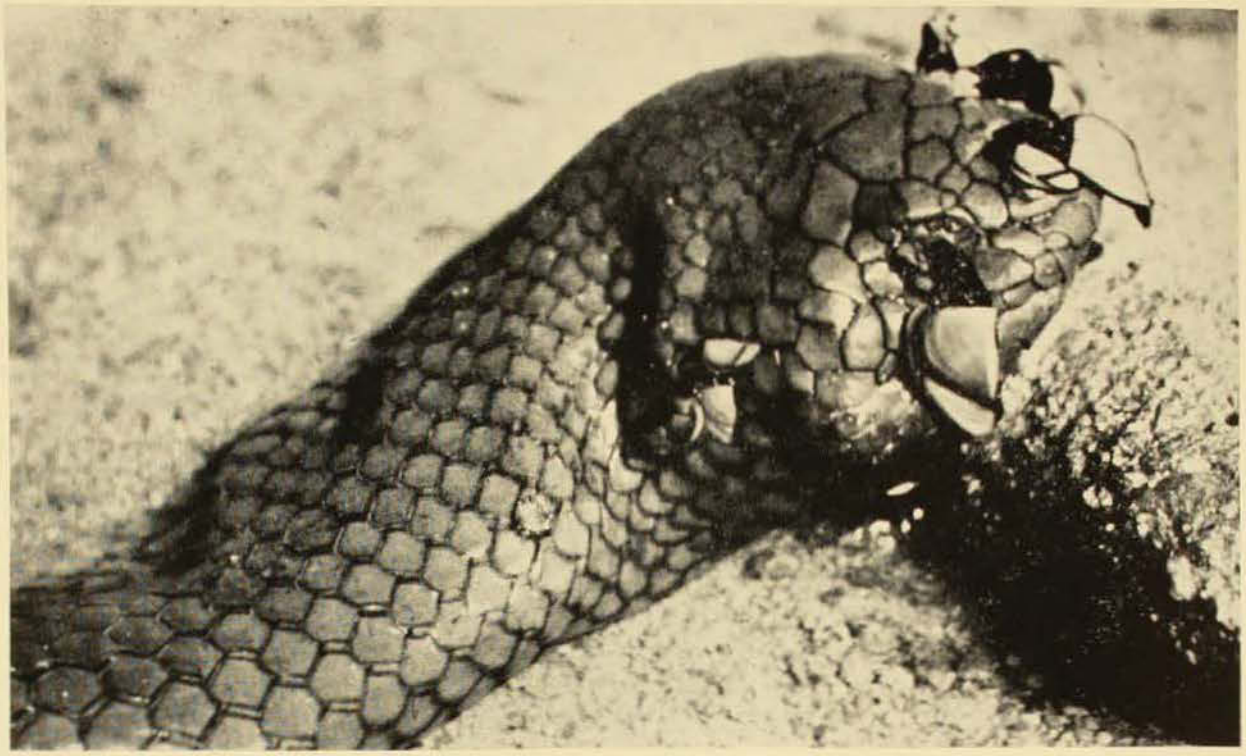
Every year on Sydney's coastline a number of sea-snakes are found alive, but in a weakened condition, high up on the beach out of reach of the surf. Such specimens are usually suffering from exhaustion after being battered by heavy seas caused by violent storms off the coast.

By far the commonest species off the New South Wales coast is the yellow-bellied sea-snake (*Pelamis platurus*), a form which is black on the upper half of the body and bright yellow on the lower, the two colours meeting along the side of the body without any intergradation. This species has been known to inflict a fatal bite, and specimens washed up on our beaches are usually reported to attack viciously when challenged. Whether these specimens occur along the New South Wales coast during the whole of the year, or whether they merely stray down with occasional warm currents, is uncertain. They are usually observed between June and October, when our waters are coldest. It would seem strange that so many would be observed if they had strayed into these cold waters by accident. Also, if they were warm-water migrants we would expect that more would be seen when the tropical currents reach our shores about February-March.

Altogether, the evidence suggests that there are a number of species of sea-snakes which are permanent inhabitants of the waters of New South Wales. Records from Victoria and Tasmania, however, probably result

The Banded Sea-snake (*Laticauda colubrina*) has blue-black and cream or white bands. Members of the genus *Laticauda* spend part of their lives on land.

Photo.—Author. (By courtesy Taronga Zoological Park Trust.)



Sea-snakes are sometimes covered with barnacles and other marine life. Goose barnacles are growing over the eyes of this specimen (*Aipysurus laevis*), and were probably the cause of its weakened condition when it was caught on a line on the Great Barrier Reef, Queensland.

Photo.—Author.

from wandering individuals rather than a permanent population.

In northern waters sea-snakes are observed the year round, and the variety of species found is far greater with decreasing latitude.

It is not known whether sea-snakes are most active at night or during daylight. In all probability they differ from species to species in this respect. Most will take a baited line freely, and catches have been made in this way both during the day and at night.

**Breeding**

Apart from one or two species which come on to land to lay eggs, most sea-snakes are ovoviviparous—that is, they produce living young, which may vary in number up to 20 or more. Whether there is a definite breeding season is not known with certainty. Malcolm Smith states ". . . in the Gulf of Siam the majority of species produce their young during March or April." Specimens of the yellow-bellied sea-snake with fully-developed young in their oviducts have been washed up on Sydney beaches in June and July, so it would seem that the young of this species are born in mid-winter.

Little is known about the specific breeding habits of sea-snakes. Those forms which remain in the immediate vicinity of land, frequenting certain bays and inlets, probably mate by single individuals seeking each other out. On the other hand, a number of species travel considerable distances in the open sea, and our only clue to the breeding of these forms is that given by the observations of a few people who have seen large numbers of sea-snakes from ocean-going vessels.

For example, W. P. Lowe, in his book "The Trail That Is Always New", writes of an experience he had while on a ship between Sumatra and the Malay Peninsula in the month of May. Coming on deck after lunch, he ". . . saw a long line running parallel with our course. None of us could imagine what it could be. It must have been four or five miles off. We smoked and chatted, had a siesta and went down to tea. On returning to the deck we still saw the

curious line along which we had been steaming for four hours, but now it lay across our course, and we were still very curious as to what it was. As we drew nearer we were amazed to find that it was composed of a solid mass of sea snakes, twisted thickly together. They were orange-red and black, a very rare and poisonous variety known as *Astrotia stokesii*. Some were paler in colour and as thick as one's wrist, but the most conspicuous were as thick as a man's leg above the knee. Along this line there must have been millions; when I say millions I consider it no exaggeration, for the line was quite ten feet wide and we followed its course for some sixty miles. I can only assume it was either a migration or the breeding season. . . . It certainly was a magnificent sight. As the ship cut the line in two, we still watched the extending file of foam and snakes until it was eventually lost to sight."

Whether some sea-snakes have a mass migration accompanied by a mass breeding, as do the eels, we do not know, but such observations as those of W. P. Lowe raise some interesting speculation.

**Natives Eat Sea-snakes**

Sea-snakes are preyed on by a number of big fishes, especially sharks, while in coastal waters they are taken by the larger birds of prey. They are a not infrequent item in the diets of many natives in Asia and the Pacific Islands.

It is not uncommon to find sea-snakes covered with barnacles and other marine life. It has been suggested by some authors that the encrusting barnacles serve to camouflage the snake, and thus prove advantageous. However, the specimen shown in the accompanying photo (*Aipysurus laevis*), which was caught on a line off Heron Island on the Great Barrier Reef, was in a weakened condition, due, almost undoubtedly, to the goose barnacles which grew over its body and actually covered its eyes, greatly reducing its hunting capacity.

As with land-dwelling snakes, sea-snakes shed their skin at intervals which may vary from a few weeks to a year, but unlike the former, which generally shed their skin as a whole, sea-snakes lose theirs piecemeal, so that it can be seen hanging in long shreds from their bodies. When sloughing occurs, any attached organisms, such as barnacles, are usually cast off at the same time.

Sea-snakes are often confused with eels by the casual observer, but closer examination will reveal that eels have smooth skin and pectoral and dorsal fins, whereas sea-snakes have scaly skin and no fins.

Few species of sea-snakes reach a length of more than about 4 ft. The largest known from Australian waters is *Hydrophis elegans*, which grows to about 6 ft. 6 in. and which is frequently found as far south as Sydney.

Twenty-one species, belonging to 12 genera, have been recorded from the Australian region, while other forms undoubtedly stray occasionally into this area.

It is evident that our knowledge of the biology of these interesting animals is scanty. Few of the many sea-snakes which are washed up on our shores ever find their way to a scientific institution, and it is requested that, wherever possible, any specimens found be forwarded to the Australian Museum, Sydney, for further study.

## *LECTURES AT THE MUSEUM*

The Australian Museum's 1959 Popular Science Lecture Series, which began in May, will continue until October. Lectures yet to be given are:—

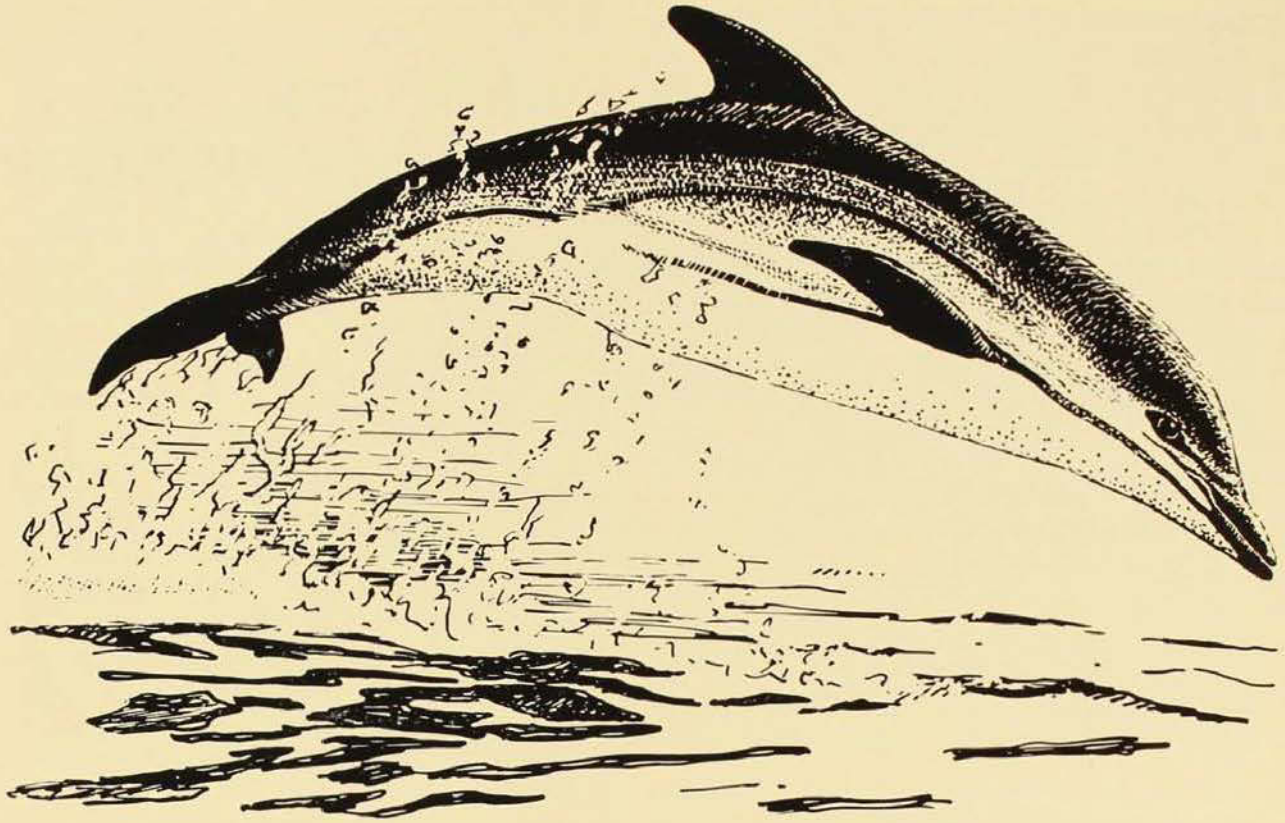
July 15: "The Australian Continent and its Importance in Evolutionary Studies", by J. A. Keast, Ph.D.

August 12: "National Parks and Faunal Reserves in New South Wales", by A. Strom, A.S.T.C.

September 9: "The Evolution and Adaptive Radiation of Marsupials", by B. J. Marlow, B.Sc.

October 14: "Man's Expanding Universe", by Harley Wood, M.Sc., F.R.A.S.

The lectures will be given at 8 p.m. in the Hallstrom Lecture Theatre. Admission is free.



Dolphins are often seen in Australian waters swimming in an undulating manner at the surface or "playing" about the bows of ships. Above is a Common Dolphin leaping out of the water.

# *Dolphins and Porpoises*

**By B. J. MARLOW**

**Illustrated by B. P. Bertram**

DOLPHINS and porpoises are members of the order Cetacea, which also includes the whales. Though their hairless skins, torpedo-shaped bodies and absence of hind limbs give them a superficial resemblance to fishes, they are in fact true mammals which bear their young alive and suckle them on milk.

Furthermore, unlike fishes, they are warm-blooded and breathe atmospheric air. They also have the muscular diaphragm between the thorax and abdomen and the four-chambered heart which are characteristic of mammals. The hairy covering typical of most mammals is represented only by a few scattered bristles on the chin of certain species of whales, either in the adult or foetal stages.

Cetaceans fall naturally into two main groups—the whalebone or baleen whales, which have teeth only while embryos and which feed by filtering plankton through the whalebone sieves in their mouths, and the toothed whales, which have teeth in the adult stage and are active carnivores, feeding on fish and squid. It is to this latter group that the dolphins and porpoises belong.

The cetaceans most familiar to Australians are the dolphins (Delphinidae), which are often seen swimming in an undulating manner at the surface of the sea or "playing" alongside the bows of ships.

True porpoises (*Phocaena phocaena*) do not occur in Australian waters. The smaller

cetaceans here, which are often called porpoises, are actually dolphins.

Porpoises are divided into two genera—the true porpoise (*Phocaena*), which has a low, triangular dorsal fin, and the finless porpoise (*Neophocaena*), in which the dorsal fin is absent. True porpoises, which are about 6 ft. 6 in. long, occur mainly in the north Atlantic Ocean, but related species are found around the coasts of South America, Alaska and Japan. The finless porpoise (*Neophocaens phocanoides*) occurs in the Indian Ocean and west Pacific.

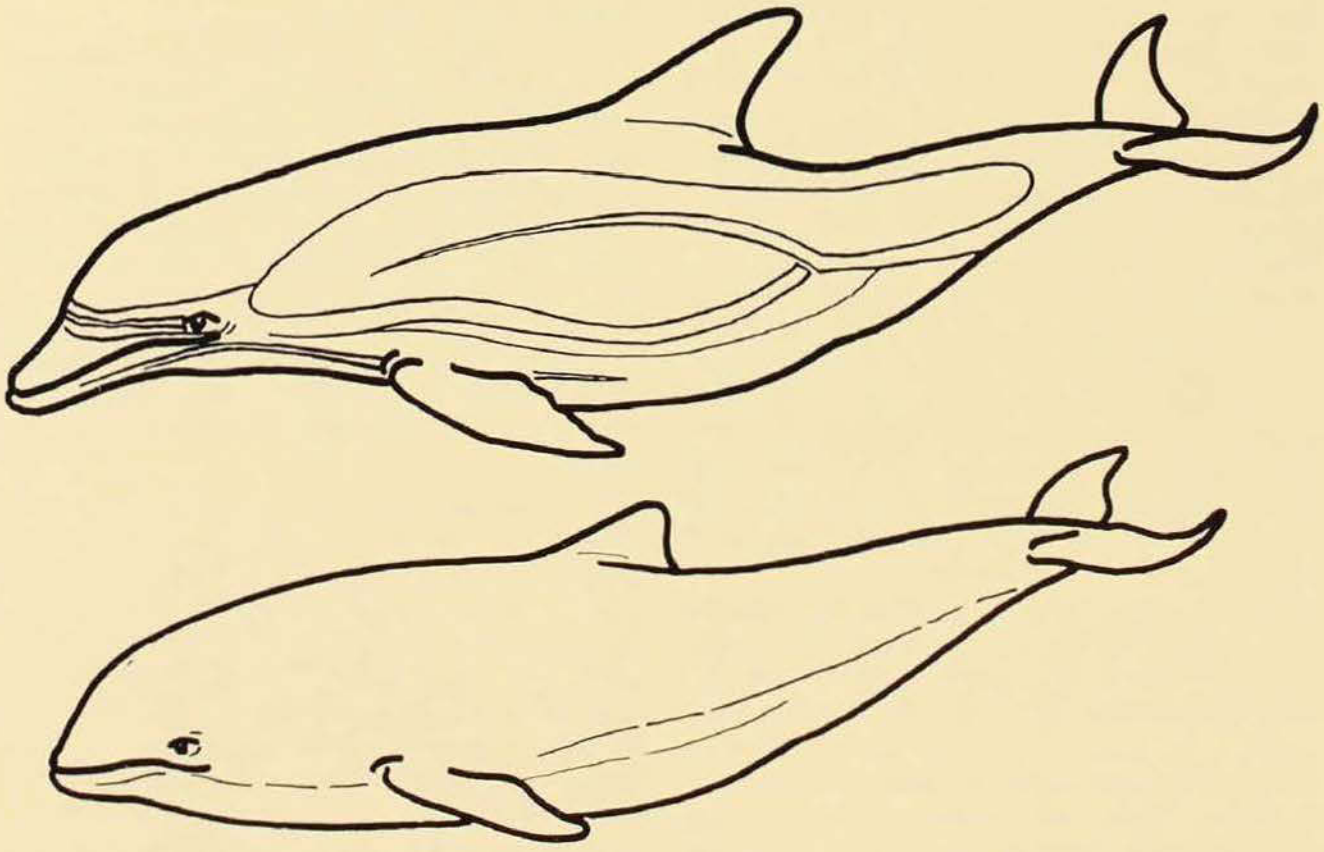
Dolphins are distinguished from porpoises by their beak-shaped snouts and conical teeth. Porpoises have spade-shaped teeth.

Among the many genera and species of dolphins the following forms are the most noteworthy:—

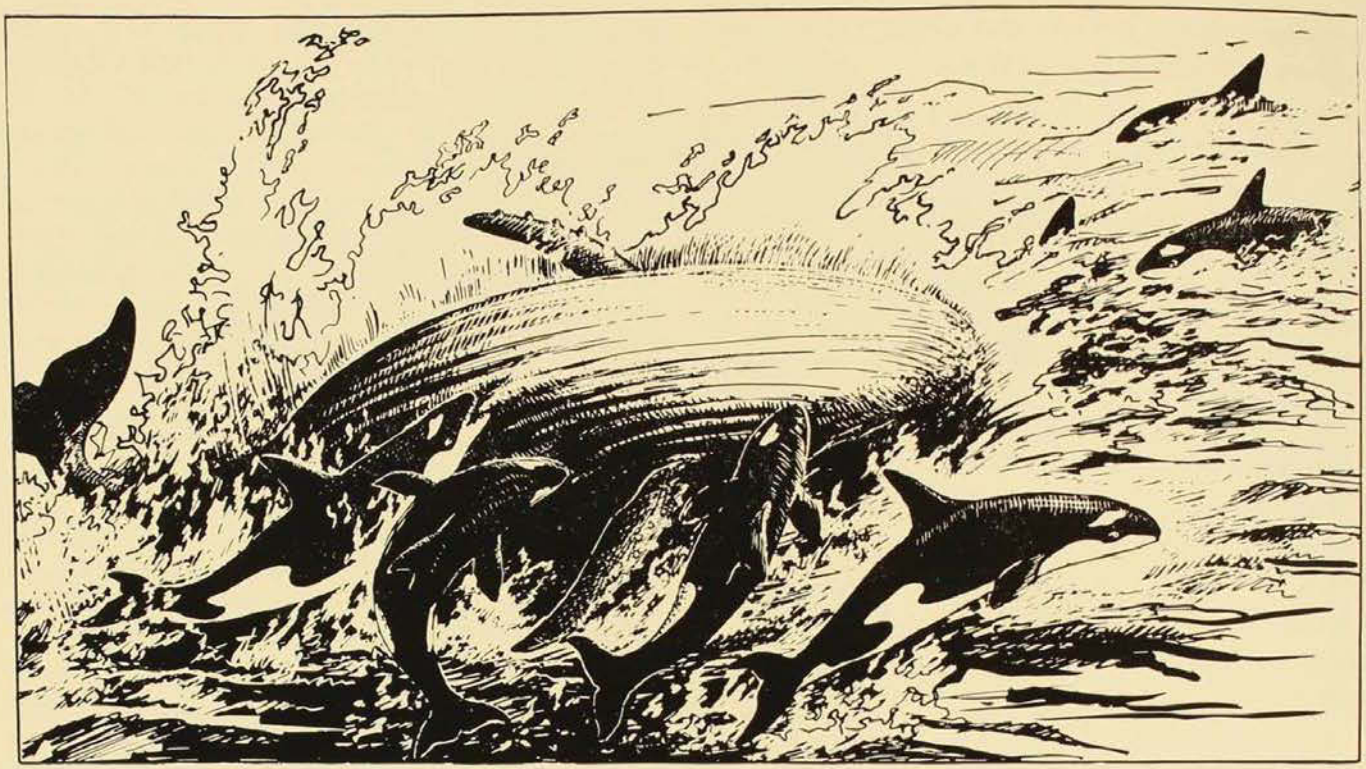
The common dolphin (*Delphinus delphis*), which can grow up to 8 ft. long, is widely distributed in most oceans and may be distinguished by its high curved dorsal fin; long-snouted dolphins, about 6 ft. 6 in. long, from the Atlantic and Indian Oceans; rough-toothed dolphins, up to 10 ft. in length, which are confined to the cold northern oceans; Commerson's dolphin, about 4 ft. 6 in. long, one of the smallest species, which occurs in the south Atlantic and Pacific Oceans, and the right whale dolphins, strikingly marked with black and white, which are found in the north Pacific and which are so named because, like the true right whales, they lack a dorsal fin.

**The Killer Whale**

The largest species of dolphin is the killer whale (*Orcinus orca*), which grows up to 30 ft. long. This mammal swims in schools of up to 50 individuals, and is found in all oceans. It is a voracious carnivore, and, besides feeding on fish, will also eat seals and other whales. One specimen examined was reported to contain 14 dolphins and 14 seals. It is black and white in colour, and the males, which are larger than the females,



Dolphins are often miscalled porpoises, which do not occur in Australian waters. This picture shows some of the differences between the dolphin (above) and the porpoise (below). The dolphin has a beak-shaped snout and high curved dorsal fin, compared with the porpoise's rounded snout and low triangular dorsal fin.



Killer Whales attacking a Hump-backed Whale. Killer Whales are the largest of the dolphins, and may reach a length of 30 ft. Found in schools of up to 50 in all oceans, they feed on other cetaceans, seals and fish.

may be recognised by their high, curved dorsal fins. Each half of each jaw contains about 12 conical teeth, every one of which is about 2 in. wide.

Two species of dolphin which diverge from the normal type are the white whale or beluga (*Delphinapterus beluga*) and the narwhal (*Monodon monoceros*), both of which are confined to the Arctic regions.

The white whale has a rounded head, lacks a dorsal fin and is about 14 ft. long. It feeds on fish, squid, crustacea and marine worms such as the pump worm (*Nereis*). It is hunted extensively by the Eskimos, and a superlative quality leather is manufactured from its hide. It lives in small schools of about a dozen individuals.

The narwhal, too, lacks a dorsal fin and has a rounded head. Its teeth are much reduced, but in the adult male the left incisor grows out as a spirally-twisted tusk about 9 ft. long. This tusk has a clockwise spiral. In rare cases a right tusk is also present. This, too, shows an interesting asymmetry in twisting clockwise. Narwhals live in small groups of about six individuals, and feed on fish, cuttlefish and sea cucumbers.

**Behaviour Of Dolphins**

Many species of porpoises and dolphins are highly gregarious, and dolphins may form schools of several hundred individuals. The members of these schools seem to have a very highly developed herding instinct, which, in the case of pilot whales and false killer whales, causes them to make spectacular beachings which have never been satisfactorily explained. This phenomenon is put to good use by man in the Pharoe Islands, where schools of pilot whales are surrounded by boats and driven towards the shore.

A social hierarchy has been found to exist among the bottle-nosed dolphins (*Tursiops tursio*). In it the dominant animal is a male who establishes and maintains his position by combat with other members of the group. Once this "peck order" has been established it is difficult for a strange dolphin to join, because it is attacked by all the other members and is either driven out or relegated to the most inferior position in the hierarchy.

Another interesting phenomenon in the behaviour of the smaller cetaceans is their habit of swimming alongside the bows of ships. Two Australian forms which do this

are the bottle-nosed dolphins (*Tursiops* sp.) and, more particularly, Risso's dolphin (*Grampus griseus*), of which Pelorous Jack of Cook's Strait, New Zealand, is the most famous example.

Unlike porpoises, dolphins rarely enter fresh-water rivers. However, two remarkable forms, the Guiana and Irrawaddy River dolphins, have been recorded 900 miles upstream from the sea.

Most porpoises and dolphins feed on various species of fish, but there are no accurate data on the diet of dolphins in Australian waters.

**Reproduction And Life History**

Our knowledge of the reproduction of the smaller cetaceans is limited to very few species, but it would seem that they have only one breeding cycle a year and that they give birth to a single offspring. The period of gestation is about 300 days in porpoises and dolphins and 360 days in the killer whale. Copulation occurs soon after the birth of the young, which normally takes place in late autumn. The young dolphin shows the anomaly of being born tail first and of remaining attached to the female for several days by its umbilical cord. It takes its first respiration 10 seconds after birth, and begins to suckle after about four hours. All cetaceans are very large at birth—about one-third of the size of the adult—and do not develop their layer of blubber until they have been suckling the milk, which is very rich in fats, for some weeks. This absence of blubber limits breeding to temperate latitudes. Puberty is attained at about the age of two years.

**Locomotion**

Cetaceans' bodies are well streamlined, and propulsion is effected by vertical movements of the tail and flukes. The fins are used as rudders and balancers. Dolphins have been recorded as swimming at a speed of 25 knots, and a 6 ft. dolphin, weighing 3 cwt., would need to develop 14 horsepower to travel at this speed. This would mean an energy output of 87 horsepower per ton of body weight, which is about six times that of a trained human athlete. This very high muscular efficiency is probably due to the high rate of oxygen utilisation by the muscles and by their ability to incur a considerable oxygen debt, which is repaid later when the mammal surfaces to breathe. An example of such repayment in humans is the panting of an athlete after a race.

Like the greater whalebone whales, porpoises and dolphins do not normally dive deeply or stay submerged for long periods. However, some cetaceans, such as the sperm whale, can dive to great depths and stay submerged for up to 30 minutes.

All cetaceans have special physiological adaptations which enable them to remain below the surface of the water for relatively long periods. The ventilation of the lungs is much more efficient than in the case of terrestrial mammals, so that 80-90 per cent. of the air in the lungs is changed at each respiration, compared with 15-20 per cent. in man. The red blood-cell count of cetaceans is appreciably higher than that of man. For example, it is 8,500,000 $mm^3$ in the porpoise and only 5,000,000 $mm^3$ in man. In addition, the presence of large quantities of myoglobin, which gives the muscles their characteristic dark colour, enables cetaceans to store extra oxygen in this tissue.

The diaphragm, a muscular partition between the chest and abdomen of mammals, is very oblique in cetaceans, and, as the animal dives, the viscera compress the lungs and drive the air into the bronchi and windpipe. Here it is impossible for any air to be absorbed into the blood, and it has been suggested that it is by this means that cetaceans are able to avoid "caisson sickness" or "bends", which would otherwise occur when bubbles of nitrogen escape from solution in the blood as the animal returns to the surface. The accumulation of carbon dioxide in the blood does not seem to cause respiratory distress in cetaceans. They are able to incur a heavy oxygen debt in most of their tissues, except the nervous system, which is repaid later when they surface to breathe.

Many structural adaptations for an aquatic existence occur in the sense organs of dolphins and porpoises. The olfactory apparatus and the olfactory lobes of the brain are much reduced, and it is probable that these mammals have no sense of smell. Their

eyes are comparatively larger than those of other cetaceans, and are specially modified for under-water vision. The refractive index of the fluid in the anterior chamber of the eye is approximately equal to that of sea-water. The cornea does not magnify when immersed. Cetaceans do not appear to be able to accommodate their eyes by altering the shape of the lens. Only the smaller species, such as the dolphins and porpoises, can move the eye in its orbit. The lachrymal glands secrete an oily substance which may protect the surface of the eye from irritation by sea-water.

The external ear is absent, and the auditory canal is very narrow and may be closed with a plug of wax. Despite this, these mammals have excellent hearing.

Many species of toothed cetaceans make a variety of sounds, both above and below the surface. These include whining sounds, snorts, buzzing through the lips or blowhole, clicking with the jaws and whistling. The latter sound, in particular, seems to have some social significance, as it is produced when a strange member is introduced into a colony of captive bottle-nosed dolphins (*Tursiops tursio*).

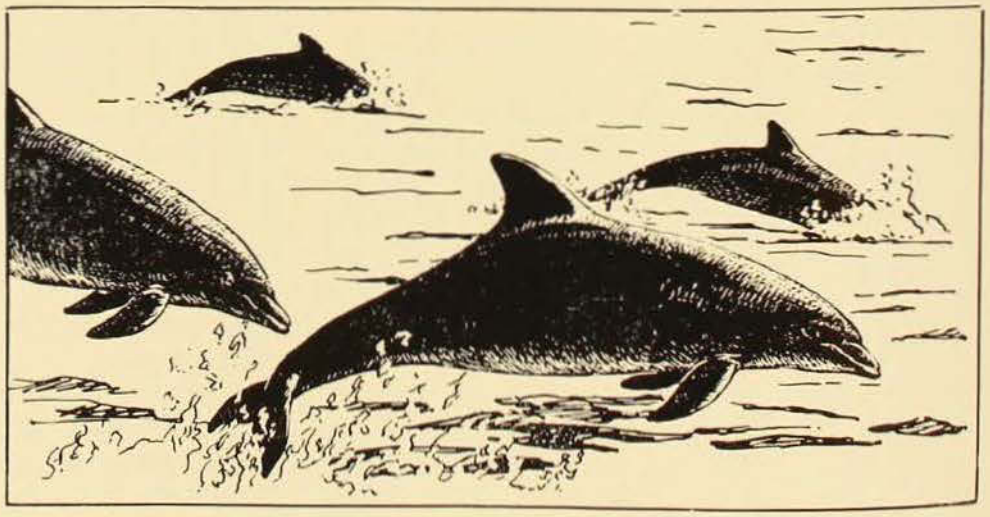
Certain workers have found that this species also responds to ultrasonic vibrations of about 80 kcs, and that it can emit sounds that produce measurable echoes. From this it has been postulated that the smaller cetaceans may possess an "echo-location" system which enables them to avoid obstructions in a similar manner to the small insectivorous bats, which can detect obstacles by the echoes received from the high-frequency pulses they utter while in flight.

**Sleep**

The little information available on the sleep of cetaceans has been obtained from observations of bottle-nosed dolphins (*Tursiops* sp.) in captivity. When sleeping, these dolphins float parallel to the surface at a depth of about 1 ft. with their tails hanging down. A gentle stroke of the tail once in 30 seconds causes the dolphin to rise so that its blowhole clears the water and enables it to breathe. The eyes are kept closed, but may be opened occasionally at the end of each 30-second period.

Porpoises and dolphins have several interesting parasites. In addition to internal round worms and flukes, they have, externally, barnacles, whale-lice and copepods, all of which are crustaceans.

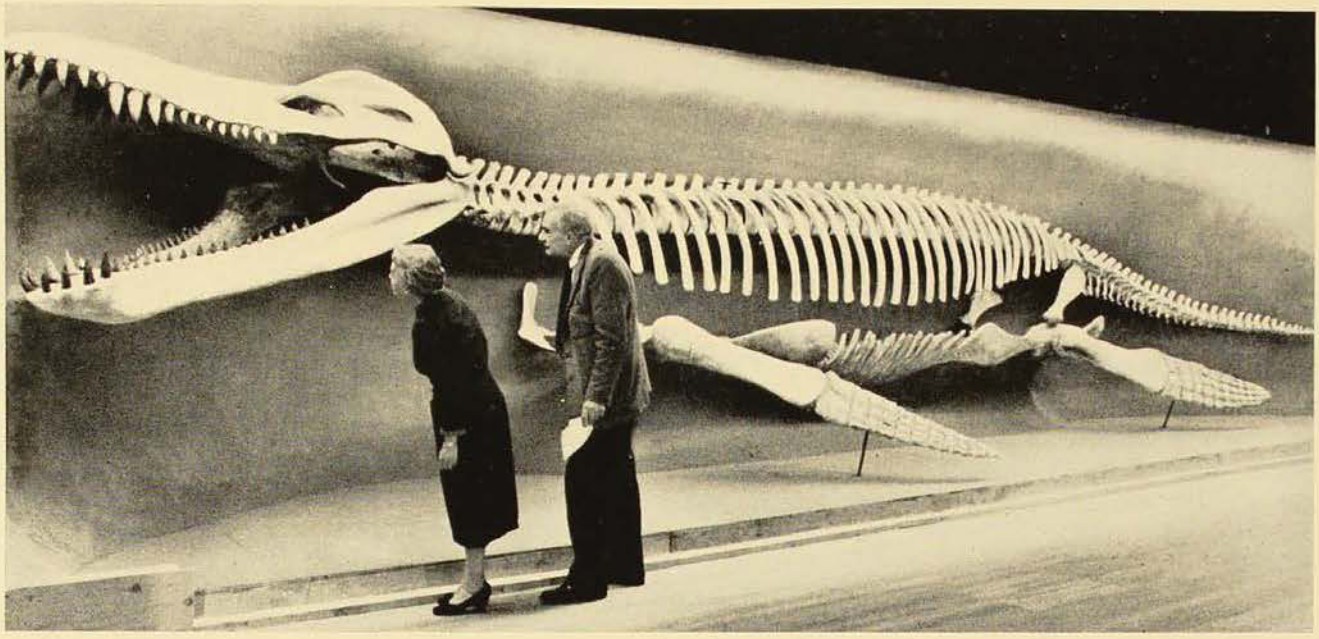
Dolphins and porpoises have been of great value in the solution of many problems of whale biology which cannot be studied in species too large to be kept in captivity. The order Cetacea has existed as a separate group of mammals since the middle Eocene, about 60 million years ago, and there is still much uncertainty as to its exact relationship with the other orders of mammals. It is best considered as a highly specialised stock which branched off the main evolutionary line of placental mammals before it had diversified into the major groups that we know today. As we have seen, the cetaceans have evolved some remarkable adaptations which enable them to survive most successfully in an environment totally alien to most mammals.



Bottle-nosed Dolphins have been studied extensively in captivity, and the existence of a social hierarchy among them has been demonstrated.

# *A Giant Marine Reptile From the Cretaceous Rocks of Queensland*

By H. O. FLETCHER



The complete 42 ft. long skeleton of *Kronosaurus queenslandicus*, a primaeval sea reptile, which was found in Queensland. It is now in the Museum of Comparative Zoology, Harvard University, U.S.A. Alfred S. Romer, Harvard zoologist, and a research assistant are here seen examining it.

Photo.—Harvard University News Office.

IN Cretaceous times, about 127 million years ago, large areas of the Australian continent were covered by an extensive sea. Almost one-third of the continent was inundated by marine flooding, and this included a large part of what is now Queensland and north-western New South Wales.

The Cretaceous is one of the longest geological periods in the earth's history, having had a time span of about 70 million years, and it is recognised as one of the most interesting and important as far as the fossil record is concerned.

The end of the Cretaceous marked the close of the Mesozoic Era, in which vast evolutionary changes took place and many large groups of animals enjoyed a full cycle of existence from their inception to their extinction.

In all parts of the world the Cretaceous sea was inhabited by a rich and characteristic marine vertebrate fauna. Some of the creatures attained giant size and became extremely specialised in their structural development. Certain of the long-necked plesiosaurs [marine reptiles] grew to a length of more than 40 ft. They must be ranked with the most ferocious carnivores of all time. Their jaws were provided with as many as 80 teeth, 10 inches in length, and, as stated by one author, were of a "murderously cruel shape"—long, slender, pointed and recurved, and deeply socketed for strength.

Over-specialisation in an animal group is usually a sure indication that it is headed for extinction. This actually happened to many of the Cretaceous animals, both marine and terrestrial. Towards the end of the period, and at its close, large groups with a world-wide distribution completely disappeared from the geological record. On the other hand, it was also a time of origin and expansion of other important animal

groups which were destined to be the ancestral forms of most of our present-day fauna.

Although sharks first came into existence in the Devonian period, 130 million years before the beginning of the Cretaceous, it was during the Cretaceous period that there was a remarkable expansion in their development. Most of the 16 or 18 families of sharks now in existence had representatives in the Cretaceous seas, and living with them were ancestral forms of the sawfish, common skate, sting-ray, giant eagle-ray and many other allied species.

It was during the Cretaceous period also that the teleost group of bony fishes achieved their greatest evolutionary success, and ever since then they have been the dominant fish in the seas. Many types of Cretaceous fishes were not unlike those living to-day, and it is of interest to know that the evolution of modern fish form had been practically accomplished more than 100 million years ago.

The most characteristic creatures of the Mesozoic Era, however, were giant reptiles which dominated the land, the air, and the seas. In the sea, the most important groups included the ichthyosaurs (fish-reptiles) and the plesiosaurs (marine-reptiles), both of which became extinct towards the close of the era.

Knowledge of the life of past geological ages is gained from the fossil remains of creatures, now embedded in rock, which in the past lived their lives in the same manner as the animals of to-day.

**Burial Ground Of Marine Fauna**

Rocks of Cretaceous age cover large areas of the continents of the world, including a large part of Queensland, and in some places are thousands of feet in thickness. They were originally laid down as sediments on the floor of the Cretaceous seas. While accumulating over millions of years, they formed the burial ground of the marine fauna of that time. Much later, at the close of Cretaceous times, these sediments, by then hardened, were exposed when the seas receded. In Queensland the rocks have become part of continental Australia, and have been subjected to weathering by wind and water.

For the greater part of the past century these rocks have been yielding an amazing variety of fossils which provide evidence of the creatures that lived as the sediments were slowly accumulating. Similar forms are found also in Cretaceous rocks in other parts of the world.

In most cases the fossil remains of vertebrate animals, particularly large animals, are fragmentary, and the palaeontologist frequently has to wait until more complete specimens are collected before a definite classification of the remains can be made.

**Fossilized Jaw-bone Found**

About 60 years ago a fossilized piece of the mandible of a large skull, with three broken teeth preserved on each side, was found in rocks of Lower Cretaceous age near Hughenden, Queensland. The specimen, which is in the collection of the Queensland Museum, is about 8 inches long and 5½ inches in height and breadth. The imperfect teeth were estimated to have been originally at least 10 inches long. The fragment was tentatively identified as portion of a mandible of a fish-reptile known as *Ichthyosaurus*.

In 1923, the late Mr. Heber Longman, then Director of the Queensland Museum, examined the specimen. He came to the conclusion that it could not be placed in the Ichthyosauria because of the large socketed teeth and the general structure of the bone fragment. He finally decided that it belonged to a new type of gigantic plesiosaur, and the animal, even though it was represented by only a small part of the skeleton, was named *Kronosaurus queenslandicus*.

In his paper describing this specimen, Mr. Longman stated: "In the circumstances it seemed necessary to give this gigantic marine reptile from the Australian Cretaceous new generic and specific names, and it is firmly believed that when other remains are forthcoming of *Kronosaurus queenslandicus* this course will be fully justified."

Little did Mr. Longman realise, when he expressed that view, that a complete skeleton of his species would be found only eight years later. In 1931 Mr. William Schevill, of the Museum of Comparative Zoology at Harvard College, U.S.A., visited Australia to collect specimens for that institution.

While passing through Army Downs, North Queensland, on his way to the Northern Territory, he noticed a number of fossil bones partly showing in the Lower Cretaceous rocks. On close examination they appeared to belong to a complete and single specimen, even though they extended on the surface for more than 40 ft.

It was decided to send all the bones and surrounding rock to America, as Mr. Schevill concluded that the skeleton was intact and still embedded in the matrix. Four and a half tons of rock was blasted out with dynamite and packed and despatched to the Museum at Harvard. After its arrival Arnold Lewis, a Museum preparator, set to work to free the bones from the solid, hard rock. This delicate operation was performed with hammer, chisel and pneumatic hammer. As each bone was freed it was immersed in acetic acid to remove small rock fragments and to clean the surface. Any gaps left in the skeleton by missing bones and eroded bone-parts were filled in, using glue, asbestos, fibre and plaster of Paris.

About six months ago this work was successfully completed, and the skeleton was put together under the direction of the Museum director, Dr. Alfred S. Romer. The skeleton is 42 ft. long. It has a triangular-shaped skull 9 ft. long, with 80 spiked teeth, each up to 8 inches in length.

The creature was one of the largest known flesh-eating reptiles ever to have lived in the sea. The characters of the teeth and mandible are identical with those of the mandible fragment recorded by Longman in 1923.

### Plesiosaurs Swam With "Paddles"

The massive newly-mounted skeleton of *Kronosaurus queenslandicus* is displayed in a room of its own at the Museum of Comparative Zoology at Harvard, and is posed against a sea-blue background.

The plesiosaurs, as a group, are well-known, and their abundant remains have been found almost everywhere in the world where Jurassic and Cretaceous rocks occur. Even though they were of great size and had a broad and flat body, they were well fitted for a marine life. Swimming was accomplished by rowing the huge body along with well-developed paddles, which were effective organs of locomotion. The long tail was of little use in propulsion as its movement was restricted. It may have acted purely as a rudder. Plesiosaurs, including those forms with remarkably long necks, swam with the neck and head directed in front. They manoeuvred themselves clumsily through the water, and caught their prey with long, lateral motions of the neck rather than by quickly swimming after them.

The posterior part of the neck was thick and heavy and could not be moved upward and downward, so earlier drawings of these creatures, depicting freely curved necks like those of swans, are incorrect.

It would appear from the distribution of their fossil remains that the plesiosaurs were equally at home in deep oceans and in shallow waters.

The cause of their final extinction is unknown, but, with others of their kind, they disappeared from the geological record at the close of the Mesozoic Era.

The writer is indebted to the Director of the Museum of Comparative Zoology at Harvard for the excellent photographs of *Kronosaurus queenslandicus* and for permission to reproduce them.

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#### Shark Ray and Dugong

Professional fishermen caught a remarkable "sea-monster" in a prawn trap, six miles off South West Rocks, New South Wales, on February 24 this year. Photographs of it, published in the Sydney newspapers, clearly showed that it was a male Shark Ray (*Rhina ancylostomus*). It was evidently a straggler from more northern and warmer waters, as the species has not hitherto been reported from New South Wales. There is a cast of a record-sized Queensland specimen in the Australian Museum's fish gallery, though the New South Wales specimen has been reported larger.

An adult male Dugong (*Dugong dugon*) was washed up on a sandbank at Port Hacking, New South Wales, on February 12 this year and died the same day. It was examined the next day and several photographs of it were taken. It was 9 ft. 8 in. long, with a 3 ft. 6 in. tail. Several barnacles, which have been identified as *Platylepas hexastylos*, were attached to the tail and abdomen. It is believed that this specimen had been in the vicinity of Port Hacking for some days, because a colour film of a dugong had been taken by a Mr. Keller about three days before. Although dugong remains have been found previously in the Sydney area, this is an extremely southerly record for the live animal, which does not normally range south of the latitude of Maryborough, Queensland.

# *BIRDS—AND THEIR OBSERVERS*

By MICHAEL SHARLAND, F.R.Z.S.

Members of the Royal Australian Ornithologists' Union watching water birds at Wanganella Swamp, New South Wales.

Photo.—Author.

THE study of living birds as a pleasant and relaxing form of recreation has made marked progress in Australia since—and this not so long ago—the practice of egg-collecting and the indiscriminate destruction of birds for ornamentation both fell from favour.

People are keener than ever before to know how birds live, rather than what they look like dead. The nest with eggs in it has more appeal than have merely the empty shells in a cabinet. It is the living, animated bird, going about its normal affairs, and in so doing posing all sorts of interesting problems, that is the fundamental object and the very basis of most ornithological studies of current times.

We find an ever-growing number of persons taking an interest in the study of birds, their interest being expressed in varied ways. Along with economic studies and important projects for banding birds and thereby tracing their regular movements, bird-watching finds its expression in photography, in the annual gatherings of ornithologists at well-organised field camps, and in extensive continental expeditions in search of unusual species. Its popularity is also reflected in the increasing attention now given to caged birds.

The upsurge of interest in wild birds is occurring in most countries, and Australia perhaps is but following oversea trends. In both America and England the increase in membership of bird-study clubs has been astonishing.

It will not be long, judging by trends here, before the same condition of affairs prevails in Australia. The fact that Australia has many species with unusual habits and be-

haviour—to say nothing of the richness of their variety—fully justifies widely expanded field studies and is an incentive to those about to undertake such studies. After more than a century of getting to know the bird-life of this country it can be said that we are just about gaining a nodding acquaintance with the native birds; many more students and a great deal of work and field observation are needed before we can claim to be getting intimately acquainted.

Ornithological problems, some of great complexity, continue to crowd upon us. The wider our knowledge of birds the more are these problems presented for solution. It is chiefly because of the recognition of the work yet to be done and the extensive gaps in ornithological knowledge to be filled that membership of amateur societies and clubs concerned with field studies has been growing. In addition, many people are realising that herein lies the opportunity to become interested in a fascinating pursuit outside the normal walks of life.

It is obvious that in studying wild birds every observer almost automatically becomes interested in their welfare. This often leads to better measures for protection, and is, therefore, one of the most important attributes of amateur societies.

**Bird-Watchers' Clubs**

The opportunity to join an organisation with the object of furthering an interest in ornithology in Australia is certainly not lacking. Amateur bird-watchers, dispersed through the continent, are brought together in a common interest by the clubs and societies they have created to foster the knowledge and appreciation of native birds. Anyone may join such clubs. An inquiry at any natural history museum will enable those interested to get in touch with local secretaries. All States have bird-study clubs and field naturalist societies, some confining their main interest to local districts, and a few having much wider affiliations.

Most important of these, since its membership is world-wide, is the Royal Australasian Ornithologists' Union, with headquarters in Melbourne, where it was founded in 1901 with some six enthusiastic "bird men" as its first members. It has achieved high status as the result of scientific research carried out by its members, but is supported principally by the rank and file—the plain amateur observers, keen students all of them. Its journal, "The Emu", published quarterly, in which are recorded news of birdlife and results of research into ornithological problems, ranks as one of the more important bird journals of the world.

There is a branch of the union in each State. Members are always ready to welcome newcomers, who require no other qualification than an interest in birds, which in itself is a guarantee of new friendships and many pleasures.

An important activity of the union is the annual "camp-out", held, usually, in each State in rotation. This provides an opportunity for members to meet, hear what the other fellow is doing in field work, and view the often remarkable pictures of wild birds taken during the year.

Last year's outing was at Noosa Heads, on the Queensland coast about 100 miles north of Brisbane, an excellent place for birds. More than 200 species were listed for the district, some of which were new to several members.

The camp-out this year will be at Kangaroo Island, South Australia. A proposal also is being considered for the holding of a camp in New Guinea in the near future.

Though it was a long time before the community recognised the value of professional advice on economic problems associated with birdlife, actual necessity has now brought about the appointment of trained ornithologists in official places, so that they, as with scientists in other spheres, have come into the picture far more than was envisaged as necessary a few years ago. As yet there are but a handful of such men, devoting their services to ornithological studies, but their numbers will increase as the importance of birds is more widely appreciated.

**Scientists Help Amateurs**

A gratifying aspect of ornithology in this country is the congenial relationship between the amateur ornithologist and the professional. It seems that in most fields there is a tendency for the scientist to ascend to lofty heights as far as his relations with the

amateur are concerned, and to minimise the value of the amateur's work, which is often restricted by lack of time. However, in ornithology in Australia, the professional men have assumed no such superior airs. Instead, they are fully aware of the importance of the amateur's work, and not only welcome but help to foster it. How better could this be demonstrated than by the fact that, almost without exception, they are themselves members of these amateur organisations and give leadership and inspiration to ornithological projects? This helpful guidance prevails particularly in the Royal Australasian Ornithologists' Union, where the membership includes several specialists and full-time workers in ornithology. It also occurs in the many field naturalist clubs and kindred societies throughout Australia.

However, the backbone of most of these clubs and societies, the physical structure that supports them, is the interest of the rank-and-file amateurs who comprise the bulk of their membership. It is the amateur, the spare-time naturalist, who so often has been responsible for establishing the clubs and raising them to a high status in relation to biological studies.

A distinguished record of ornithological work has marked the history of the Victorian Field Naturalists' Club, founded in 1880 and including in its ranks scientists and amateurs alike. In Tasmania, the Field

This unique photo. shows four adult Dusky Wood-swallows and a young one in a hollow in the bark of a tree. They chose this spot to roost.

Photo.—Author.

Naturalists' Club at Hobart, founded in 1902, has an equally good record and has given rise to the formation of three similar clubs in provincial towns. All four are now joined in a federation—probably the first Australian federation of natural-history clubs.

In New South Wales, as well as field naturalists' clubs and similar organisations, there is a very live Ornithological Section of the Royal Zoological Society. It is strong in membership, rich in enthusiasm and active in ornithological research.

Rapidly gaining ground in membership and status is the Victorian Bird Observers' Club, which publishes its own journal and carries out specific programmes of field studies and bird-banding on a large scale.

All these bodies welcome new members. They have obtained many of their members, both directly and adventitiously, from the schools, a source that has been rich in the cultivation of the principles of nature study and, particularly, the sympathetic appreciation of birds.

**Gould League Of Bird-Lovers**

In Australia, this source has been exploited, to the community's great advantage, by the work of the Gould League of Bird-Lovers, whose disciples have been the teachers pointing the way in matters of bird preservation to the thousands of young members passing through their hands.

Unostentatiously, but none the less zealously, and with the support of school authorities, the league has done much to educate the young mind in the value of nature study and the need to protect birds. Its influence has, perhaps, been more profitable and more enduring than that of any other nature-study organisation. Branches of the league —the name of which commemorates the work of the famous ornithologist, John Gould—are widespread and functioning in all States except Queensland and South Australia. There, natural-history clubs tend to take the league's place.

Here are some remarkable figures on league membership:—

In Victoria, where the league was formed in 1909, there are 1,800 branches (each school is regarded as a branch), and more than half a million members have been enrolled.

There are 3,000 branches of the league in New South Wales, total membership being 140,000. Formed in 1910, the New South Wales league has been able to establish a scholarship from proceeds of book royalties. This Cayley Memorial Scholarship is valued at £100 for each of two years and is available to students taking second year (or more) science course, which must include zoology, at a university.

In Western Australia league branches number 352, constituting about one-third of the total primary-grade classes in the State. Membership to the end of 1958 was 13,500. In Tasmania the league's membership is not as yet substantial.

**Big Scope For Bird Studies**

From this exceedingly fertile ground there has grown a harvest of great value to the community, the measure of which is becoming more apparent as we observe improvement in the public attitude towards birds and more insistent demands for their protection and for the reservation of their breeding places.

Many an experienced bird-observer will admit that his interest in birds was first aroused by his Gould League lessons at school. It is an admission that the present author makes in tribute to his teachers, who were imbued with the league's ideals. Where the work of the league ceases on the pupil leaving school or graduating to higher schools the clubs and societies are ready to take over.

The scope for bird studies in Australia is unlimited, whether sponsored officially or initiated and conducted solely by amateurs. Problems associated with ornithology are being investigated by State Governments and by the Commonwealth through the Wild Life Section of the C.S.I.R.O.; bird-banding schemes are being undertaken fairly extensively, and the economic value of birds is being studied more vigorously.

This is good for Australia, as such studies must ultimately be of national benefit. And in this development the amateur bird-observer has an important part to play.

# *NEW EXHIBIT OF INVERTEBRATES*

Artists, preparators and carpenters installing an Australian Museum exhibit which will show the wide variety of animals without backbones and their relationships to each other. The 32 ft. long panel has been in preparation for more than 18 months, and should be completed in July. Nearly 200 species, in the form of models, paintings and actual specimens, will be shown. Special lighting effects and fluorescent plexiglass lines will indicate the inter-relationships of the various groups of invertebrates, and labels and models will tell of the probable origins of life.

Photo.—Howard Hughes.

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### "Black Swan" Film

A seven-minute, 16-mm., educational sound and colour film, "The Black Swan", has been made by the Australian Museum. It shows some details of the life of a pair of Black Swans found nesting on a lake near Pittown, N.S.W., in 1957, and includes sequences depicting swans in flight and the development of cygnets. The film is intended for primary-school children, but is also suitable for general audiences. Organisations wishing to buy copies of it should write to the Director of the Museum. Still photos taken of the swans were published with an article, "Monarch of the Swamps", by Allen Keast, in this magazine (Vol. XII, No. 7).

### Exhibition of Museum Photos

The Australian Museum, in association with Kodak (Australia) Pty. Ltd., held an exhibition of official Museum photographs in the Kodak Gallery, Sydney, in February, 1959. The display consisted of nearly 100 enlarged photographs depicting a wide range of natural history subjects. Most of them were taken by Howard Hughes, of the Museum's staff, and have appeared in past issues of this magazine. The exhibition has created wide interest, and will be displayed in main Kodak branches throughout Australia. When it has completed its Australian tour (about October, 1959) it will be shown in the Australian Museum for an extended period.

# *The Barramundi, North Australia's Finest Food Fish*

By GILBERT P. WHITLEY

THOUGH long known as an extremely fine food-fish in Queensland, and often served to long-distance travellers in that State's railway refreshment rooms, it is only in recent years that the barramundi has appeared on tables in southern Australia.

About 1952 some enterprising northerners flew some down to Sydney, and in September, 1955, a trial consignment of fillets came to the Sydney markets by air from Burketown, Queensland, and sold at 3s. 6d. a pound. Then in May, 1958, fish in the round were flown from Darwin to Sydney, followed by weekly consignments while the season lasted.

The name barramundi has been used for at least three different kinds of fishes in Australia: (1) The Queensland Lungfish (*Neoceratodus*); (2) the true barramundi (*Scleropages*), for which the name should be retained and which has been dealt with before in this magazine (G. P. Whitley, VII, 8, 1941, p. 264); and (3) the subject of this article, *Lates calcarifer*, the giant perch, or palmer, generally miscalled barramundi, or simply barra. The two first-mentioned live exclusively in fresh water, but the third occurs in marine, estuarine or fresh water.

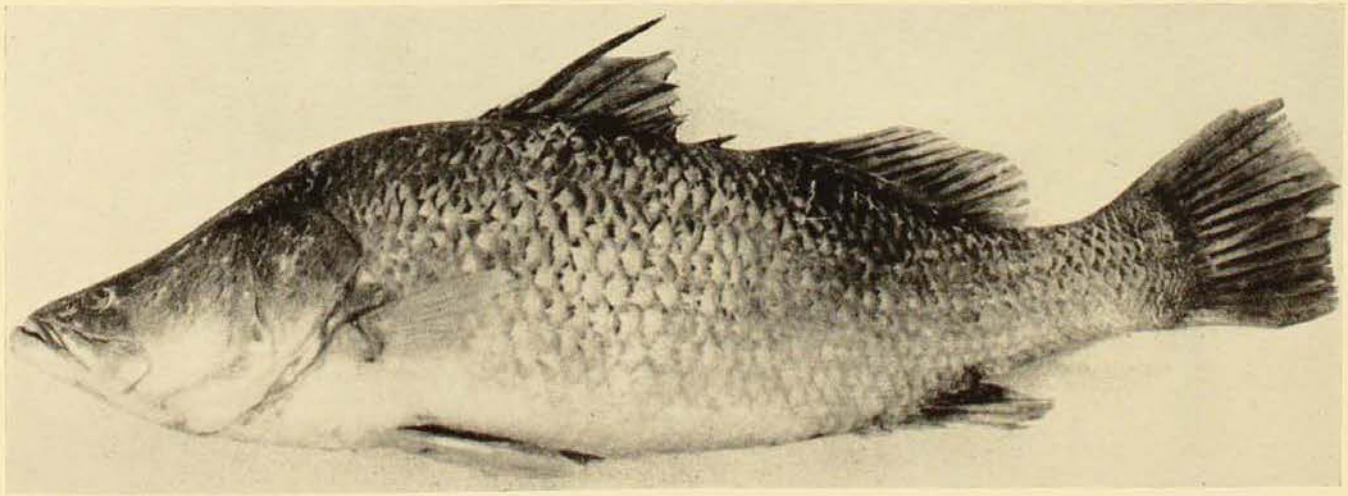
Because of the confusion of names, fisheries biologists discourage the use of the name barramundi for *Lates calcarifer*, and prefer it to be called giant perch, or palmer.

The barramundi is known from India (where it is called cockup and bekti) through Indo-Pacific waters to China, southern Japan, New Guinea, the Northern Territory, Western Australia (south to the Abrolhos Islands) and Queensland (south to the Mary River). It occasionally exceeds 130 lb. in weight and about 6 ft. in length.

## Glowing Red Eyes

The barramundi is bluish-grey to greenish-grey above, shading to silvery on its sides, and white below. The pinkish or red eyes "glow like live coals, especially at night."

The fish is of typical perch-shape, with a steep profile, upper jaw reaching beyond the eye, and nostrils close together. These characteristics distinguish it from the sand bass or nightfish (*Psammoperca*), a smaller fish with which it is sometimes confused.



A Giant Perch, generally known as Barramundi, from Cairns, Queensland. A model for exhibition in the Museum will be made from this fish.
Photo.—Howard Hughes.

Sharp, spur-like spines on the sides of the head sometimes enable it to force its way through nets and wound anyone handling it. A man at Darwin was struck in the face by a barramundi which leaped out of his net. Its dorsal spines seriously wounded him below the left eye. The first dorsal fin is peaked, and consists of seven or eight strong spines.

H. A. Lindsay wrote ("The Age," Melbourne, December 2, 1957): "The best way to cook barramundi is to wrap it in banana leaves and steam-bake it in a hole in the sand or ground, lined with flat stones, in which a good fire has burned down. The ashes are shovelled out, the leaf-wrapped cutlets are placed on the bottom, a layer of leaves goes over them, some water is sprinkled on the covering and then the earth or sand is heaped on top to retain the heat. Anyone who tries the fish cooked in this way will understand why Barramundi was the favourite food of the aborigines around our northern coast."

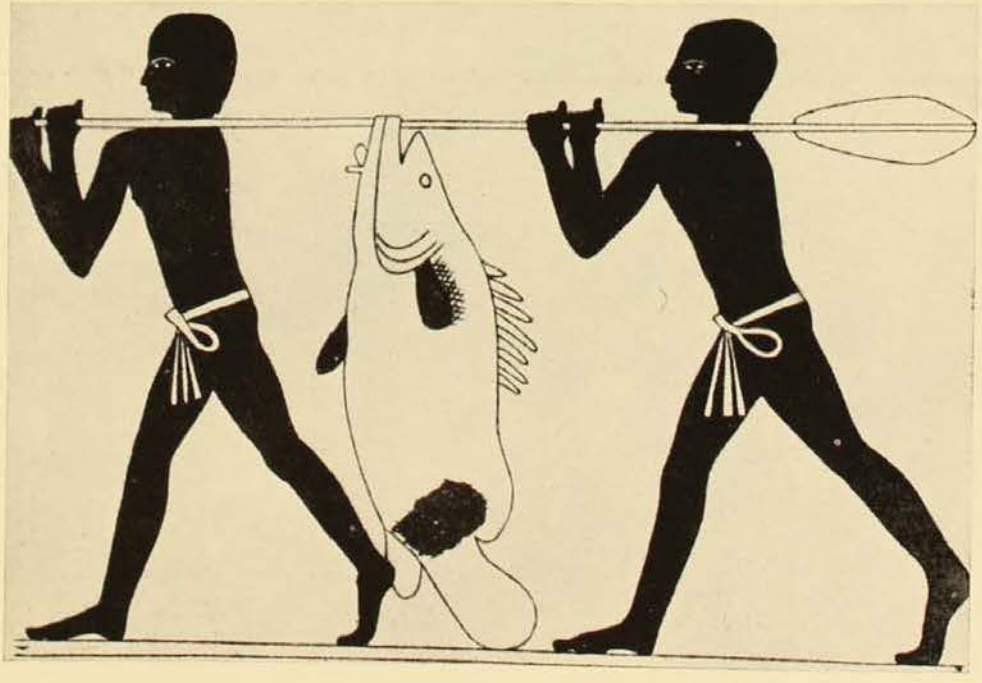
**Barramundi In Aboriginal Lore**

Interesting Aboriginal lore about barramundi is contained in some reminiscences of Mr. W. Linklater. He wrote that at Mountain Creek, Northern Territory, where he was in 1905, a red sandstone monolith about 25 ft. high stood a few yards from the side entrance of a cave. An Aboriginal boy said that as long as the pillar remained upright the rivers would be full of barramundi. If the pillar fell down the barramundi would be "finished."

Mr. Linklater said that barramundi start moving up the Katherine River from its estuary when the Kudjuah Kudjuah birds (so-called because of their call) fly along the river banks in search of berries at the beginning of November. Hearing the birds' calls as they fly up the river, the aborigines say that the barramundi are coming. "I hear the Kudjuah Kudjuah calling out to the barramundi fish to come along," they cry.

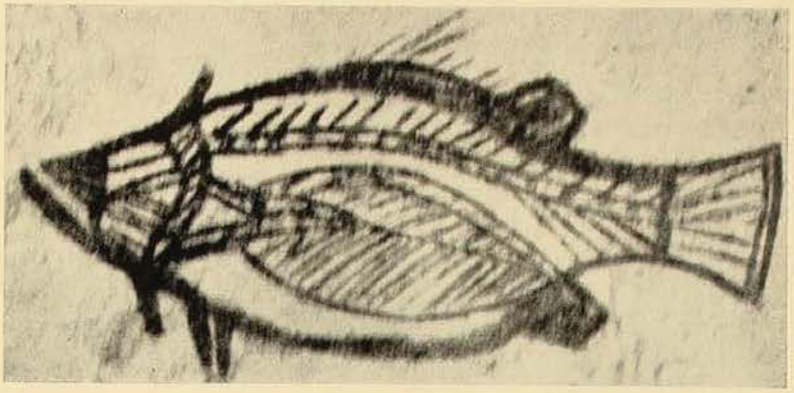
In north Queensland the aborigines said the barramundi came to the rivers when the Leichhardt tree flowered.

The Aborigines often drew or painted the barramundi and their representations of it are in many anthropological books and papers. [See, especially, N. Tindale, South Australian Naturalist, IX, 2, 1928, p. 35, Pl. i (Cave Painting in the X-ray style, Northern Territory); Colin Simpson, "Adam in Ochre," pp. 17, etc., and plates and figures; and C. P. Mountford, Records of the American-Australian Expedition to Arnhem Land, i, 1956, pp. 86, etc., pls. 29, 37, 38-40, 42, 43, 45 and 80, also text figures.]



An Ancient Egyptian painting of a Nile Giant Perch, to which the Barramundi is closely related.

After Petrie.



A Northern Territory Aboriginal cave painting of a Barramundi. This is an example of Aboriginal "X-ray" art, showing internal parts, as well as the exterior, of the fish. The Barramundi was a favourite food of the Aborigines.

After C. P. Mountford.

In the Northern Territory the barramundi is called Ukulpaindi, and is credited in Aboriginal legend with creating streams on its migrations. The Aborigines have a song in its honour (Mountford, in the above-mentioned report, p. 86). The art of painting famous "X-ray" pictures in caves at Oenpelli, Northern Territory, unfortunately died out about 50 years ago. In the "X-ray" painting mentioned above, the backbone and internal organs were shown, as well as the outline. The barramundi is still featured in Aboriginal bark paintings.

Dr. Catherine H. Berndt, of the University of Western Australia, tells me that various Aboriginal myths and songs refer to the barramundi, but that some of them are still unpublished.

She writes, as regards Arnhem Land: "The sacred myth of Laindjung-Banaidja concerns the barramundi, since that fish is one manifestation of this Ancestral Being . . . The myth covers, topographically, a relatively large area, from Blue Mud Bay to Arnhem Bay, and changes several times. A large bound paperbark pad (see Mankind, Vol. 5, No. 6, 1958, p. 258) is used to represent a barramundi in sacred rituals . . . One bark painting from Western Arnhem Land showed a mythological scene involving a large barramundi. This fish is said to have lived, in the mythological era, at the head of the East Alligator River. He was observed one day by three hunters, one of whom (named Nalgwungbid) speared him. The barramundi, however, broke loose and started off in the direction of the coast, making the river as he went, and followed by the hunters. Finally, at Gulari Point, at the river's mouth, he turned himself into a rock, which may be seen at low tide today. This drawing is an excellent example of X-ray art."

In Papua, native fishing is restricted to between late October and mid-February, when the fish have moved down the rivers to the coast.

**Queenslander's Observations**

Mr. F. M. Allan, writing to me from Rockhampton, Queensland, in 1940, stated:—

"I live about 50 ft. from the Fitzroy River, just opposite the first bar of rocks that puts an end to navigation. It is here that a great many Barramundi are taken on the rod when the season is on, which is just after the freshes, for they seldom or never take the spinner when the water is salt, when it is always clear. Yet at Port Alma, where the water is always salt, I have seen the fish rush the crudest of spinners—quite on a par with the gear used by Adelaide watersiders in catching Barracouta, where the fish are flung over their heads, not unlike a navvy throwing dirt with a shovel. In the upper reaches of the river, beyond the tidal influence, I have seen the fish at times take the spinner in clear water, but not often. They like to take shelter among snags, and when hooked generally manage to tangle the line in them and get away.

"On cold mornings they have a habit of coming to the surface with the dorsal fin out of water —to get the sun, I presume. They are then very easily shot.

"The natives used to spear them frequently. An old native told me that in his youth the blacks had great feasts some seasons; but since then the white man and his nets and dynamite have spoilt matters. The same fellow told me that at night these fish like to lie under the lily leaves, where they are easily speared from a boat—one man spearing while the other holds a light. Of the truth of this I cannot say.

"I can, however, vouch for the fact that these fish show their presence very clearly at night by their habit of "chopping", which means that they make a loud noise, something like a handclap. It is claimed they do it by biting at their prey; I am not sure of this, although I have at times

heard them make this noise when rushing my spinners. They sometimes follow the bait until it is being lifted from the water, and then make a fearful effort.

"I know no freshwater fish whose eye compares with the Barra's; if the gem-like eye redeems the toad from ugliness, the Barra's eyes alone entitle him to a place among the lords of the fish world . . .

"I think the Barra is a hardy fellow, as I have caught them with large cat-fish spines projecting two inches through their sides; at the same time, they cannot stand dirty water and, after every large fresh, great numbers die owing to the silt in their gills.

"My own idea is that this fish is a saltwater fellow that breeds there, and makes up the rivers to stop there and grow fat and large. Being so large, his only real enemies in the brave old days were the crocodile and the aboriginal—not counting droughts and floods . . .

"Some Barramundi when hooked make a very fine fight, leap out of the water many times and shake themselves in a wonderful manner to throw the spinner free. At times I have seen it cast many feet into the air when they are successful in doing so.

## Life History

The life history of the barramundi is still incompletely known. Indian accounts of its biology are not available to me. In Thailand, it seems of a smaller size that in Australia, and spawns in different months.

Preliminary investigations into its biology were made by tagging small fish near Rockhampton, Queensland, late in 1952. A numbered tag was clipped to the base of the gill-cover of each fish. Early returns included one fish which had grown $4\frac{3}{4}$ ins. in $2\frac{1}{2}$ months and migrated 80 miles to the Fitzroy River. There was evidence that two growth-rings are formed in the scales annually—the first during the winter months, the second during the wet season (November to March), when flood-waters caused the immature fish to return to coastal waters. The first winter ring was formed in Rockhampton fish when the mean length was nearly $9\frac{1}{4}$ ins. and the total first year's growth was $18\frac{1}{2}$ ins. The length at the end of the second year is apparently about 34 ins., but the growth-rate may well vary with locality or food supply.

The stomachs of small fish from fresh water contained mixed plant and animal detritus, the animals being aquatic insects, small crustaceans and fish-fry. Larger barramundi contained various freshwater fishes and prawns.

E. J. Coulter stated in the annual report of Department of Harbours and Marine, Queensland, 1953: "Spawning takes place in coastal waters at a time closely approximating the wet season, November to January. It is believed to occur in the backwaters of bays and estuaries, where there is no surf and little current, and in the vicinity of river-mouths, where there are shallow mud flats, the sand being covered with 3 ins. to 6 ins. of mud.

"Barramundi mature when approximately 17 lb. in weight and 33 inches in length. Scale readings indicate that such barramundi might be two years old. After spawning the mature barramundi remain within the limits of the continental shelf, in coastal waters or estuaries. Young barramundi migrate upstream from estuaries. They survive, in the river head-waters, in holes when the rivers dry back. Holes which will dry up during a prolonged dry season are avoided."

Barramundi inhabiting the east coast of Queensland and the Gulf of Carpentaria show differences. Fresh and salt water inhabitants show diversity of form, also. This suggests that the widely-ranging barramundi may be separable into different races or subspecies, and that some control over extensive fishing in certain localities will have to be exercised.

## Giant Perch Of The Nile

Our barramundi is closely related to the giant perch of the Nile (*Lates niloticus*), which is shown in early Egyptian hieroglyphics and mummies of which have been found in perfect preservation after 25 centuries. The old Egyptian city of Latopolis was named after this fish, which was shown on the city's Greek coins. The city is now called Esneh.

Fossil *Lates*, from Pleistocene back to Eocene deposits, have been reported from various areas in Africa, but the modern distribution in Africa is the Nile, Congo, Senegal and other West African rivers and No, Chad, Albert, Tanganyika and other lakes.

# *FLESH-EATING PLANTS*

**By N. H. WHITE**

Associate Professor of Plant Pathology, Faculty of Agriculture, University of Sydney

IT is well known that animals depend primarily on green, chlorophyll-containing plants as a source of energy—energy which the plants trap from the sun in their process of photosynthesis. Many people, however, will be surprised to know that some chlorophyll-containing plants prey on insects, and, to a lesser extent, other small animals, as a source of energy.

These plants are called carnivorous (flesh-eating) or insectivorous plants. As many of them do not restrict their diet to insects, the term carnivorous plants is more appropriate.

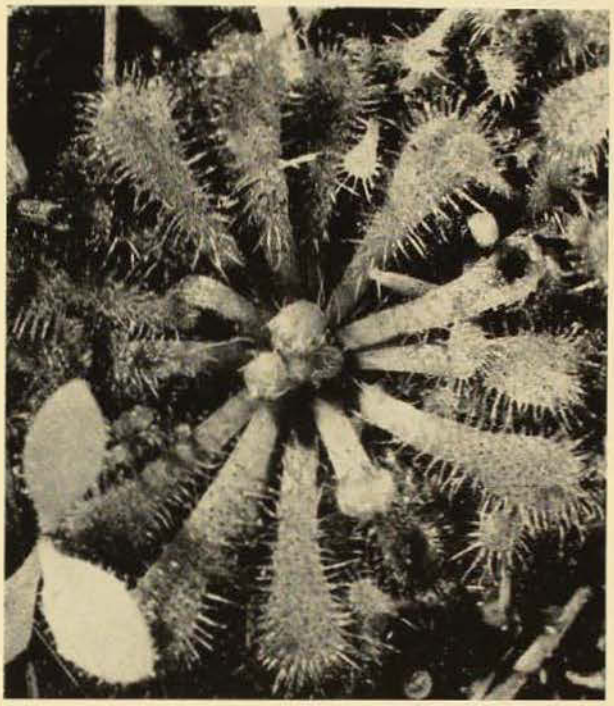
"Man-eating" plants are figments of the imagination—principally the imagination of fiction-writers. Fantastic examples are to be found in Mandeville's tales of travel.

Carnivorous plants were the object of much study by the great naturalist, Charles Darwin, the centenary of whose book, "The Origin of Species," is being commemorated this year. He considered these botanical curiosities to be the "most marvellous plants in the world," and he wrote a book about them, "Insectivorous Plants."

None of these carnivorous plants ever grow into large trees or shrubs. They are often insignificant, innocent-looking, herbaceous plants. Many of them are brilliantly coloured or marked, and have scent and honey to lure their prey.

In Australia, the most familiar carnivorous plants are the brilliantly coloured "sun dews", seen growing as red-coloured rosettes about 1½ ins. in diameter on wet soil in swampy ground or on the edges of waterfalls and creeks.

Some of the larger carnivorous plants grow to the size of a clump of aspidistra. A few have a trailing habit, growing to a length of about four feet. Mostly, they are associated with an abundance of moisture, and are therefore found in swampy localities, ponds, water-holes and other pools of non-flowing water. This is probably because their prey are abundant in moist places.



This Sun-dew (genus *Drosera*), growing near Sydney, feeds on insects which are caught in the sticky hairs on its leaves. The hairs bend over the insect and dab their sticky surfaces on to it.

Photo.—Howard Hughes.

Among the carnivorous plants are certain non-chlorophyll-containing plants belonging to the fungi, which prey on eelworms or nematodes in the soil or attack insect larvae there, producing the rather odd-looking "vegetable caterpillars" characteristic of the Cordyceps fungi.

All carnivorous plants first catch their prey and then dissolve or digest it.

### Prey-trapping Methods

Methods of trapping prey are very varied and ingenious, each one depending on the habits of the victims in specific localities. The late Professor F. E. Lloyd made a lifetime study of carnivorous plants, and investigated particularly their methods of trapping their prey. This investigation required much patience and ingenuity.

He found that there are two kinds of traps —passive traps that do not require any special activity on the part of the plants when the prey makes contact with them, and active traps which require special mechanisms to be set in motion by the presence of the prey. The passive traps are the simplest in design, and are not very selective as far as the range of prey is concerned. They were classified by Professor Lloyd as:—

(*a*) The pitfalls or slippery-dips, found in the so-called pitcher plants, some of the leaves of which have tendrils modified into pitcher-like structures with slippery mouths, and often lids as well. When the prey arrives at the neck of the pitcher-like leaf it slides into the well of the pitcher, which contains water and secretions from the plant. Once inside the pitcher, the victim, usually one of a wide variety of insects, has no chance of escape and is drowned in the liquid, to be digested later by plant enzymes.

(*b*) The lobster-pot trap is the most specialised structure found among the passive types of trap. It is really nothing more than a narrow pitcher with interior walls armed with downward-pointing hairs, so that the trapped insect has an additional barrier to overcome should it try to escape.

(*c*) The fly-paper or tangle-foot trap, the simplest of all the passive traps, is a viscid or sticky mucilaginous secretion on hairs on the surface of the plant's stems and leaves.

Professor Lloyd classified the active traps as follows:—

(*a*) The snare or noose traps, a favourite method of trapping wriggling eelworms by the carnivorous fungi. These snares consist of a loop of usually three cells of the fungal hyphae, coiled over. When the eelworm tries to push through the loop the latter tightens around its body. The prey is firmly held until the fungus pushes into its body penetrating hyphae which kill it and absorb its contents.

(*b*) The active fly-paper traps are similar to the passive fly-paper traps, except that the hair cells, which secrete the mucilage, bend over and dab the mucilaginous surface on to the insect. This means that the "fly-paper" is virtually pushed on to the prey.

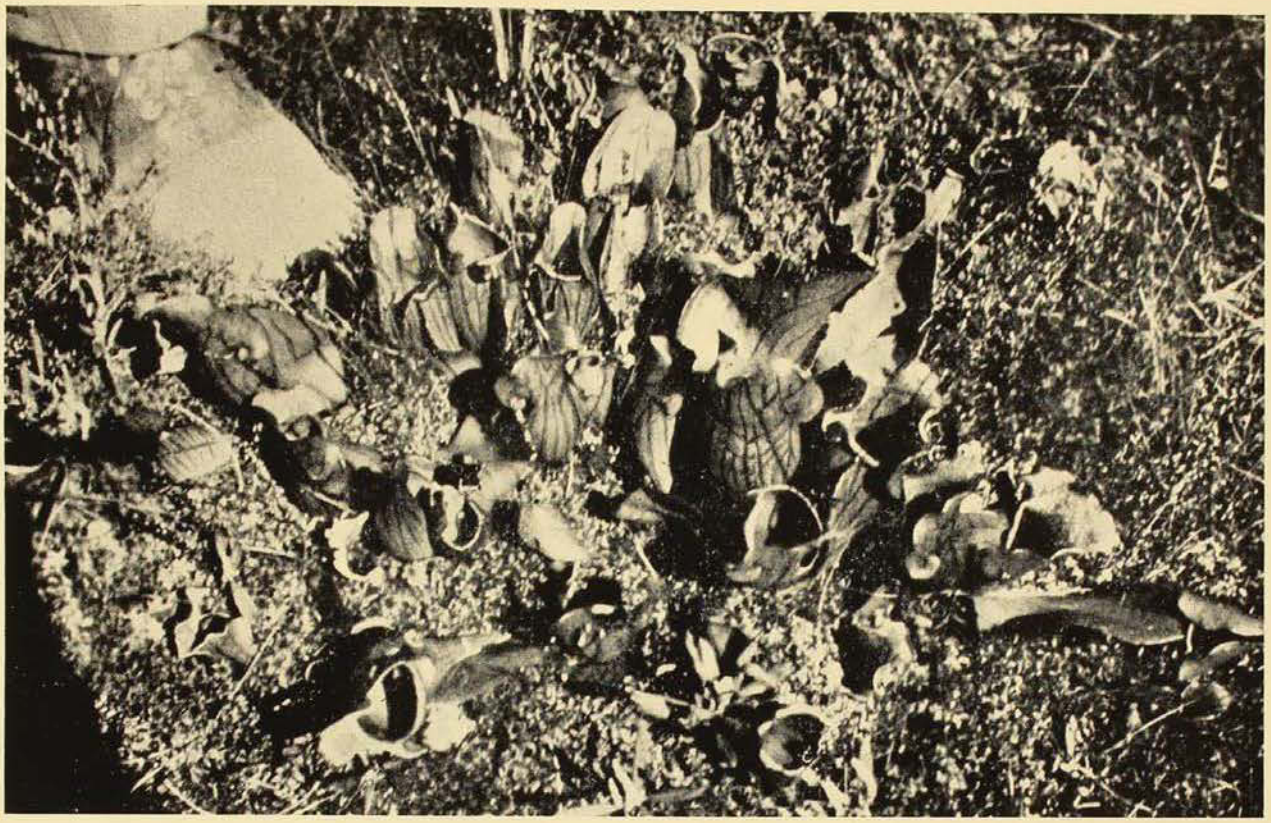
(*c*) The steel traps are a particularly ugly type of active trap, and were regarded by Darwin as the most marvellous in the world. They are developed at the ends of the leaves, like two valves of a shell fish. The margins are armed with stiff, bristle-like hairs. On the inner surface of each lobe are trigger hairs, which, when touched, cause the two lobes to spring together with the bristles on their margins interlocking. These traps usually remain shut until the trapped prey ceases to move; then the lobes open again to receive more victims.

(*d*) The mouse-trap type, the most complex of all, occurs in carnivorous plants growing in pond water, where the prey are small swimming animals. These are not just those simple spring "mouse traps", but the elaborate, automatic, self-setting ones which catch their prey as fast as they come. Added to this is a disposal arrangement which automatically empties the indigestible remains of the prey, for it is important that there should be room for fresh and continuous supplies of victims. The ingenuity of these traps, all compacted into rather insignificant little vesicles about five millimetres, or less than a quarter of an inch, in diameter, surpasses anything else in the plant world. Their complexity and uniquenes challenge Darwin's statement about the steel-trap type of mechanism, mentioned earlier. Though there is considerable variation in the details of the designs of these traps among the different species, they essentially have two valves, a tripping mechanism, and a spring which opens one of the valves. The strange thing about these traps is that no similar mechanism is found among other plants, and, though the traps have moving parts, the property of irritability is not used, for plants, unlike animals, have no nervous system.

It would be impossible to provide anything like a description of these mechanisms in a short article. For such information the reader is referred to F. E. Lloyd's book, "Carnivorous Plants".

## Carnivorous Flowering Plants

Quite apart from their trapping mechanism, it is convenient to consider the carnivorous plants as two groups—flowering plants and fungi. For reasons of space, this article deals with the flowering plants only.



The Pitcher Plant (*Sarracenia*), found only in eastern North America, feeds on insects which fall into the wells of its pitcher-like leaves. There the insects drown in water and secretions from the plant, and are later digested by plant enzymes.

Photo.—Author.

These plants are widely distributed over the earth's surface. Some are confined to certain localities, like *Cephalotus*, to Western Australia, and *Sarracenia* to eastern North America, but others are ubiquitous, like the "sun-dews" belonging to the genus *Drosera* and the mouse-trap (*Utricularia*). Though they belong to families that are strictly carnivorous in habit, their families are scattered among the other families of Angiosperms, suggesting that the carnivorous habit among flowering plants has arisen a number of times during the course of evolution.

To some extent, the methods of capturing prey are common to all families of carnivorous plants, suggesting further that the origin of the trapping mechanism has been repeated several times. The complex mouse-trap type of prey-capturing organ is found only in the family *Lentibulariaceae*, and then only in the genera *Utricularia*, *Polypompholyx* and *Biovularia*. Other genera of this family, like *Genlisea*, have the lobster-pot type, and *Pinguicula* has the active fly-paper type. The development of the same trapping methods by different families of carnivorous plants is quite common. For example, the pitcher type of trap is found in *Sarracenia*, of the family *Sarraceniaceae;* in *Nepenthes*, of the *Nepenthaceae*, and in *Cephalotus*, of the *Cephalotaceae*.

**Australian Species**

The carnivorous flowering plants occurring in Australia are: The ubiquitous "sun-dews," or *Drosera*, species, with their active fly-paper traps; the rather rare *Byblis*, confined to Western Australia, with its passive fly-paper trap; the very rare pitcher plant of *Cephalotus*, found only in the extreme south-west of Western Australia, and *Utricularia* and *Polypomphloyx*, which grow in ponds and have complex mouse-trap vesicles attached to stolons that trail through the water.

Since all these plants contain chlorophyll pigment, and therefore should be self-supporting, it might be asked to what extent they depend on animals as a source of

energy. This is not known, but one thing is clear—their seed must be able to germinate and develop into a mature plant without being supplied with animal food, for the animal-trapping organs only develop as the plant matures. It may be that these plants require the rich nitrogen source or other substances supplied by their prey in order to develop the flowering stage with its subsequent seed development. This also is not known, nor is it known how this curious habit has apparently originated a number of times. What is clearly known is that a wide range of small animals are trapped, including many types of insects (flies, mosquitoes, ants, bees, wasps, butterflies, moths and beetles), spiders, nematodes, etc. After being trapped, these animals die and are digested by enzyme secretions produced in special glandular tissue on the trapping organs of the plants. The pioneering work on this digestion was done in the 1870's by the botanist J. D. Hooker, who kept Darwin informed of his experiments so that he could include the results in his book. Hooker proved that tiny pieces of meat were digested by the secretions of these plants. Since then, there have been many studies on the plants' "gastronomic habits" which amply verify the findings of those early workers.

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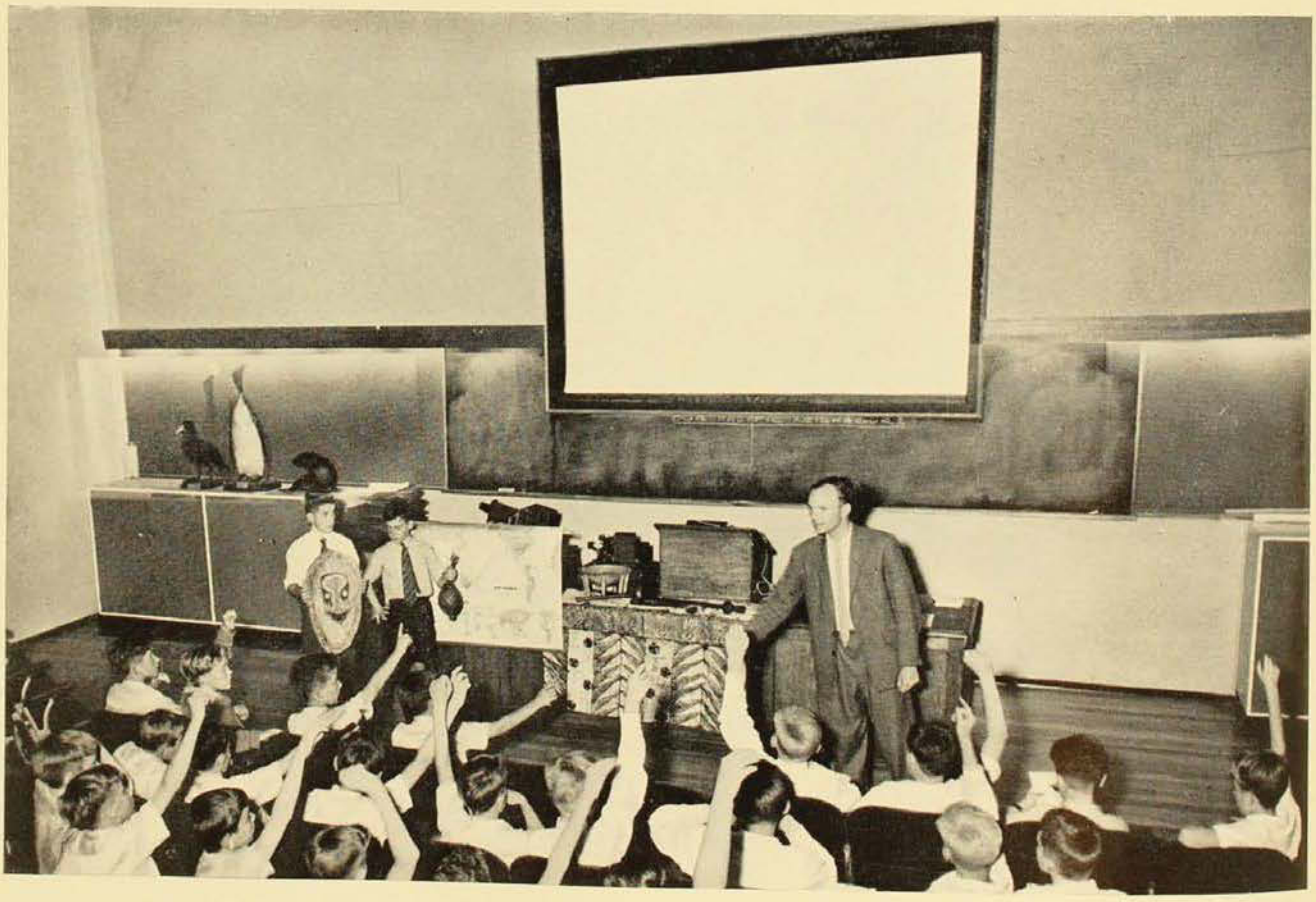
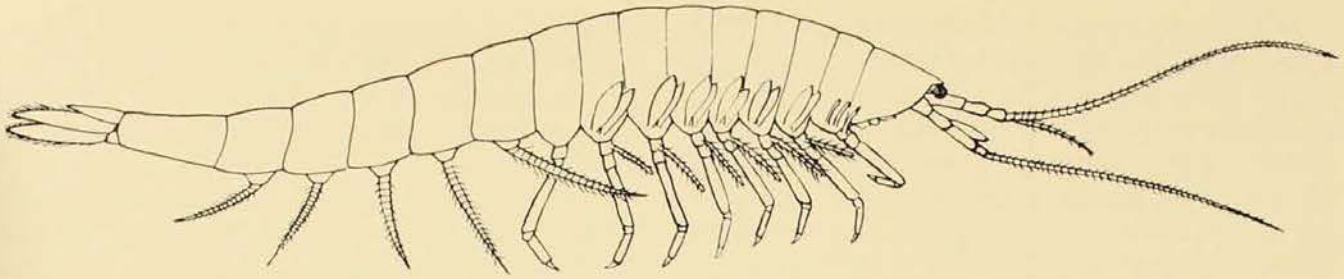
## *Class In The Museum's Hallstrom Theatre*



The Australian Museum's Assistant Education Officer, Mr. John Kirkpatrick, conducts a class of school children in the newly-designed Hallstrom Lecture Theatre. More than 12,000 children come to the Museum in classes every year for talks on natural-history and other scientific subjects.

Photo.—Howard Hughes.



*Anaspides*, the Tasmanian mountain shrimp, a "living fossil" which has survived, almost unchanged, since late Palaeozoic times, about 250 million years ago.

Drawing by the author.

# *The Syncarid Crustacea, A Living Link with Remote Geological Ages*

**By F. H. DRUMMOND**

Zoology Department, University of Melbourne.

THE discovery, a few years ago, of the remarkable coelacanth fish *Latimeria* naturally aroused intense interest, for it belongs to a group which was thought to have been extinct since the Cretaceous period. Equally important was the discovery in 1892 of *Anaspides*, the mountain shrimp of Tasmania, for it proved to be a member of the Syncarida, an ancient division of the Crustacea previously known only as fossils from the Permian and Carboniferous strata of Europe and North America. *Anaspides* differs so little from some of these fossil forms that it would appear to have persisted almost unchanged since Palaeozoic times. It is indeed a "living fossil".

A number of these crustaceans has since been found. One of them, *Bathynella*, had been discovered before *Anaspides*, but had not been recognised as a syncarid. This was perhaps excusable, for it is less than one-twentieth of an inch long, and, at the time, only two specimens were known. These had been collected from a well in Prague, and no more were found for 30 years. However, *Bathynella*, or allied forms, are now known from a number of localities in Europe and have also been described from Africa, Malaya and Japan. They are all subterranean in habit and, as is usual in such circumstances, are unpigmented and lack eyes.

Apart from the Bathynellids, present day syncarids are known only from Tasmania and Victoria. *Paranaspides*, the second species described from Tasmania, occurs in the Great Lake. For a period, following the raising of the water level in the lake and the resulting destruction of aquatic vegetation, *Paranaspides* suffered a severe decline. Fortunately, it has since recovered and now is not uncommon.

*Anaspides* lives in weed-grown pools and streams, fed by perpetually flowing springs, on the higher slopes and the plateau of Mt. Wellington, and also on some other mountains in southern Tasmania. It feeds on algal and diatom growths scraped from weeds and rocks, but also hunts and devours tadpoles and worms. In these pools *Anaspides* meets with little interference. This must be an important factor in its survival, for it is quite defenceless, and, as Dr. Manton has observed, can be killed instantly by a caddis-larva one-quarter its size.

Until recently only one syncarid was known from the Australian mainland. This is *Koonunga*, which was described in 1907. Originally it had been found at Ringwood, now an outer suburb of Melbourne, and the stream in which it lived was long ago converted to a storm-water drain. In 1930 Searle reported that he had searched the locality for it without success, and it was feared that *Koonunga* was extinct. During the past few years, however, it has turned up in a variety of places, and is now known to occur sporadically right across the southern part of Victoria.

While *Anaspides* and *Paranaspides* bear some resemblance to true shrimps, they are really quite distinct. In true shrimps, as well as in crayfish and crabs, the anterior segments of the body are covered by a shield or carapace which encloses a gill chamber on either side. In syncarids the segments remain distinct and there is no carapace, so that the gills, which are attached to the base of the legs, are freely exposed. Another peculiarity of most syncarids is that the female does not carry the eggs after laying; they are simply deposited on aquatic plants or in mud or debris and left to develop unattended.

*Koonunga* is quite unshrimplike both in appearance and behaviour. It is about one-third of an inch long, brownish in colour, and has a slender, almost cylindrical, body. Its eyes are very small, and, unlike those of *Anaspides* and shrimps, are not stalked. It can swim actively using its legs and abdominal appendages, but is more often found running rapidly over the bottom. This method of locomotion is so distinctive that *Koonunga* cannot be mistaken for any other aquatic animal. It must rely on its agility and on its capacity for burrowing into mud to escape from enemies, for it is quite helpless against predatory aquatic insects. Indeed, it sheers violently away after contact with creatures much smaller than itself. Its diet is predominantly vegetarian, but it also eats dead animal tissues.

*Koonunga* lives in small permanent or semi-permanent swamps and in pools in streams which flow vigorously only after heavy rains. Since many of these places are apt to become dry during the summer, and since the adults cannot withstand desiccation, it had been supposed that *Koonunga*, like so many other fresh-water crustaceans, would lay drought-resistant eggs. We now know, however, that the breeding season is during winter. The eggs, which are inserted singly or in small batches into decaying plants, develop over a period of about two months and hatch in the spring.

It thus seemed that *Koonunga* could survive drought only by descending underground; and, in fact, we have obtained them from pits 2 ft. to 3 ft. deep in the beds of dried-out streams. *Koonunga* can burrow swiftly into soft mud, but would not seem capable of forcing its way through heavy subsoil, and the indications are that, in making its descent, it uses the burrows of fresh-water crayfish. These crayfish are known to follow the water table down to a depth of 6 ft. or more, and could thus provide a safe refuge for *Koonunga* during periods of drought. In some places *Koonunga* must remain underground continuously for six months or more.

From this mode of life it would seem only a short step to a wholly subterranean existence, and work in Victoria over the past few years does indicate the presence of a rich underground fauna of syncarids. So far four new species have been found. As might be expected, they lack eyes, and have suffered a general reduction in pigmentation so that they have a translucent white appearance. The largest species is nearly half-an-inch long, the smallest only one-sixth of an inch.

Though these syncarids are typically subterranean in habit they may, in special circumstances, live in surface water, and this is where we have found them. Chance has played a large part in their discovery, for the pools are often only temporary. One species was found at the base of a fallen tree in a shallow pit which contained only about six inches of muddy water and which, on a second visit three weeks later, had dried out. Pools such as these are advantageous to syncarids in that few other aquatic animals live in them and there is therefore little competition.

A characteristic of this and other localities where these subterranean forms occur is the abundance of land crayfish. These peculiar crustaceans, which occur only in Tasmania and in Victoria south of the Dividing Range, are not dependent on surface water. They live in damp soil, in which they construct tunnels running almost vertically to a depth of many feet and ending commonly, if not always, in a pool of water. It seems highly probable that these pools provide the normal habitat for the syncarids.

The survival of *Anaspides* almost unchanged since Palaeozoic times has been attributed to its living in a stable environment and to its freedom from predation. Conditions on the mainland are less stable. *Koonunga* and its allies would seem to owe their survival to their close association with the fresh-water and land crayfishes.

# THE LIFE AND HABITS OF THE SAWFLY

By P. B. CARNE
Principal Research Officer, Division of Entomology, C.S.I.R.O.

SAWFLIES are structurally among the most primitive of the Hymenoptera, and lack the highly-organized social life of many of the more specialised ants, bees and wasps. They include a number of species of major pest status, e.g., the Pear, or Cherry, Slug.

Australia has a large fauna of native sawflies, many being associated with eucalypts. The largest genus is *Perga*, and the best-known species, *P. dorsalis*, the common "spit-fire" of the Sydney area. The larvae of this insect are commonly seen clustering during the day in compact colonies on the branches or trunks of eucalypts. When disturbed the larvae raise their heads and tails in unison and disgorge a sticky yellow fluid smelling strongly of eucalyptus.

A closely related species, *P. affinis*, is common in central New South Wales and northern Victoria. Its favoured host trees are the forest red gum and yellow box, both of which it often completely defoliates. A current study of the ecology of this sawfly has revealed some interesting facts concerning its life cycle and behaviour. Some of these are described in this article.

A colony of Sawfly larvae, in their final growth stage, moving across the ground from a tree they have severely defoliated to another.

Photo.—Author.

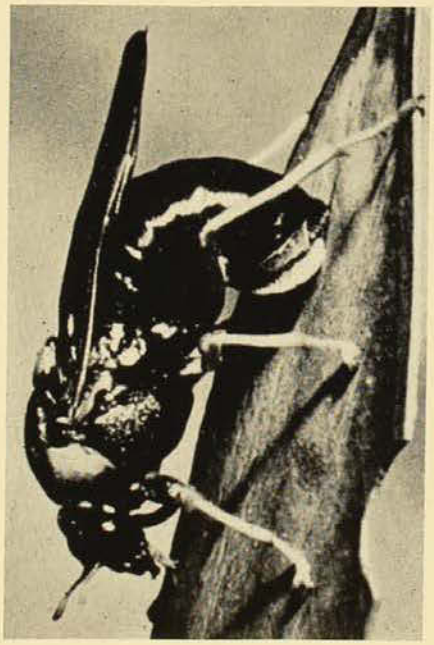
## Life Cycle

The adult wasps, which are a dark metallic green with pale brown transparent wings, are active during February and March. They emerge from honeycomb-like masses of cocoons found in the soil against the trunks of trees. The females fly actively, seeking suitable leaves in which to lay their eggs. Males are very scarce, and it is almost certain that they play no part in reproduction. The eggs are laid in a long row adjacent to the midrib of the leaf, and are completely enclosed in the tissues; they take some 30 days to hatch. The young larvae immediately cut their way to the surface, where they congregate in a circular pattern, their heads directed outwards. They spread out at night to feed on the leaf margin, resuming their cluster formation before dawn. Later in their development they cluster on twigs, branches and, finally, on the trunk, moving out every night to feed on young foliage.

Altogether, they pass through six growth stages, or instars, while on the tree. In early summer they cease feeding, and the colonies crawl down the trunk, burrow into the litter and soil below and form compact masses of hexagonal brown cocoons, each about an inch long and a quarter to half an inch wide. Inside the cocoon the larva moults

again, giving rise to a prepupa. This sedentary, non-feeding stage persists until pupation and emergence of the adult in February. For reasons as yet not definitely known, a variable proportion of prepupae fail to pupate at this time and carry over for another 12 months. Indeed, prepupae have been known to persist for as long as four years before successfully giving rise to adult wasps. This phenomenon could be of major importance to the species, ensuring its survival even during a series of years in which adverse conditions obtain.

With this brief account of the life cycle of the sawfly as a background, we can now discuss certain of its features in greater detail.



*Above*: A female Sawfly scraping the waxy surface off a leaf before laying her eggs in a series of cavities beside the leaf's midrib.

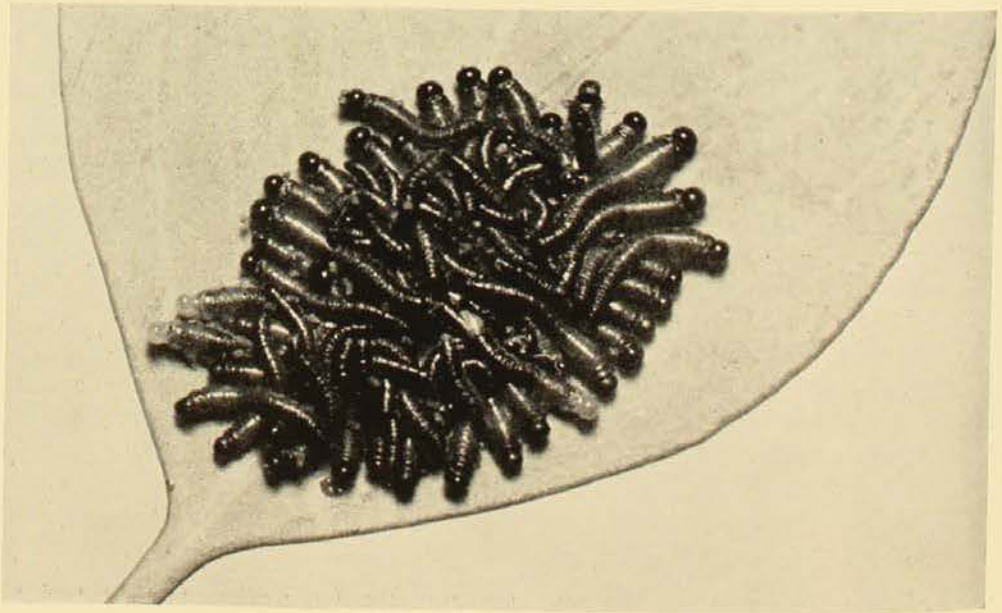
*Right*: In the daytime Sawfly larvae congregate in a more or less circular formation, with their heads pointing outwards. They move out at night to feed on the leaf margin, and resume their cluster formation before dawn.

Photos.—D. H. Wilson.

## Egg-laying A Laborious Task

After emergence and some flight activity, the female wasp sets about selecting a leaf for oviposition. She will often inspect a great number, walking over their surfaces, grasping the margins with her legs, and appearing to test the surface in some manner with her palps. She usually selects a leaf that has recently matured and is on a part of the tree protected from prevailing winds. She then moves head downward to the tip of the leaf, and begins a lengthy process of scraping away the waxy layer from its surface with her abdomen. At this time the ovipositor is retracted into a groove in the under-surface of her abdomen, but the raised outer margins of the groove bear a series of fine transverse ridges that make them an effective scraping tool.

By grasping the margins of the leaf with her claws, the female scrapes away by bodily force. Her action may be compared to the abrasion of a surface with a fingernail, pressure being applied as the finger is extended. By moving her body slightly to either side, she works over a median zone some half to three-quarters of an inch in width. She then moves slightly backwards and scrapes another area overlapping the first. In this manner she works her way backward towards the base of the leaf, stopping only if the leaf broadens beyond the



span of her legs. Having completed this portion of her task, she rests for a few minutes before moving to the tip again, crawling around to the other side and scraping that surface in the same way. Not content with this, she repeats the entire process two, three or even four times.

The leaf is now prepared for oviposition. The female moves back to the basal limit of the abraded area, withdraws her ovipositor and, holding it at right angles to her body, drives its point into the leaf just beside the midrib. The ovipositor is really a modified sting. It consists of two saw-toothed structures, one of which fits inside the other and can be reciprocated at great speed, forming a most efficient cutting device. When the ovipositor has been inserted by muscular force, the saw begins to operate. The whole organ then flexes sideways and penetrates through the midrib into the leaf tissues on the other side. Into the cavity so formed an egg is laid, passing down a duct protected by the chitinous walls of the inner saw. The ovipositor is then gently withdrawn, the female moves slightly forward and the whole process is repeated.

The eggs, of which as many as 100 may be laid in a single leaf, are elongate and colourless, and lie parallel to each other at remarkably regular intervals. The whole process of leaf preparation and oviposition occupies from two to five hours.

**Communication Between Larvae**

The larvae of *P. affinis* are at all stages highly gregarious, and aggregate in such a way that the abdomen of one lies across the thorax of another behind it. This contact is maintained during colony movement, each larva constantly checking on the presence of a follower by tapping with the hardened tip of its abdomen.

If a larva strays from the main colony and its abdomen fails to contact one of its fellows it becomes obviously disturbed and taps vigorously on the branch. The vibration is perceived by the colony, which responds with a barrage of similar tapping. The stray larva soon rejoins its fellows by moving towards the source of this vibration, stopping at intervals to obtain a new "fix". When all the larvae are united the excitement dies down and the colony remains motionless, except for occasional tapping by its hindmost members.

When disturbed the larvae react instantly, rearing their heads and abdomens and regurgitating quantities of the so-called "repugnatorial fluid", produced by a special gland that occupies the greater part of the thorax. This fluid appears to serve a variety of purposes. Its regurgitation is commonly supposed to discourage attack by birds. Whether it does so or not remains to be proved, but it is remarkable how little the sawflies are attacked by predators of any kind. The fluid is bitter, acrid and strongly redolent of eucalyptus oil; it may serve as a means of disposing of these oils, which form a substantial part of the larval diet. Apparently the oils are not digested but are in some way by-passed into this special gland, as larval excreta are dry and practically odourless. Finally, the fluid is an essential material for the fabrication of the cocoon, in which the insect spends a large part of its total life cycle.

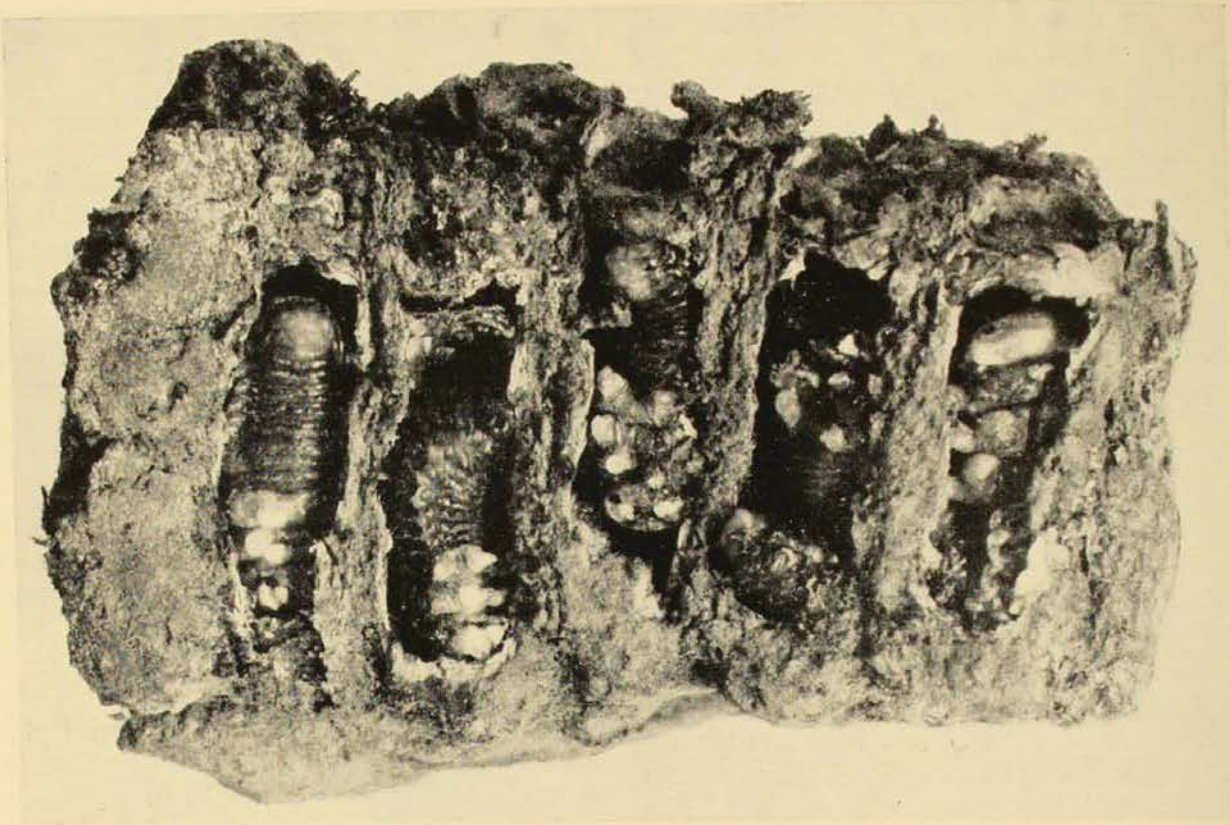
**Colony Migration**

If a tree is so densely populated that it becomes severely defoliated before the larvae are fully fed, the colony will readily climb down the trunk and move in an amoeboid fashion across the ground, directing its movement with great precision towards the trunk of another tree.

That the larvae can perceive objects at a distance can be demonstrated if the observer stands ahead of a migrating colony, and to one side of its line of movement. It will quickly respond by wheeling about and moving directly towards him. If the observer then steps back behind the colony, it will resume movement towards its original target, which once again becomes the nearest outstanding object on its horizon. Colonies have been observed to move from 20 to 30 yards over even ground, but they can probably cover even greater distances.

*Perga* larvae construct quite complex cocoons, and the process has been studied in some detail.

In early November, when the larvae are fully fed, the colonies leave the trees and burrow through the litter and into the top



Part of a Sawfly cocoon mass from which the cell walls have been cut away to show the prepupae inside.

Photo.—D. H. Wilson.

inch of soil adjacent to the trunk. They keep in close contact during their descent. First, they saturate and bind the surrounding soil with a mixture of faecal matter and repugnatorial fluid. This forms an open cylinder of rough fibrous material about each larva. The larva then adds to this, and forms a rounded base to the cocoon, by alternately smearing the inner surface with repugnatorial fluid and then overlaying it with a network of fine silk.

The silk is produced by special glands in the abdomen that open into spinnerets in the mouth. The upper end of the cocoon is lightly closed by an open network of fibres. The larva then moults in such a way that its cast skin lies in this upper region. The prepupa, as it now is, lacks repugnatorial glands, but is still able to spin silk. It lays down a sparse, open, transverse network which holds the cast skin in place. Then, a little below this, it constructs a thicker and much more complex transverse septum, perforated with small circular apertures. For some days thereafter, the prepupa moves about inside its cocoon, spinning additional silk on to its walls and, especially, the undersurface of the septum. Finally, it rests head-downward and remains in that position until just before pupating, when it must reverse its position to allow the adult wasp to leave the cocoon.

The adult cuts through the septum with its mandibles, pushes the septum and the overlaying cast skin aside, and climbs up through the overlying soil and litter. It is then fully matured, and immediately takes to its characteristic vigorous and buzzing flight.

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# Obituary: R. E. Baxter

The death occurred at his Lord Howe Island home on May 10th of Mr. Robert Ernest Baxter, 75, a keen naturalist who had settled there in 1906 and who since 1926 had been an honorary correspondent of the Australian Museum. Mr. Baxter was of much assistance to scientific visitors to Lord Howe Island. He collected many fishes, insects and marine animals there, and several newly-discovered species were named *baxteri* in his honour.—G.P.W.