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CONTENTS

● **FRONT COVER: The Grey-headed Flying Fox (*Pteropus poliocephalus*), which is found in the coastal areas from Rockhampton (Queensland) to northern Victoria. Flying foxes spend the day-time in camps in trees, going out in search of food at night. Some camps are estimated to contain 250,000 flying foxes. The photo on our cover was taken by Mr. J. E. Nelson, of the Zoology Department, University of Queensland, whose article on flying foxes appears on page 12.**

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New Caledonia, the Coral-ringed Island

By ELIZABETH C. POPE

THE islands of the New Caledonia group are situated on the edge of the tropics, lying between latitudes corresponding to those of Mackay and Bowen on the Queensland coast, and are about 800 nautical miles to the east of Queensland. They enjoy a mild climate and are a delightful place to spend a winter holiday. Even in July and August air and sea temperatures make swimming, aqualunging and shore collecting along the many reefs very pleasant, while in the summer months the normal heat of those latitudes is tempered, so that the average maximum temperature remains about 80 degrees F., by the action of the strong E.S.E. trade wind (l'alizé) which blows across the island from the sea. The period of high summer should be avoided by the tourist, not because of heat, but because of the likelihood of cyclones.

Second only to New Zealand in size among Pacific islands, New Caledonia is about 250 miles long and about 30 miles across. Like New Zealand, it is, geologically speaking, an old island, and has been widely separated from the larger continental land masses for so long that the migration of vertebrates to it was limited to those that could traverse wide stretches of sea and its vertebrate land fauna is a somewhat impoverished one when its comparatively large size and the ecological diversity of its habitats are taken into consideration.

Flying foxes (bats) are the only species of mammals native to New Caledonia, and one species known as the roussette is used in a justly famous and delicious stew. The Rusa Deer (*Cervus timorensis*), which now overruns the rolling savannah or Niaouli country on the western side of the island, was introduced in 1862 by the wife of one of the early governors. The pigs, introduced by man into the neighbouring island groups (New Guinea and the New Hebrides), did not reach New Caledonia before the settlement of the white man with his domestic animals and attendant pests, rats and mice. There are no frogs or land snakes and only a few species of lizards, including some endemic species of Geckos and skinks. Of 34 species of lizard, 30 are peculiar to these islands.

This outcrop of limestone, The Rocks of Heinghène, is a striking feature of the north-east coast of New Caledonia. It is also known as The Sitting Hen Rock or The Towers of Notre Dame, because of its appearance from different angles.

The occasional records of snakes which one meets in literature probably arise because the writers had encountered the black and cream banded sea snakes (*Laticauda colubrina*) during their land-going excursions to breed, as the author did when seven of them were seen during a short walk across the tiny coral cay, Ilot Amédée. The snakes were moving about very freely on the land, and only their flattened, paddle-like tails marked them as sea snakes.

Though one might expect fossil Horned Turtles (*Meiolania*) to be found in New Caledonia, since they are known from Walpole Island and from tiny Lord Howe Island, to the south, there is as yet no record of them.

Unique Fish

The only freshwater fish recorded from New Caledonia is an extraordinarily interesting one belonging to the family Galaxiidae—a family which otherwise has an exclusively southern distribution through New Zealand, Tasmania and South America. In fact, this unique fish, *Neogalaxias neocaledonicus*, is the only one of its family to occur anywhere in the vicinity of the tropics. One wonders if it is coincidence that it lives in the Lac en Huit (8-shaped Lake), on the Plain of Lakes, an area on the island famous as the home of many "living fossil" plants.

As in most of the islands of the south-west Pacific, birds are the most conspicuous of the land vertebrates; the recent survey by the noted American authority, Ernst Mayr, lists 68 native species of land and freshwater birds, of which 16 may be considered peculiar to New Caledonia. Included in this fauna are grebes, herons, ducks, birds of prey, button quails, rails, a few parrots and lories, cuckoos, owls, kingfishers, honey-eaters, numerous song-birds, pigeons (including the giant dark pigeon known as the Notou) and, probably the most interesting of all New Caledonian birds, the Kagu or Cagou (*Rhinochetos jubatus*).

Feathers of the Notou were formerly used to decorate the masks of the tribal sorcerers, as may be seen in the Museum in Noumea, but the bird itself is scarcely likely to be seen by tourists since it lives in the topmost canopy of the forest trees.

Also living in the forests in the southern part of the island is the ground-dwelling Cagou—a most peculiar greyish-coloured bird, about the size of a rooster, which emits a cry like the barking of a small dog. The pair seen by the author were in captivity and obligingly strutted about upon our approach with stiffly held wings and raised, outsized crests. Unfortunately, the visit was made at dusk and no flashlight was available, so no attempt could be made to photograph this rarity. Its food consists of worms and the Giant Snails called (Bulimes), which are also native to the islands. Although the Cagou is chiefly nocturnal, its somewhat trusting habits and its loss of ability to fly have made it an easy prey to hunters and domestic dogs, so it is now all but extinct. Wings are present, but the birds seem to have lost the ability to take to the air. One other bird, a rail (*Tricholimnas lafresnayanus*), was also said to be flightless, but no specimen has been seen for 50 years or more. Unlike New Zealand and other islands of similar antiquity, New Caledonia may almost be said to lack flightless birds. P. J. Darlington, Jr., wrote in his "Zoogeography" (published by John Wiley and Sons, London, 1957) that this was evidence of the fact that the vertebrate fauna of the island is not, geologically speaking, an old one and has reached it by "island-hopping" rather than across land connections.

The humbler invertebrate land fauna of New Caledonia is, zoologically, extremely interesting, with many ancient and peculiar species, of which the Giant Snails (species of *Placostylus*) and many of the insects, spiders and millipedes are found nowhere else in the world, so that there is a high degree of endemism among them. Such animals are, however, of little concern to amateur naturalists as a rule. The marine fauna, however, more than compensates for any deficiencies in the land animals. It is abundant and varied, as one expects tropical faunas to be.

Native Agriculture

The aboriginal New Caledonians—the indigènes—are chiefly Melanesian in origin, like the warlike natives of New Guinea, Fiji and the New Hebrides, but in places along the east coast traces of Polynesian ancestry may be noticed in the people in one or two areas. As might be expected in a land where game animals were scarce or virtually absent, the indigènes developed an economy depending largely on fishing and agriculture —chiefly the raising of taro roots in irrigated, terraced gardens of surprisingly large size and apparently constructed according to very sound engineering principles. Traces of these former tarodières may be seen by most travellers in inland districts when the sun is at the right angle to light up the evenly spaced terraces on certain of the hillsides where the soil was suitable and where streams could be tapped at the right height to irrigate the gardens below. The present-day Melanesians seem to have lost or abandoned the art of cultivating their crops in this way and farm in a much less "scientific" manner.

Re-thatching a native house with reeds from nearby marshes. When the author and her friends approached, the workmen sat down on the ridge-pole and ceased work.

A typical view of New Caledonia's east-coast vegetation. Along the flooded Heinghène River mangroves are backed by Coconut Palms, with native forest clothing the mountains. A few characteristic Pins Colonnaires, with their pencil-like foliage, project above the general level of the trees, behind the house.

With the establishment of New Caledonia as a French possession many other races made their homes there, and a visit to the dawn market in Noumea reveals the surprising number of peoples who make up the kaleidoscopic population of the island today. Besides the people of European descent there are Indonesians, Vietnamese, Polynesians, Wallis Islanders and native peoples from distant French possessions such as Madagascar and Trinidad, along with the Melanesians, all milling around the vendors—a most interesting study for anyone with even the slightest interest in anthropology.

Outside the townships many native huts and villages are to be seen and vary in shape from beehive to rectangular, with walls either of thatch or mud. Many are thatched with reeds from the extensive swamps but a picturesque variation of thatching is provided by the use of bark off the Paper-bark Tree (*Melaleuca*), which is laid across the supports of the roof and held in place by heavy, flattish river pebbles. Some of the huts, with walls of sun-baked mud, have friezes running round them just above the ground, making the native villages most picturesque; they are generally surrounded by plantations of coffee, taro, bananas, tapioca or coconut palms, growing somewhat haphazardly together.

The Vegetation Of New Caledonia

The main island of New Caledonia is shaped like a long cigar and has a mountainous backbone that lends great beauty to the scenery. One can readily appreciate how Captain Cook was so forcibly reminded of Scotland that he called the territory New Caledonia. This chain of mountains, the highest of which is over 5,300 ft., play a major role in controlling the island's weather pattern, for they lie directly across the path of the moisture-laden trade winds. Approximately twice as much rain falls on the east as on the west coast, and since the ranges are

closer to the sea in the east the swiftly-flowing rivers soon empty into it without forming extensive marshes or flood plains. Consequently, the rolling type of savannah country which characterises the western (or Noumea) side of the island does not develop there, and the characteristic vegetation of the two coastlines differs greatly. In the east the shoreline is bordered by a fringe of graceful coconut palms, while the west coast is bordered mainly by mangroves known locally as Palétuviers. The mangroves on the east coast occur up-river rather than along the shore. The characteristic tree of the savannah is the Paper-bark called the Niaouli which, from a distance, has much the general form of a gum tree, so that the landscape looks strangely familiar to Australian eyes—a feeling which is strengthened by views of groves of She-oaks (Casuarinas), bracken and lantana scrub, with Mimosa bushes forming a general undergrowth. In Australia one associates Paper-barks with swampy country but in New Caledonia these trees flourish up the sides of mountains to 1,500 ft. or more. Niaoulis belong to the same major plant group as the Eucalypts and, like them, contain abundant oil in the leaves, which is distilled and used medicinally. Local belief attributes the fact that malaria is unknown in the island (though rife in the neighbouring New Hebrides) to emanations of essence de niaouli from the trees.

Another characteristic and picturesque tree is the Pin Colonnaire (*Araucaria cookii*), which is indigenous to this group of islands. It was because of the dense stands of these pines on the numerous small islets (of which Kunie is the largest) that Cook gave the name of Isle of Pines in 1774 to the group lying just south of the main island of New Caledonia. Many people mistakenly seem to apply Cook's name to Norfolk Island because it, too, possesses an indigenous but different species of pine.

A car trip from Noumea to the tiny village of Yaté on the east coast takes one into a terrain that seems to belong to a different and geologically older world. Even the vegetation has an archaic look on this mountain massif, typical of much of the country where mining is being carried out. The area has an extremely high rainfall and is traversed by delightful rushing streams, many of which drain towards the central, low-lying, marshy Plain of Lakes. Drainage from this area has been dammed up by the large Yaté Dam to form a huge artificial inland lake which now supplies water and hydro-electric power to southern New Caledonia. Extensive views across rolling hills, rather bare of vegetation, are enhanced by the rusty-red colour of the soil and weathered rocks. Underfoot the ground appears to be composed of "gravel", but a fistful of this "gravel", or a small boulder, will be found to weigh very heavily in the hand, due to the quantities of iron and other heavy minerals present.

Extraordinary Forest

It is on this southern mountain massif that one encounters the most peculiar forest known as the "Dry" Forest, on the slopes where the continual trade winds desiccate the plants in spite of the rainfall. Instead of the jungle-like growths which one looks for in the tropics there is a much more open, rather sparse-growing vegetation, with gnarled and stunted-looking trees such as the Mountain Kaori and the "Dry" Forest Araucaria (*Araucaria humboltensis*), and the archaic-looking *Araucaria imbricata*, with other resinous, stunted-looking shrubs forming a loose kind of undergrowth. This area is a veritable happy hunting ground for botanists, many of the species being not only confined to New Caledonia but also in the nature of "living fossils". The soil is rich in iron, nickel, cobalt and chrome, elements often scarce in other soils, but it is poor in such essential elements as phosphorus and potassium; this may exclude many of the more ordinary plants from the area, allowing the archaic types to exist there free from competition from more highly evolved and "modern" plants.

Disappearance Of Jungle

It is becoming increasingly difficult for the tourist to visit and view areas of native jungle, for much of it has been ruthlessly cut out by the early timber-getters, especially the Sandalwoods. Scrub fires, as in Australia, are also a very serious menace to the rain forests. Once jungle is burnt out, Niaouli seedlings tend to colonise the fired

area and the original forest does not regenerate itself. Thus, the Niaouli country is increasing in area at the expense of the original jungle. Also, the papery bark chars readily during bushfires and protects the living matter of the Niaouli trees, so that they tend to survive fires, and, like the Australian gum trees, grow new foliage afterwards.

A good stand of jungle may be seen by visiting the little tourist resort at Mt. Koghi, just out of Noumea, and at the same time one may enjoy delightful views of the peninsula on which Noumea stands. Here walks have been cut through the hillside jungle which wind through the trees with trailing lianas and an undergrowth of tree ferns, pandanus palms and mosses forming a thick forest very reminiscent of Australia's tropical scrub. The thick carpet of leaf-litter is well populated by small, leaping amphipods (*Talitrus sylvaticus*), many insects, millipedes and earthworms but, although a search was made for them, no trace or record was found of the Giant Earthworms associated with similar forests in Australia.

On the roads leading into some of the jungle-clad valleys extensive masses of gossamer spider web obliterated from view the bushes along the side of the track. Patches up to 30 ft. or 40 ft. long, glistening with imprisoned water droplets which were catching the light, were not unusual and when examined closely were seen to be the communal effort of hundreds of spiders which lurked at intervals of about 6 ins. from each other among the fine veil of webs. For the most part, the jungle by day was strangely silent, and few animals were abroad.

Rich In Minerals

There is plenty to interest an amateur geologist in these islands, and the economy of New Caledonia depends almost wholly on the mining industry. Local residents refer to the "pigs" of nickel which one sees stacked on the wharves, ready for export, as "Noumea biscuits". Gold, silver, copper, lead, zinc, cobalt, manganese, iron and, most important, chrome and nickel are all found in workable amounts in the metamorphic rocks which outcrop at intervals throughout the island.

The chief concentration of minerals and, consequently, the main mining activity of the island is between Thio on the east coast and Noumea in the south-west, and is quite easy of access. Another geological attraction for tourist is the peculiar outcropping of limestone of dramatic proportions and shapes which runs like a jagged wall through the landscape near Heinghène, on the north-east coast. In one place it looks like a sphinx, in another like a ruined castle, complete with water-filled moat, and out to sea it forms the picturesque Towers of Notre Dame (or if looked at from another angle, a huge brooding hen).

World's Second Longest Barrier Reef

Another geological wonder is the barrier reef of coral which not only surrounds the main, long island of New Caledonia but extends far to the north and south of it to include the Belep Islands (north) and the picturesque southern islands. Every marine naturalist should make a trip by air to the Isle of Pines, on a day when visibility is good, in order to view the islands, reefs, cays and banks of coral along the route. It is a veritable demonstration in field coral geology. Owing to the elongated shape of New Caledonia its barrier reef is second only in size to that off the coast of Queensland, and is about 1,000 miles long. Being distant from the mainland on the average by only about six miles, it is much more accessible to naturalists than its Queensland counterpart and may be reached in quite small craft powered by outboard motors. The whole length of reef, with its sheltered lagoon, offers wonderful opportunities, especially on the leeward side of the island, for skin-diving, reef-hunting and fishing.

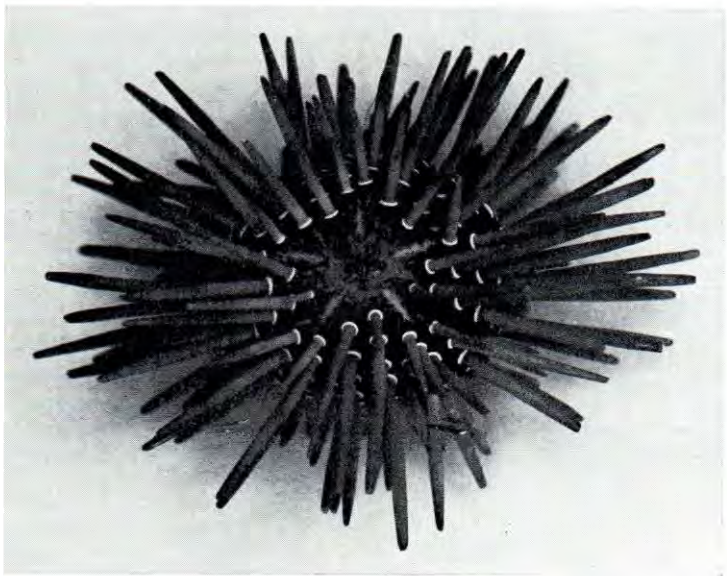
In some seaside suburbs of Noumea banks and clumps of coral grow along the shore and collecting there can be very interesting, especially at places like Rocher a la Voile or the point at Ricaudy (reached from Anse Vata). The former area provides a rocky substratum with boulders to turn over and the latter a series of sandy depressions and pools alternating with ridges of rock on which grow barnacles, corals, vermetid shells, bands of oysters and other bivalves, and cushions of zoanthid anemones of the *Palythoa* type.

The snail-like molluscs are also plentiful for those who know where to look for them. One tourist hotel on the east coast has a collection of cowries, nautilus, volutes and stromb shells that would make any collector envious. It is tantalising, too, to rake over the shore middens near the reefs where the indigènes hunt shellfish and to see from the broken pieces, opened to get the meat, what species may be expected in the region. Also interesting is the extraordinary variety of species used as food. There are four species of oysters alone. Of these, the one from the mangroves (Palétuvier Oyster) is, in the author's opinion, the tastiest. Turban shells and cockles also appear to be very popular as food.

The variety of colourful fishes seems to be almost endless, as one would expect in the tropics, and sea stars, sea urchins, brittle stars and, above all, Bêches-de-mer are more in evidence than in temperate waters such as those off New South Wales. In fact, New Caledonia is a regular happy hunting ground for an echinodermologist. Many of the species of marine animals are, as one would expect, identical with those from Queensland's Great Barrier Reef, but there are intriguing differences in the two faunas. A species which may be considered somewhat rare in Australia may be very common in New Caledonia (like the sea urchin *Parasalenia gratiosa*) or vice versa, so that collecting along the reefs can be extremely interesting to the expert.

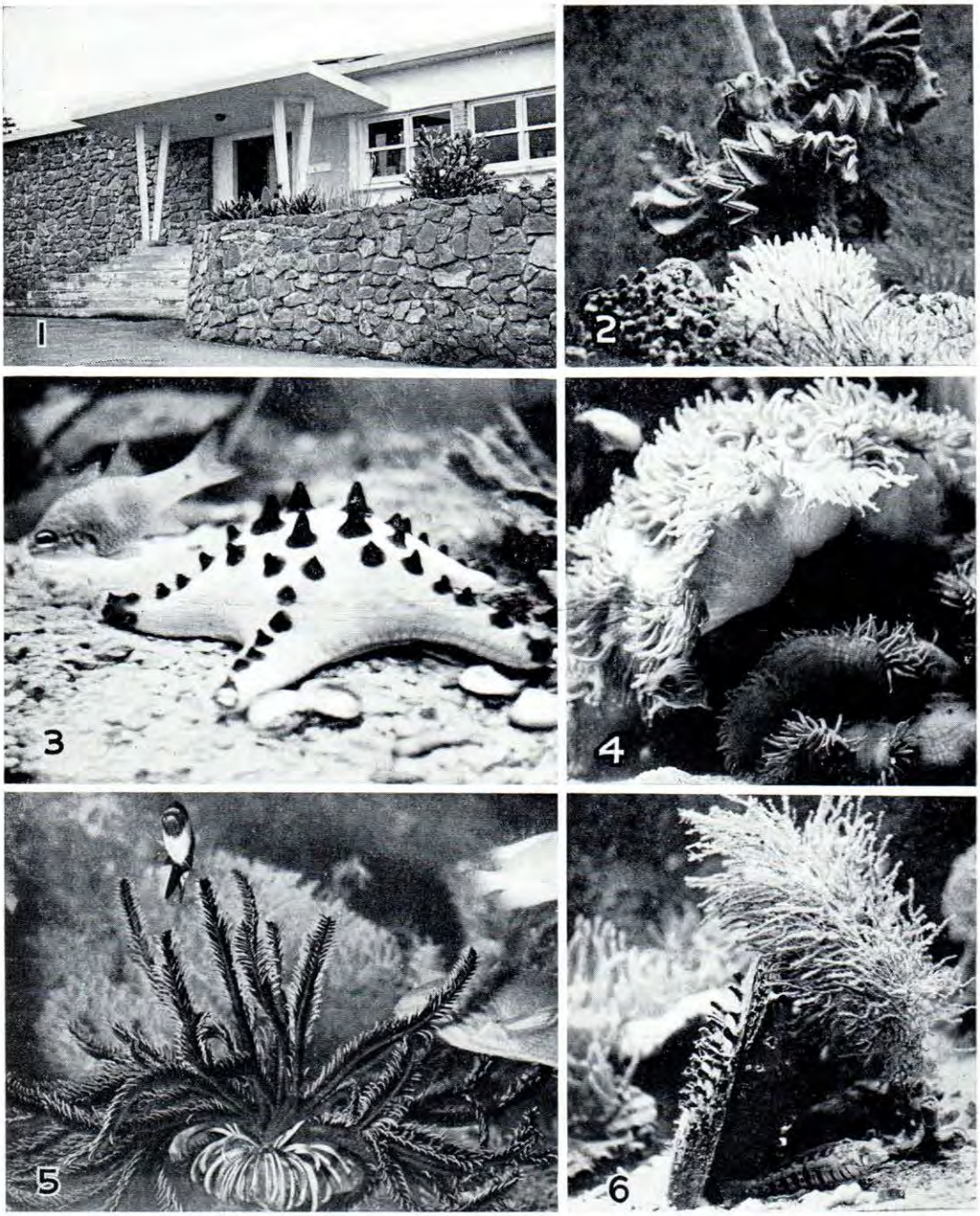
Delightful Aquarium

Noumea is now justly famous for its interesting and delightfully situated aquarium, which features displays of living corals and the associated fauna—probably the most interesting tropical collection of animals in the world. A most diverse and zoologically interesting collection of marine animals has been assembled, and some of them have probably never been continuously observed alive before, even by professional zoologists, because the problems associated with their capture and maintenance have hitherto not been successfully solved. The aquarium is owned and operated by Dr. and Madame R. Catala, both of whom have had extensive field experience in marine research, are expert skin-divers and show unflagging devotion to their captive reef animals. Over the years, they and a small band of "Friends of the Aquarium" have come to know the needs and habits of the New Caledonian reef fauna so intimately that they are able to set up and stock the aquarium and keep alive such "difficult" creatures as cuttlefish, pearly nautilus, rare deeper-water corals which they discovered fluoresced in ultraviolet light, tiny reef fish so beautifully



This dark-coloured sea urchin (*Parasalenia gratiosa*), with a white milled ring around the base of each of its spines, inhabits crevices and ledges under, or low down on, small coral boulders. Though one of the commonest inter-tidal sea urchins near Noumea, it is regarded as rather rare and sporadic in its occurrence in Australia.

Photo.—Mr. Justice F. G. Myers.



Noumea Aquarium is noted for its fluorescent corals and other beautiful creatures from the local reefs. (1) The Aquarium. (2) Coxcomb Oysters (*Lopha cristagalli*) from deeper waters, rarely seen alive. (3) Rhinoceros Seastar (*Protoreaster nodosus*), with a Big-eye Fish (*Apogon norfolcensis*). (4) Fluorescent corals (*Euphyllia* species) expanded and feeding, while a Squirrel Fish (bottom left) lurks nearby. (5) Black and Tan Feather Star (*Comatella maculata*). (6) A Grub Fish (*Parapercis cylindrica*) resting beside the Pinna-like bivalve *Atrina gouldi*.

coloured and patterned that they remind one of gaudy aviary birds, and many of the interesting commensal animals like the Giant Anemones and small Amphiprion Fish.

The site for the aquarium was chosen, after careful research, on a peninsula where clear, plankton-rich sea-water could be pumped to a hillside reservoir and from there reticulate to the aquarium tanks in a volume sufficient to maintain the plankton food-supply to the fixed animals and to keep the water in the clean natural state that so many of the reef animals need. Thousands of litres pass through the tanks every day and drain away on the opposite side of the peninsula from the point of intake.

Feeding the inmates of an aquarium is rather like running a diet kitchen for a lot of fussy hospital patients. Some, like the Butterfly Cod (*Pterois*), will eat only small fish of an exact size—neither more nor less—and the prey must be lively or it will be ignored. Another species, like the large blue-green *Coris* or Double-headed Fish, eats certain kinds of shellfish, which it cracks up like nuts in a nut-cracker. Others require a diet of crabs, while the large Rhinoceros Sea Star (*Protoreaster nodosus*) spends a lot of time in pursuing and cornering the Needle-spined Sea Urchin (*Diadema setosa*), whose armature of long spines does not seem to protect it from the bulldozing attack of the sea star.

Stinging Fishes

A special feature of the Noumea Aquarium is that one may view there such dreaded stingers as the Stonefish, the Butterfly Cod or Lion Fish, Needle-spined Urchins and the really vicious stinging urchin, *Araeosoma*, which looks like a blown-up beret covered with irritant spines and spikes, some of them electric-blue in colour. The collection includes a small brown anemone (genus not known) which inflicts stings, the large feathery stinging anemone *Actinodendron*, which retracts into the sand in the evening, and several stinging so-called "corals" such as Millepora and stinging hydroids. Sea snakes are also represented. So visitors may become aquainted with the appearances and habits of most noxious animals and thus avoid them on the reefs.

NEW NAME FOR MAGAZINE

The Australian Museum Magazine's name has been changed to *Australian Natural History* as from this issue.

The new title has been adopted because it more accurately describes the magazine's scope.

The nature and content of the magazine will remain unchanged.

Many hours may profitably be spent in the Aquarium either just admiring the beauties of the animals or making behaviour studies of their rhythms, feeding and reactions to other species. The story of the animals in the Aquarium alone would need the space of a large text book. Perhaps some day its story will be told in a fitting manner, but meanwhile it is a place every marine naturalist should visit.

There is no end to the interest that amateur naturalists may enjoy by visiting this most stimulating island of New Caledonia.

[*Photos in this article are by the author, except where stated otherwise.*]

ORNITHOLOGY IN THE MUSEUM

Dr. Allen Keast, Curator of Ornithology at the Australian Museum since 1957, has been appointed Assistant Professor of Biology at Queen's University, Kingston, Ontario, Canada.

Dr. Keast will be best remembered at the Australian Museum for his work in the preparation of the new bird gallery. In this work he transformed the old crowded and drab cases, filled with a bewildering array of perching birds, into colourful and modern exhibits.

Mr. H. J. de S. Disney, who has replaced Dr. Keast, is a graduate of the University of Cambridge, and has had a wide experience of ornithology in many parts of the world.

Before the war, in which he served in the R.A.F., he collected birds in North Finland and Newfoundland, and subsequently spent a period on the staff of the Kaffarian Museum in South Africa.

In recent years he has been an applied biologist in East Africa, engaged in the study of the biology of various injurious birds and mammals.

Little Red Flying Foxes (*Pteropus scapulatus*) hanging from trees at Grafton, New South Wales.

Photo.—Author.

FLYING FOXES

By J. E. NELSON

Department of Zoology, University of Queensland

FLYING foxes (or fruit bats, as they are sometimes called) are grouped into the sub-order Megachiroptera of the order Chiroptera; bats comprise the other sub-order, the Microchiroptera.

"Chiroptera" means "hand-winged", which describes accurately the wings of bats and flying foxes, for the wings are a double fold of skin stretched between the body, the arm and the greatly elongated finger bones.

The Megachiroptera are blossom, nectar and fruit eaters, and are found from Africa through Egypt, India, the Malay Peninsula, the islands of the East Indies and New Guinea to Australia.

The Microchiroptera are mainly insect-eaters, although some species feed on blood, fish, small birds, smaller bats, and fruit. They are cosmopolitan, found in both the Old and the New World.

In Australia there are 10 known species of Megachiroptera, varying in size from the small solitary blossom bats, only 2 in. to 3 in. long and weighing ½ oz., to the large colonial flying foxes, which are about 10 in. to 12 in. long and weigh about 2 lb.

Huge Camps

The smaller Megachiroptera are rarely seen, and little is known of their habits. The four large colonial species of flying fox, of the genus *Pteropus*, are found in coastal Queensland in large "camps", some of which have been occupied seasonally for 80 years. In Northern Queensland these camps are very large, Ratcliffe has estimated that in some of them there were a quarter of a million flying foxes. In

these camps, which may be found in rain forests, tea-tree swamps, or mangroves, the flying foxes spend the day sleeping, scratching and fighting.

The four large colonial species differ in their geographical distribution and in their habits:—

- *Pteropus poliocephalus,* the Grey-headed Fox, is found in the coastal areas from Rockhampton (Queensland) to northern Victoria.
- *Pteropus gouldi,* the Black Fox, is found in the coastal areas from Broome (Western Australia), through the Northern Territory, Cape York and New Guinea, to just south of the Queensland-New South Wales border.
- *Pteropus conspicillatus,* the Spectacled Fox, is found in New Guinea and in Cape York Peninsula as far south as Cardwell.
- *Pteropus scapulatus,* the Little Red Fox or Honey Fox, is found from Roeburne (W.A.) through the Northern Territory, Queensland and New South Wales. This species may be found up to 400 miles inland.

Normally each species forms its own camp, but occasionally two or three species may be found in the one camp. In one such camp, in the southern part of its range, a small group of 200 *Pteropus gouldi* were found in a camp of *Pteropus poliocephalus* containing 8,000 to 10,000 individuals.

The Search For Food

At dusk, the flying foxes leave their camps in long columns to search for food. As the column moves over the countryside, the flying foxes spread out from the column and fly to flowering blossoms, which form the main constituent of their diet. They prefer the blossoms and nectar of eucalyptus, tea-trees, apple gums, and bottle brushes, and the fruits of rain-forest trees such as figs and quondongs.

A small percentage of flying foxes prefer cultivated fruit, and the preferred fruit varies with the species. *Pteropus poliocephalus,* for instance, does not favour citrus fruits or mangoes, whereas *Pteropus gouldi* considers both a great delicacy.

On their nightly feeding forays, flying foxes may move up to 40 miles from the camp. In the early hours of the morning,

Grey-headed Flying Foxes (*Pteropus poliocephalus*) at Murwillumbah, New South Wales.

Photo.—Author.

they begin to arrive back in the camp in twos and threes, so that by dawn all have returned.

In all species except *Pteropus scapulatus*, the single young are born about October; in *Pteropus scapulatus*, the young are born in April. The birth occurs while the female is hanging from a branch, and, as soon as the young emerges, the female presses the young against her body to prevent it from falling until it has attached itself. The claws of the young have sharply-curved tips, and the teeth curve towards the rear of the mouth. By biting into the teat, and by hooking the claws into the fur, the young are able to cling to the female while she flies about the camp.

The young are born with their eyes open, and with no fur on the ventral surface. They are carried everywhere by the female for the first month or so of their life, even to the feeding grounds. When they are about a month old the fur has grown on the ventral surface, and the young are left in the camp at night while the mother flies out for food. At this age the young are unable to fly. The young are fed by the mother when she returns in the morning, and each female finds its own young—apparently by smell. When the young are two months old they can fly, and at three months they leave the camps at night to feed.

Flying foxes locate the blossom on which they feed by their sense of smell. Moehres and Kulzer have shown that *Rousettus* (the tomb bat of Egypt) is able to locate 100 milligrams (or 1/300 of an ounce) of banana extract from a distance of three to four metres (about 10 ft. to 13 ft.), and is able to distinguish between the synthetic banana essence and the natural banana extract.

Echo-location

The Megachiroptera, unlike the Microchiroptera, do not use ultrasonic sounds (those above the range of human hearing) to echo-locate obstacles. The Microchiroptera emit, from the larynx, pulses of ultrasonic sounds, and they are able to locate obstacles by listening for the echoes from them. As the obstacles in which the Microchiroptera are interested are small insects, the wave-length of the sounds must also be small, hence the necessity for ultrasonic sounds of short wave-length.

No Megachiroptera produces ultrasonic sounds, but three species of the genus *Rousettus* use audible sounds to locate obstacles. As these obstacles are the walls of caves and tombs, there is no necessity for an ultrasonic sound. In complete darkness *Rousettus* echo-locates, but when there is sufficient light it avoids obstacles by using its eyes as do all other flying foxes.

The eye of a flying fox is unique in that the wall has been pushed up into 20,000 to 30,000 conical projections, so that the visual elements lie on the sides of the conical projections like "trees on a mountain". The result of this is that objects at various distances from the eye are all in focus at the same time, but at varying levels in the cones. During the day, the size of the pupil is reduced to a pin-head, while at night the pupil widens to allow a larger amount of light to enter the eye. The eye of a flying fox is well adapted for vision in twilight, and in flight, and owing to changes in pupil-size the flying fox is able to see very well during the day.

The Microchiroptera, on account of their small eye (which functions like a pin-hole camera), have all objects in front of the eye in focus at the same time. But, in spite of this, they have very poor vision, for they can only see objects which subtend 15 degrees at the eye.

So the old saying, "As blind as a bat", is true, but from the term "bat" we must exclude the flying foxes.

One of the most outstanding features of all Chiroptera is their ability to hang upside down. The Chiroptera are able to do this because the blood from the wings and from the head is pumped back to the heart and against the force of gravity by the autonomous beating of the veins themselves. In the wings, these veins are supplied with valves so that the blood will not be forced back into the arteries with the beating.

During their evolution, flying foxes have become highly adapted to a nectar-feeding, nocturnal life. This adaptation is no doubt the main reason for the success of the species.

CHIMBU PLUME TRADERS

By RALPH BULMER

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SINCE the 1920's it has been illegal for Europeans to trade in bird of paradise plumes. Before that thousands were sent each year from New Guinea to the milliners of Europe. Today the greatest traders in birds of paradise are the Chimbu, named after the small highland valley which is their traditional home, and the related peoples of the Wahgi Valley. It is hard to find any part of the recently controlled interior of Australian New Guinea where Chimbu do not penetrate, demonstrating in an unusual way the truth of the old adage that trade follows the flag.

There are good reasons why it is the Chimbu who dominate this trade. Plumes were, and still are, extremely important in their traditional way of life, not only, as in most parts of New Guinea, as ceremonial ornaments, but also as objects of value used in formal exchanges and in particular in bridewealth gifts at any marriage. Two or three dozen skins may be included in a single bridewealth.

The 60,000 Chimbu are among the most densely settled people in the island. Dr. Brown and Dr. Brookfield, of the Australian National University, who have recently made a detailed study of their social organisation and system of land-use, report that some Chimbu communities are living at densities of up to 600 per square mile. This means that both natural and cultivated timber are sparse in their domain, and birds of paradise, which require tall tees and thickets, are correspondingly scarce. Increasing pressure of population, the cessation of warfare which in past times occupied the men, and the scarcity of local employment as a source of cash income, have all increased the impetus for outside trade, as is shown by the enthusiasm with which Chimbu sign up for paid labour away from home.

A dancer at Christmas celebrations on the northern slopes of Mt. Hagen wears bird of paradise plumes collected in the Papuan lowlands, more than 300 miles away.

Photo.—Author.

The Lesser Bird of Paradise (*Paradisea minor*).
Photo.—Capt. Frank Hurley.

The Chimbu traded plumes from their immediate neighbours long before 1933, when Europeans first met them. According to Father Nilles, an anthropologically-trained missionary who has lived for many years among them, they made expeditions to the north slopes of the Bismarck Mountains and into the Upper Jimi Valley, to barter a wide range of commodities. We may assume that these included feathers. Thus the Chimbu have a tradition of external trade by barter, as well as the highly developed systems of gift-exchange between kinsfolk and in-laws present among all New Guinea peoples, which accounted for most of the flow of goods and services in pre-European times. What is striking now is the geographical range to which they operate. In my own travels in New Guinea in 1955-56 and 1959-60 I met or heard reports of them on the north slopes of Mount Hagen seeking the long-tailed Sickle-bill, Stephanie's and Ribbontail Birds of Paradise of the mountain forest; in the Sau Valley, further to the north, purchasing the Blue (Rudolph's) and Yellow (Lesser) Birds of Paradise of the northern mid-mountain and lowland forest; in the Schrader Mountains, seeking the enamel-plumed Duke of Saxony and anything else they could get; in the Jimi Valley, which is particularly rich in the Yellow Bird of Paradise; and at Tari in the Southern Highlands, where they were acquiring, in particular, the fast-disappearing Blue Bird of Paradise which abounds there in the tracts of tall timber between the garden lands.

Many Chimbu reach these and similar localities by getting legitimate employment there as policemen, storekeepers, medical orderlies, forestry workers, or servants to Europeans, and then trade in feathers on the side. Others set out on free-lance trading expeditions, consisting generally of half a dozen or so men and boys. The wide distribution of Chimbu employees on European stations throughout the interior assures them of hospitality and protection. In some parts plume trade is combined with other enterprises, such as gold-panning or casual work for Europeans. Mainly they get from place to place by walking, but some buy flights in aircraft to localities like Tari, which are difficult to reach by land.

They offer both money and goods for feathers. In 1955 traders in the Baiyer and Sau Valleys were offering up to 10s. or 12s. for a skin of Stephanie's Bird of Paradise, and up to 15s. for the Lesser Bird of Paradise, though they apparently acquired many for less than these sums.

Most frequently their aim is to purchase feathers, but sometimes they also offer them for sale. Two parties came through Yaramanda, the Kyaka Enga settlement on the north slopes of Mr. Hagen, where I was working in the last four months of 1959. Both brought plumes of the Greater Bird of Paradise with them. This creature is very rare on the north slopes of the dividing range, and is more prized by the Kyaka than any other species except the *Harpyopsis* eagle. They timed their visits well, since the local people were preparing both for the four-day Christmas dancing and for the traditional cycle of ceremonial exchange festivals known as the Moka or Te, which occurs every four years or so, and there was great demand for ornaments for both these occasions. Local men said, cynically, that once the festivals were over the Chimbu would be back to buy-up the plumes again at cut-rate prices.

Each party visiting Yaramanda consisted of six men, or men and boys. The first group had 14 skins for sale, and the second 22, all in excellent condition. Although the red-plumed Greater Bird of Paradise occurs in the Wahgi and Chimbu Valleys, I was very surprised that surplus skins were available from these areas. However, examination led me to suspect that they came from somewhere else. The highland variety of this species generally has deep red, almost tawny, display tresses: these trade plumes were brighter and glossier. When I asked where they came from, I was told Port Moresby. One or two members of each trading party, together with kinsmen not then present, had been indentured labourers in the Papuan lowlands and had bought the feathers from the local Papuans who legally owned shot-guns and illegally used them to kill birds of paradise. One very striking orange-tressed plume, with throat and breast feathers which also differed from the rest of the collection, was said to come from "Kasem near Madang and Lae" (i.e., from somewhere in the northern coastal belt) where, again, it had been purchased by an indentured labourer.

Costly Skins

The Chimbu said that they had paid up to £5 for each skin, and that one particularly magnificent ornament made of the display tresses of two birds had cost £10. I took this to be salesman's hyperbole, for I found it hard to believe that a group of indentured labourers, earning, at that time, only 25s. each month, could raise over £100 to buy feathers. On the other hand, Dr. Murray Groves has told me that Gabadi shooters in the Galley Reach area near Port Moresby sometimes obtain as much as £5 for a single bird from Chimbu labourers on the rubber estates.

In any case, the Chimbu were not now asking money for their wares. They said they wanted pigs, or, alternatively, skins of the long-tailed birds of the mountain forest. One pig they had already accepted for a plume was quite a small one, less than 30 lb. in weight and not worth more than 30s. by local standards. When I asked why they were prepared to accept such a small return for an object which had cost them so much, they said that pigs were very short in Chimbu and much more valuable than here, and that in any case they came on these expeditions more for the adventure and the interest than for material profit.

Traders' Cool Reception

The reception the traders get is variable. In 1955 the Yaramanda people received them most hospitably, but the 1959 parties had a cooler reception. When the first arrived, the assistant headman of the local clan, a Christian convert, addressed the assembled crowd, using the local language which the visitors could not understand, and exhorted them not to give their pigs or hard-earned money for mere feathers. The headman, a pagan, did not criticise the trade as such, but nevertheless made a speech, which he had translated to the traders, to the effect that it was traditional among his people to offer food freely to visiting strangers; however, he said, some youths from Yaramanda had recently walked through Chimbu territory while travelling in search of work, and had had to pay 1s. for a meal of a few sweet potatoes, and therefore the Chimbu themselves should expect to pay for food that they were given. The assistant headman meanwhile sent a youth to fetch a bunch of cooking bananas. The Chimbu leader ostentatiously gave him 9d. for it. The general opinion at Yaramanda was that the Chimbu were bad, dishonest people, but

Above: Chimbu arrive at Yaramanda settlement with plumes, wrapped in flat parcels of pandanus leaves and brown paper, for sale or barter. Right: They display 14 red plumes of the Greater Bird of Paradise.

Photos.—Author.

their sophisticated dress and appearance were admired—all wore garments of European cloth, were clean-shaven and had their hair trimmed short. I heard of no case in this area of trouble caused by Chimbu visits, but I have been told of bloody fights and litigation in some other places, started by men who alleged that the visitors had cheated them.

Although people from the homesteads all around flocked to Yaramanda meeting-ground to see the plumes, and clearly coveted them, only one prospective purchaser was found. This was a brash youth who had worked for Europeans and acquired more personal wealth than most. He announced that he would fetch a pig and give it for a plume; but he did not return until after nightfall, when the Chimbu had moved on. He said the pig had "gone bush" and he could not find it, but on questioning admitted that he had had a furious argument with his parents who had upbraided him for wanting to exchange a pig which he ought to be saving up for use in bridewealth. Unlike the Chimbu, the Kyaka do not use plumes in bridewealth or other ceremonial exchange, and only value them as ornaments.

When Christmas came, however, it was clear that men in other Kyaka settlements had succumbed to the temptation which Yaramanda had resisted, for several of the glossy orange-tinted plumes were well in evidence.

Law Broken

The Chimbu break the law by trading in plumes outside their own administrative subdistrict, and also by transferring livestock (i.e., pigs obtained by barter) from one subdistrict to another without a permit from the agricultural authorities, who are necessarily vigilant to prevent epidemic disease. European administrators, like local Papuans, give the Chimbu a mixed reception. Many, especially those on remote patrol stations, are very suspicious of them and of the trouble their activities may sometimes cause, and do their best to shift them out of their areas. Others find them useful in places where even semi-sophisticated and semi-skilled labour is at a premium, and turn a blind eye to their private enterprises. The Chimbu are now probably the most widely-travelled, confident and sophisticated people in the highlands, setting fashions in dress and trade and private enterprise which other groups quite clearly imitate. They are bound to become increasingly important as local and central government pass into native hands. It is unfortunate that their enterprise is necessarily illegal and inevitably leads them, sooner or later, into conflict with European authority.

As to whether this trade is eliminating the birds of paradise, absence of systematic study means that on this point one can only guess. My guess is that they are stimulating hunting to a dangerous extent in areas where particular species are barely hanging on, but that in the long run they are a much less important agency of extermination than the forest-clearing native gardener and the European-employed pit-saw team.

SCOMBROID FISHES

The Museum's Curator of Fishes, Mr. G. P. Whitley, attended a symposium at Mandapam Camp, South India, in January, to discuss Scombroid fishes, particularly those of Australia and New Zealand. The Scombroid fishes are the mackerels, tunas, kingfishes and swordfishes, all good food-fishes which range over great areas of sea. Their biology is therefore of international and economic importance.

ABORIGINAL CULTURE

Mr. F. D. McCarthy, Curator of Anthropology at the Museum, has been elected a member of the Interim Council of the Australian Institute of Aboriginal Studies, recently established by the Commonwealth Government to promote research work on the now fast-disappearing cultures of the Aborigines.

SURVEY OF BARK LICE

The Museum's Curator of Insects, Mr. C. N. Smithers, recently spent two weeks collecting in the coastal areas of New South Wales between Grafton and Sydney. The object of this field work was to collect the Psocoptera (or bark lice, a little-studied order of insects in Australia), as part of a survey of these insects in the State. Future field work is planned to cover other parts of New South Wales.

BOOK REVIEW

THE OPAL BOOK, by Frank Leechman; Ure Smith, 1961: pp. 255; pl., 9 colour, 10 b. and w. Price, £2/5/-.

As this reviewer wrote in the foreword to this book after reading the manuscript version some years ago, it is a noteworthy book because it is the first time that such a complete account of the subject has been written. It is full of the most useful information on all opal fields, both Australian and foreign, and it gives the latest and most correct theories on the cause of the play of colour in opal. Those who wish to go prospecting for opal will find much of interest on mining methods. A series of useful hints are given on how to grind and polish the precious stone.

The fact that so much information is available between the two covers of one book will be appreciated by those already interested in the subject. It should also arouse the interest of those not yet familiar with our national gemstone. The book can be recommended particularly to overseas visitors.

On the debit side, it is unfortunate that the author gives the impression that opalization is taking place at the present time by stating that an opalized skeleton of a cat was found at Lightning Ridge. He apparently misread the original account, which stated that the object was the opalized skeleton of a reptile as big as a cat. It was undoubtedly a Cretaceous plesiosaur which become extinct about 100 million years ago. Also, in a laudable attempt to discount the various superstitions about opal bringing bad luck, the author goes too far in the other direction and attempts to show that opals are bringers of good luck by quoting the phenomenal number of lottery prizes won by the well-known Sydney curio dealer who handled opals as a sideline. The more likely explanation of his success is that he bought a phenomenal number of lottery tickets.—R.O.C.

Notes and News

LUMINOUS EARTHWORMS

Mr. T. A. McDonald, of the Biology Department of Armidale Teachers' College, wrote to the Australian Museum some months ago enquiring about luminous earthworms. He said:—

"During a recent trip in north-western New South Wales, I saw for the first time a large earthworm showing a most marked luminescence. I found this species in a small creek-bank, near the Macintyre River, between Yetwan and Boggabilla. The discovery was entirely accidental, as I was using them and a somewhat similar species for fish bait".

Numerous records of luminosity in earthworms were found in books and research papers. It seems to occur in quite a variety of genera, including those in the family Megascolecidae, to which many native Australian worms belong. However, this is the first actual report of luminosity in an Australian species, according to the records and catalogues in the Australian Museum. Mr. McDonald was therefore asked to collect and forward some of these worms for inclusion in the Museum's research collection.

In September, some dozen or so worms taken at Goondiwindi in northern New South Wales were sent by Mr. McDonald and were alive when received, but their transportation by post had taken some time and they would not luminesce to order in Sydney. The worms were fairly large, varying from about 9 in. to 12 in. in length and being about four-tenths of an inch in diameter. They were a dark, purple-mauve above, with the lower surface lighter in colour, and belonged to the family Megascolecidae.

Most recent researches state that certain cells floating in the coelomic fluid in the cavities of the body of the worms contain granules and that these are responsible for the production of the light which one writer likens to the glow produced by "a bar of iron heated to white heat".

The fluid, with its light-producing cells, is often emitted as a response to stimulations to the worm of quite a minor nature, such as handling or the digging-up of the soil in which they live. The cold, luminescent light is produced by the oxidation of some light-producing chemical, but the presence of luciferin and luciferase (responsible for light-production in many other animal groups) has yet to be proved in earthworms.—E.C.P.

VISITOR TO MUSEUM

The Director of the South African Association for Marine Biological Research, Durban (Dr. David H. Davies), visited the Australian Museum in September. He is the author of a number of papers on sharks and shark attacks, and examined specimens and records in the Museum.

Two stonefish: *Synanceja trachynis* (left), with the more anterior of its dorsal spines erected, and *Synanceja verrucosa*, with all or most of its dorsal spines erected.

Photos.—Author.

STONEFISH

By R. ENDEAN

Department of Zoology, University of Queensland

OF the many kinds of venomous marine animals found in tropical Australian waters, few have a more sinister reputation than the stonefish. Evidently North Queensland Aboriginals were well aware of its venomous nature, for they used beeswax models of the fish and mimed the effects of a sting during their initiation ceremonies. However, there are few authentic records of stonefish stingings in Australian waters, although there is reason to suspect that many cases have, for one reason or another, not been reported. Be this as it may, stonefish well deserve their evil reputation for they have been responsible for severe injuries and occasional deaths in many parts of the tropical Indian and West Pacific Oceans.

Two species occur in Queensland. One, *Synanceja verrucosa*, has been found in Barrier Reef waters, while the other, *S. trachynis*, appears to be confined to mainland waters from Moreton Bay northwards. Both species have a grotesque appearance. Bony eminences, deep hollows and fleshy outgrowths occur in the head region, and wart-like bumps stud the trunk and extend onto the large fan-like pectoral (shoulder) fins. The up-turned mouth is partially hidden by a fringe of serrated skin. All these features tend to disrupt the contours of the fish. Further camouflage is provided as a result of the production of a milky fluid by the wart-like excrescences. This fluid forms a coating of slime over the fish and to this coating algae, detritus and small sedentary animals such as hydroids and polyzoans adhere. Should part of this coating be removed, the true colours of the fish can be seen. Even then, irregular blotches of rust-red, brown and white provide a good example of a disruptive colour pattern which tends to break up the outline of the fish.

Several structural features enable the two Queensland species to be distinguished readily. In each, the eyes are carried on bony bosses. In *S. trachynis* these bosses are conjoint and project well above the eyes. In *S. verrucosa* the bosses are well separated and do not project above the eyes. This species, too, has a remarkable mechanism for covering its white-encircled eyes, which are perhaps the only flaw in its camouflage. Below each eye there is a "drawbridge" of tissue. When this is raised it meets a flap of skin which is lowered over the eye and in this way the eye is completely hidden. The wart-like bumps on the skin of *S. trachynis* are larger and more numerous and there are deeper hollows in the head region than is the case in *S. verrucosa*. Also, the cavity of the mouth has a yellow green lining in *S. trachynis*, while the whitish lining of the mouth cavity of *S. verrucosa* is flecked with the red of small blood vessels.

Left: The eye (pupil arrowed) of the stonefish *Synanceja verrucosa*. Right: The same eye covered from below by a raised "drawbridge" of tissue and from above by a flap of skin—a form of camouflage.

Photos.—Author.

The habitat and behaviour of stonefish ensure that their camouflage is used to full advantage. Both species are sluggish and appear to spend the greater part of their time living on the substratum in shallow water. Recent observations indicate that *S. verrucosa* occurs chiefly amongst weed-covered coral rubble and/or dead clam shells where there is an admixture of coral sand. *S. trachynis* lies amidst weed-covered rocky rubble where there is a substratum of muddy sand. This species has been observed to settle in its hiding place. First, the large pectoral fins are used to scoop up sand and a hollow is formed into which the fish settles. Sand is then scooped up to cover the tail and part of the trunk. The fish then lies motionless, except for the scarcely detectable movements of its gill covers, and it will not move irrespective of the amount of disturbance created in its immediate vicinity. Its resemblance to a partially embedded weed-covered stone is complete, and it represents one of the best illustrations of camouflage to be found in the animal kingdom. The trained observer can detect the fish if a glimpse is obtained of the yellow-green lining of the cavity of the mouth framed in the crescentic slit of the partially open mouth, but otherwise there is no indication of the presence of the fish.

Voracious Appetites

Thus concealed, it waits for its prey—usually small fish, shrimps and other crustaceans—to swim within reach of its upturned mouth. Then there is a surprisingly swift upward leap, and the prey is engulfed. Despite their normally voracious appetites, it is usually difficult to entice stonefish kept in small aquaria to feed. Some fish have refused to eat for up to three months without apparent loss of condition. Average-sized adult specimens are about 11 in. in length, but they are reported to attain a length of about 2 ft.

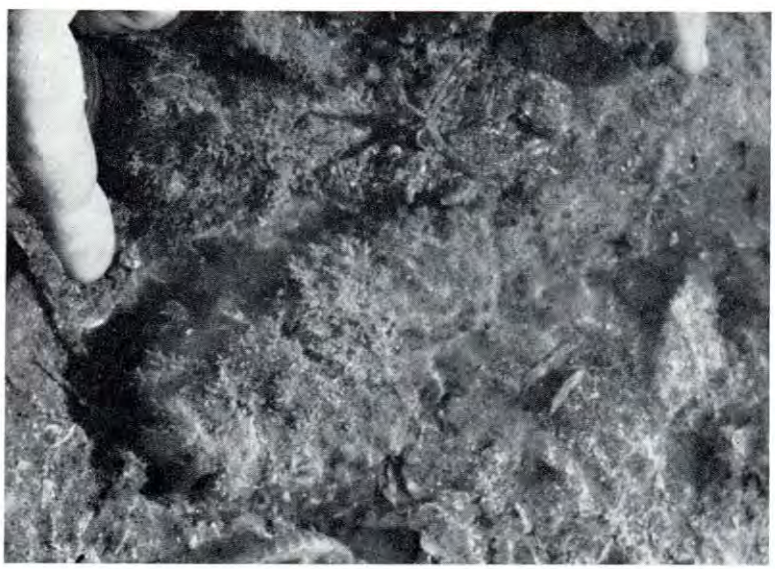


Photo of a stonefish (*Synanceja trachynis*) taken through 2 in. of water in its natural habitat. The fish is partially embedded in muddy sand and only its weed-covered upper surface is exposed. The head (to the left) and tip of tail are indicated. Note how the fish blends perfectly with its weed-covered surroundings. The features on the head which somewhat resemble a human eye and mouth are part of the algae-fringed lower jaw.

Photo.—Author.

At periods of low tide they may be exposed to the air and the main body of water may be a considerable distance away. At such times they utilize oxygen from the air. Indeed, as long as their surroundings are kept moist, they can survive long periods (at least 24 hours) exposed to the air.

When the fish is undisturbed, 13 stout spines, each enclosed by a fleshy sheath, overlie one another along the mid-line of the upper surface of the trunk. Attached to each spine are twin venom glands, and a duct from each gland opens near the tip of the spine. If a fish is molested, the spines are immediately raised and their tips protrude through their respective sheaths. Should a barefooted person tread on the spines, the sheath of each spine which penetrates the victim's flesh slides down the spine and constricts the twin venom glands. Venom is then forced through the ducts leading to the tip of the spine and injected deeply into the puncture caused by the spine.

If one is barefooted, a walk across some of the oyster leases in Moreton Bay, where oysters are farmed on rocks and where stonefish abound, bears a marked resemblance to a walk across a minefield. In "stonefish country" particular care should be given to the nature and condition of one's footgear. In 1957, a Western Australian woman received a sting as a result of a spine passing through a small hole in her shoe. This year in North Queensland a man wearing thong-type sandals received a sting on an exposed toe. Moreover, tests have shown that thin-soled rubber shoes can be readily penetrated by the spines of adult fish.

There is no dearth of stonefish in Queensland waters. One oysterman who has on several occasions demonstrated his skill in detecting stonefish maintained that he killed an average of two or three each time he visited his oyster lease. Indeed, it would appear that the main reason why they seem to be somewhat rare lies in the fact that they escape detection because of their perfect camouflage. In this respect, it is significant that the majority of stonefish sent to the author from various Queensland localities were caught on fishing-lines.

Then, too, it would appear that the main reason why so few Australians are stung lies in the fact that few of us would normally venture into the rubbly areas frequented by stonefish unless our feet were adequately protected against the sharp stones and shells that would be encountered in such areas. The position is different in those tropical regions where natives habitually walk barefooted on rocky or coral reefs in search of marine animals for food. Numerous stingings have, for example, been reported from New Guinea waters in recent years.

As well as the danger of treading on a stonefish, the danger involved in careless handling of a fish caught on a fishing-line or in a fish trap should be appreciated. The effects of the venom would be no less severe if the sting were received in a hand instead of a foot.

It is evident that the venom apparatus is a defensive mechanism. As the fish normally lies partially embedded in the substratum, the apparatus is perfectly positioned to deal with an attack from above. Obviously, it was not developed to protect the fish from man—a newcomer to the marine environment. Immediate and intense pain follows a sting received by man, and presumably similar effects would be experienced by other animals, such as large fish which might conceivably prey on stonefish.

The venom is very potent and the contents of even one venom gland are sufficient to kill hundreds of mice. Apart from agonizing pain and pronounced swelling of the area in the vicinity of the puncture, a sting from a stonefish causes irregular respiration, a marked lowering of blood pressure and often partial paralysis. There is usually a long delay in recovery from the effects of a sting. In view of all this, the recent development by Dr. S. Wiener, of the Commonwealth Serum Laboratories, of an antivenene against stonefish venom is good news. Also, since the venom loses its toxicity if heated or exposed to dilute acids, it would appear that there is a scientific basis to the use of hot vinegar—a remedy for fish stings used by several Queensland fishermen —as a first-aid treatment for stonefish stings.

There may even be a credit side to the ledger. Any substance which causes a marked lowering of blood pressure warrants attention, and this property of stonefish venom is being investigated.

A Baler Shell laying its egg-mass, consisting of hundreds of separate capsules, each containing an egg that will hatch into a small, crawling "snail." The animal takes several months to complete the laying, by which time the first-laid capsules are almost ready to hatch. This photo was taken on the Great Barrier Reef by G. C. Clutton.

BALER SHELLS

By DONALD F. McMICHAEL

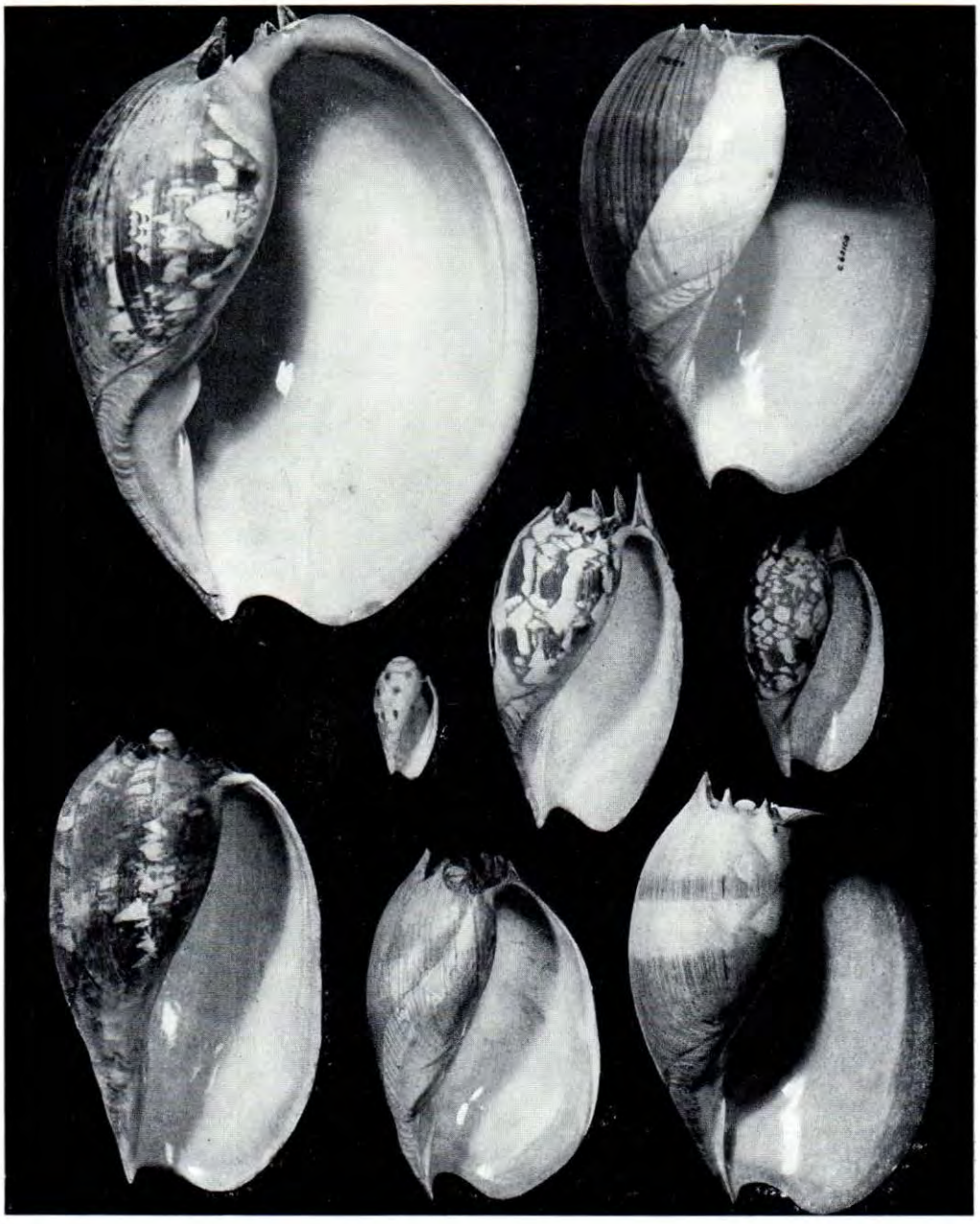
AMONG the many large and vividly coloured shells which are found in the warm tropical waters along the northern Australian coast, none are more spectacular than the giant volutes known as Melon or Baler Shells. These monsters of the molluscan world reach over 18 in. in length and as much as 12 in. in diameter. Even an average large specimen would be 10 in. or 12 in. in length. They are not the biggest of the gastropods, however, for the False Trumpet Shell of northern Australia attains a length of over 2 ft.

Balers have probably been known to science from the earliest times, because these shells were brought by traders from the Orient to the Mediterranean region, where they were known under the name "Crown of Ethiopia", no doubt because of the many small spines which circle the top of the main body whorl like spikes on a coronet. Probably these first-known Balers came from reefs around the Philippines or Malaya, as the species which lives in that area is the one illustrated in all the early books and referred to as the "Crown of Ethiopia". Another species well known to the early conchologists differed in that the spire lacked the circlet of spines completely. In this species the body whorl grows up over the spire in such a manner as to produce a very smoothly rounded shell, so it became known as the Melon Shell.

The "Father of Zoology", Linnaeus, named the first of these species *Voluta aethiopica* and the second *Voluta melo*. Later on these shells were separated from *Voluta* and placed in the genus *Melo* (though many writers have used the genus name *Cymbium* for them, which is incorrect).

Balers Smother Bivalves

Balers belong to the family Volutidae, and like the other volutes they are carnivores, feeding on shellfish, mostly bivalves which they come across while ploughing along through the sand. They enfold the bivalves (which may be quite large species



Some Baler Shells.—Top left: *Melo umbilicatus* (12 in. long). Top right: An unnamed species from the Coral Sea (10 in. long). Bottom left: *Melo miltonis* (10 in.). Bottom centre: An unnamed species (8 in.) from Moreton Bay, Queensland. Bottom right: *Melo amphora*, the Common Baler, a 9 in. specimen. Centre: Three growth stages of the Common Baler, from the newly-hatched shell to a length of 4 in.

Photo.—Howard Hughes.

such as the Horse Shoe Clam, *Hippopus*) in their large foot, which smothers the bivalve and causes it to relax its adductor muscle, so that the shell valves open. The Baler then inserts its proboscis—a long, tubular, snout-like organ containing its horny tongue or radula—into the fold of its foot and proceeds to tear away the flesh of its victim until it has entirely consumed the soft parts. The Baler then proceeds on its way, leaving the empty shell behind.

Balers will also devour any convenient gastropods, such as cowries, and one collector has found this to be an easy method by which he can have his shells cleaned; he simply puts them into a cage with a Baler and next morning collects the empty shells! Young Balers have also been observed to eat their younger brothers soon after hatching.

Baler shells were used by the native peoples of northern Australia as water carriers and, of course, as utensils for baling out their canoes, hence their common name. They were also used by the Aborigines for fashioning ornaments and magic devices, and the shells were traded over vast distances. Shells which must have originated in northern Australia have been found in southern New South Wales, and may well have taken centuries of hand-to-hand trading to travel that far.

Large Egg-mass

One of the most interesting features of the Baler Shells is their characteristic egg-mass. This is a very large, horny structure, containing many individual capsules linked together. Each capsule is about $\frac{3}{4}$ in. in diameter, and the whole mass may reach a length of 17 in. or more and a diameter of about 6 in. It takes many weeks for the Baler to lay this huge egg-mass, during which time the female crawls about with it attached to her body. The young take several months to complete development, but the earliest-laid capsules are ready for hatching a short while after the egg-mass has been completed.

The young snail which emerges from each capsule is about $\frac{3}{4}$ in. long, consisting of a bulbous protoconch and a portion of the first whorl, with traces of colour pattern already apparent. The spines do not begin to develop until a few weeks later. The young shells feed actively on small gastropods and grow very slowly. After eight months' growth in their natural environment, young specimens of *Melo umbilicata* at Heron Island, Queensland, had reached a length of only $1\frac{1}{2}$ in. It would seem that a fully-grown Baler 18 in. or more in length must be very old indeed.

There may be a difference in the size of the shell in male and female individuals. It has been suggested that the small shells commonly found are males, while the very large, swollen shells are females. An observer with access to a population of Balers could check this easily, as the males are at once identifiable by the long, finger-like penis which protrudes from the side of the animal, just behind the head.

There has been much confusion in the past over the correct names for the various kinds of Baler Shells, which seem to vary considerably in colour, size and the degree of development of the spines. This variation is due to their method of reproduction, which does not allow for a drifting larval stage during development. As a result, Balers tend to form colonies which breed within themselves, with the result that each colony tends to become genetically distinctive. This means that from any one locality there is a general uniformity of shell type, while from a neighbouring locality, perhaps only a few miles away, quite a different style of shell may be found. Despite this, it has been possible to work out the various species found in Australia by studying a sufficient number of shells from every possible source and the names of the various species can be decided fairly accurately.

The most distinctive of the Australian species is the Southern Baler (*Melo miltonis*), which seems to have been able to withstand the colder temperatures of the southern oceans and which lives today in the Great Australian Bight and around into south Western Australia as far as Shark's Bay. Its bold colour pattern of cream to white roughly-triangular patches on a reddish-brown background, combined with its slender form and crown of many small spines, make it easily recognised. Another distinctive species is that mentioned

previously, *Melo umbilicatus*, which inhabits coastal Queensland and occurs from time to time on coral reefs as far north as Torres Strait. It has a characteristic immersed spire, as a result of the growing of the body whorl up above the level of the protoconch. The spines are well developed and slope decidedly inwards so as to partly cover the spire, and consequently the protoconch is set at the bottom of a deep cavity in adult shells; this feature gives the species its scientific name.

Unnamed Forms

A recently-discovered form from Moreton Bay and south Queensland appears to be as yet unnamed. It is a rather small species with a colour pattern of small, light-coloured triangles on an orange-brown shell, and when young it has a most distinctive protoconch which projects up high above the crown of short spines. The spines slope in a little, but not as much as in *Melo umbilicatus;* the adult shell, which does not seem to exceed about 9 in. in length, has the protoconch a little obscured by the spines of the body whorl.

Another form which appears to be nameless is found in the waters of the northern part of the Coral Sea, on reefs about New Guinea and the Bismarck and Solomon Islands. This has been called *Melo aethiopicus*, but it differs from the typical Indo-Malayan species in growing to a much larger size (about 12 in. in length) with a crown of a few short, spaced spines which cease developing when the shell is half-grown. It has a greenish periostracum, with the external colouration a purplish-brown, and the inner part of the body whorl is usually marked with two broad, light-brown bands. Both these species are illustrated in the accompanying photographs.

In the various books on shells, the common Baler of Australian waters will be found referred to under a variety of names, including *Cymbium flammeum, Melo diadema* and *Melo amphora*. All three of these names are based on the same figures in the old shell books, and these figures all illustrate the common spined Baler, with irregular brown markings, which ranges right around the northern coast of Australia. Its correct name is the oldest of the three mentioned, *Melo amphora*. This species shows a great deal of variation in its colour pattern, which is generally of zig-zag lines and flames of reddish-brown on a cream to orange ground colour. The shape varies a lot. It changes, as the shell grows, from a fairly slim young shell with well-developed, spaced-out spines, through an intermediate stage in which the spines, having reached a maximum length, suddenly cease to develop, to the old and swollen stage in which the ravages of time have obscured the colour pattern and practically obliterated the spines except for the broken stumps on the early whorls. A variety of other names have been applied to populations falling within this series, but it is doubtful whether any of them are worthy of recognition, even as subspecies.

There may be one or two more species of Baler which occur rarely in Australian waters, but up to the present time we have not sufficient specimens to be certain whether they are really distinct, or just slightly aberrant examples of the common forms. The accompanying photographs illustrate the species which have been described and should assist in the identification of most Australian Baler Shells.

ABORIGINAL ART RECORDED

A Museum party comprising Messrs. F. D. McCarthy, Curator of Anthropology; H. Hughes, photographer; J. Beeman and D. Rae, artists, has returned from western New South Wales, where 31 caves of Aboriginal paintings were recorded in scale diagrams and photographs.

In the rock shelters studied are preserved several thousand colourful figures—in red, white, yellow and black, principally of men and women dancing, fighting, hunting emus and kangaroos, performing rituals and hunting-magic rites. With them are stencils of human hands, feet and weapons, and an important series of linear designs which link the paintings with the carved trees of this State.

Two cave floors were excavated to establish cultural associations and the antiquity of the paintings. Colour film of the paintings and excavations were made.

The project was financed by the Nuffield Foundation of Australia.

Detailed studies of extensive local series of rock art have been carried out elsewhere by Mr. McCarthy to further the understanding of Aboriginal art as a whole, to ascertain the relative importance of local and diffused motifs, the changes in the art during prehistoric times, and the relationships between various kinds of Aboriginal art.

BOOK REVIEW

PROBLEMS IN THE ZOOGEOGRAPHY OF PACIFIC AND ANTARCTIC INSECTS, by J. Linsley Gressitt, with appendices by T. C. Maa, S. Nakata, I. M. Mackerras and L. W. Quate. Pacific Insects Monograph 2, Entomology Department, Bernice P. Bishop Museum, Hawaii, 1961.

This is a most useful publication, since it brings together under one cover information on insect distribution in the vast area of the Pacific, and in no other region are the zoogeographical problems so varied and so puzzling.

The author suggests that the most pressing problems in need of investigation are the sources and histories of the faunas of isolated oceanic islands; the nature and history of dispersal; the nature of the "southern continent"; the relationships and geological histories of these areas, and the relationships of the Oriental and Australian regions.

Some results are given of the trapping of air-borne insects over the Pacific and Antarctica and nearby seas, and disclose, as might have been expected, that the types of insects trapped can be correlated with the prevailing representation of the insects on the more isolated islands.

Attention is drawn to the problems of the inter-relationships of the faunas of Australia and New Guinea and, in particular, to the fact that while the vertebrate fauna of the island has close affinity with that of Australia the insects of New Guinea are for the most part of Asiatic origin. A provisional explanation of this discrepancy is provided by the suggestion that the long insular history of New Guinea, which antedated the age of mammals, prevented the influx of terrestrial higher mammals from south-east Asia, whereas insects were able to cross water barriers and Australian mammals had ample opportunties to gain access to New Guinea during the Pleistocene.

While this explanation is sufficient to account for the absence in New Guinea of mammals of Asiatic origin, it seems inadequate to explain the very distinct vertebrate fauna of the island, which, surely, cannot have acquired its special characteristics in the short period since the Pleistocene.

Possibly there were at least two separate periods of land association between Australia and New Guinea in late Tertiary times. During the earlier one, various marsupials and plants, such as *Nothofagus*, which are associated with a wet and possibly a cool climate, may have reached the island, while during the later one an interchange of tropical fauna and flora took place. Furthermore, it was during the second association that certain characteristic New Guinea marsupials, such as tree kangaroos (*Dendrolagus*) and cuscuses (*Phalanger*), entered north-east Australia.

While detailed, and informed, accounts of the distribution of two families of Coleoptera, two families of Diptera, a Homopterous family and the Phasmatodea are given by the several authors, the greater part of the work consists of an uncritical compilation. As is consequently inevitable in the circumstances, statements are recorded which are not universally acceptable, but which nevertheless are not without value since they may result in the stimulation of constructive criticsm. Among such statements are the quoted opinion of Mackerras (page 16) that the Oriental insect fauna was originally weak and was populated by an earlier Ethiopian intrusion and a later Palaearctic influx and that the former had more influence in the South Pacific. While this may be so for Tabanids, it is certainly not for several other groups of insects.

Another unacceptable statement is that there are almost no New Zealand elements on Lord Howe Island.

As well as problems of dispersal, those relating to island speciation and ecology are discussed.

The work is well illustrated by maps and photographs, many of the latter being in colour.—J.W.E.

THEY'RE GOOD BAIT!

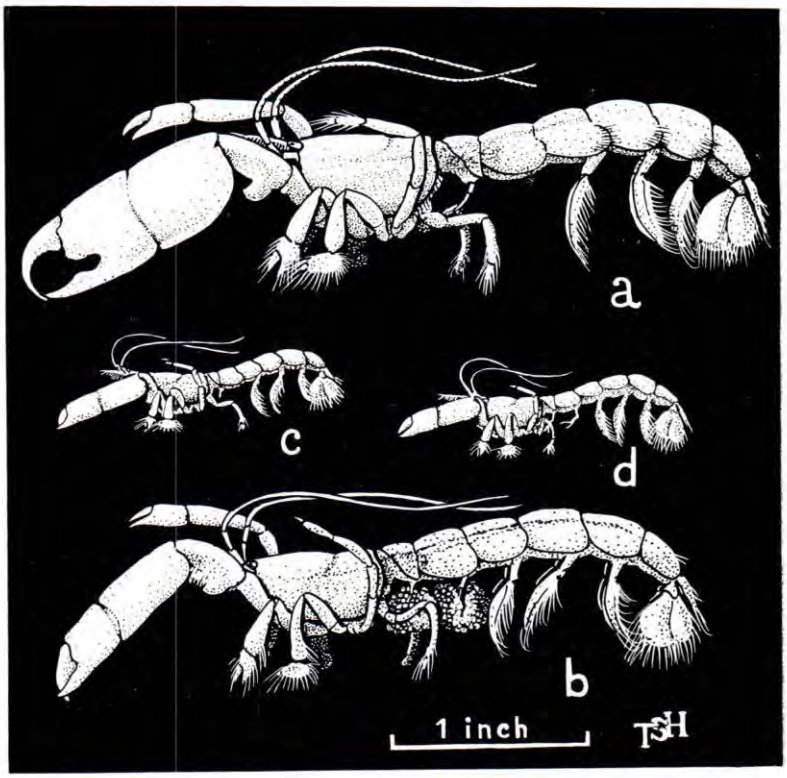
By T. S. HAILSTONE
Department of Zoology, University of Queensland

ALONG the eastern Australian coast, angling is a popular pastime, particularly during the warmer months of the year. If you talk with the amateur fishermen in the estuaries, eventually the talk turns to Marine Yabbies (Ghost Nippers or Burrowing Shrimps), and you will be told "they're good bait". However, though many fishermen know of the yabby's qualities as bait, few wonder about its way of life. Because of the large numbers that are used annually it might be of interest to know how the yabby lives.

The animal that the fisherman knows as the Marine Yabby (see the illustration below) is a prawn-like crustacean. The resemblance to a prawn is only superficial, however, as the yabby has more features in common with the hermit crabs and crayfish. The yabby was described first in 1852 by J. D. Dana from specimens collected in the Illawarra District of New South Wales. Dana named this animal *Trypaea australiensis*, but in modern terminology it bears the name *Callianassa australiensis* and is but one of the 70-odd world species of *Callianassa*.

Marine Yabbies live in burrows in intertidal, estuarine sandflats and, as far as we know, they rarely, if ever, leave their burrows voluntarily. The entrance of a burrow is easily recognised, but collection of yabbies from the burrow presents a problem. The fishermen's ingenuity, however, solved the problem when they devised three different types of collecting equipment or "yabby pumps".

Two of these are now sold commercially and are manually operated, while the third is motor-driven. Both manual pumps are



The Marine Yabby (*Callianassa australiensis*), seen from the left side: (a) an adult male; (b) adult female (carrying eggs); (c) juvenile male; (d) juvenile female. Sexual differences are shown in the anterior two pairs of swimmerets and, in adults, by the large cheliped.

Drawn by the author.

essentially coring tubes which, when pushed into the sand and extracted, remove a core of about 2 ft. in length and from 2 in. to 4 in. in diameter. Either pump is then reinserted into the hole so formed and suction is applied (with the aid of a plunger in one model or by closing off air outlets and withdrawal of the pump in the other model). As a result of this suction, water, sand and yabbies are drawn into the hole and removed. The motor-driven pump works on the reverse principle, i.e., water under pressure is driven deeply into the sand and yabbies are flooded to the surface. The two manual models work best when there is little or no surface water, whereas the motorised model works best in a few inches of water.

Bait collectors work regularly amongst the yabby colonies or yabby beds in the more accessible parts of estuaries. In a densely populated bed, an hour's pumping may yield over 200 yabbies and, with a number of collectors working on the one bed over a period, it is not surprising that it may become impoverished quite quickly. This is only localized depletion, however, for in less accessible areas the yabby is relatively free from human interference. Luckily, this also acts via the fishermen, as when the beds are nearing depletion the difficulty in collection deters bait collectors. The beds are soon re-colonised with yabbies (probably juveniles) recruited from less accessible areas.

The yabby is known only from the eastern coast of Australia (Low Isles in northern Queensland to Port Phillip in Victoria). Within this range it has distinct habitat preferences. It is found only in estuaries or the lower reaches of coastal rivers and streams (where it is most abundant on sandbanks or gently sloping sandflats composed of fine-grained sand mixed with lesser proportions of mud) and in the central portion of the intertidal range. Yabbies can also be found in other substrata and outside this portion of the tidal range, but never as densely as in the above habitat.

The yabby burrows for two reasons. Firstly, it is a soft-bodied crustacean and the burrow offers protection, much as a discarded marine snail's shell is used by a hermit crab. Whether the ancestors of yabbies burrowed because they were soft-bodied or whether the soft body is a result of the burrowing habit is debatable. Secondly, the sand into which the yabby burrows contains particulate, organic matter which is sieved from the sand grains through hairs on the mouthparts. This organic matter is passed into the mouth and portion, at least, is digested.

A burrow is excavated by each yabby during its juvenile life and, as far as we can ascertain, this is its permanent residence, being extended both vertically and into side galleries as the animal grows. Burrowing is accomplished by the use of the large nippers (chelipeds) and the following two pairs of legs. The latter limbs are used to scoop the sand forwards into a "basket" formed between the chelipeds and the preceding pair of mouth appendages. The sand in this "basket" may be either sifted for food or carried to the entrance of the burrow, where it is pushed out to the exterior. As the burrow is not much wider than the widest part of the yabby's body, the animal is faced with a problem of "one-way traffic". This problem is solved by the excavation of wider chambers ("turn-arounds") at intervals along the burrow, particularly where galleries branch from the main shaft. In these the animal can reverse direction by somersaulting.

The walls of the burrow are lined with fine particles which are compacted by the constant movements of the animal and possibly also by secretions and/or bacterial deposits. The burrow of a large specimen may descend to a depth of at least 30 in., and beyond that depth it is difficult to trace because of water seepage.

From diverse lines of investigation, it appears that two to three surface openings correspond to one yabby. In densely colonized yabby beds there may be up to 800 openings per square yard of surface, and under these conditions adjacent burrows, no doubt, often interconnect.

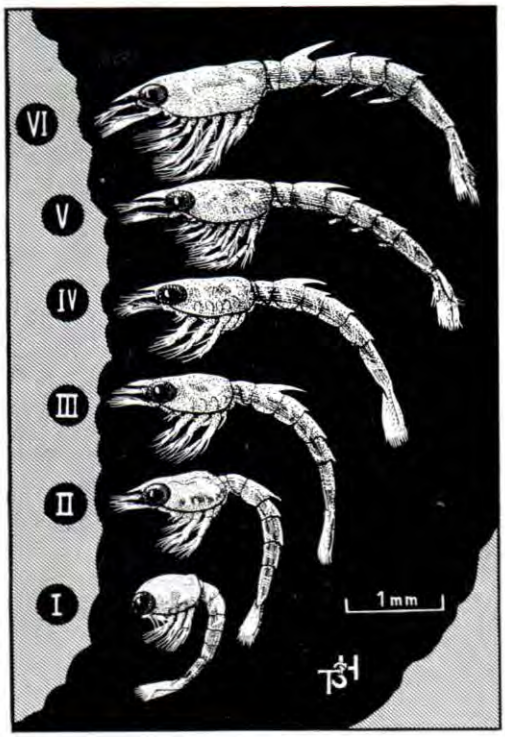
The effects of interconnection of burrows can be seen if yabbies are kept in glass tubes (of about burrow diameter) filled with sea water. When two adult males share a tube, they fight vigorously, the large chelipeds being entwined and each endeavouring to break off the cheliped of the other. When this happens, the "victor" rams the "loser" out of the tube with his own cheliped. If

two adult females are placed together, preliminary fighting commences but is not continued. After a time, they separate and may thereafter avoid each other. If an adult female or a juvenile of either sex is placed with an adult male "sparring" may commence, but eventually the female or juvenile is tolerated by the male. All of this suggests that within the burrows territoriality may exist and that there is some form of sexual recognition.

Sexual recognition is probably via touch, for the fighting behaviour is released or withheld when the large chelipeds make contact or when the cheliped of one touches the lower anterior side of the abdomen of the other. In both positions there are sexually different features (see the first illustration) in adults, while in juveniles, though the abdominal sexual appendages differ, the chelipeds are alike in both sexes and proportionally similar to those of adult females (i.e., relative to other body measurements).

The idea of sexual recognition leads to the subject of reproduction. The gonads of yabbies reach sexual maturity when the animals are about 1½-in. long. We have not witnessed copulation between yabbies nor are there any literature records of such observations. Presumably, copulation takes place in the burrow during summer (at least in south-eastern Queensland) for in the autumn mature females may be collected with eggs under their abdomens. Another reason for postulating this as the time of copulation is that during January the majority of males have moulted and the females likewise during February, which, to the carcinologist, suggests a precopulatory moult as in many other types of crustacea. A minor breeding season occurs also in spring.

Each female may carry about 2,000 eggs under her abdomen. These are cleaned regularly and are aerated by movements of the swimmerets to which they are attached. The eggs develop in this position for about six weeks until the larvae hatch from their surrounding egg membranes and escape or are forced from the burrow. They then join the myriads of other planktonic organisms which drift in the sea water and, after a planktonic existence for about three months, during which time they pass through six larval stages (see the illustration on this page), they settle to the substratum as juveniles about half an inch long.



The six planktonic, larval stages of *Callianassa australiensis*, shown in sequence of development (I to VI).
Drawn by the author.

Juveniles of this size have been found only amongst or near patches of Eel Grass (*Zostera*) and in proximity to established burrows of older specimens. Within patches of *Zostera* their burrowing activities accompany the formation of small circular clearings ("yabby circles") which extend as the animals grow. It is during these early stages that recruitment of depleted yabby beds is most likely to occur, and thus, from the fisherman's angle, the yabby may seal its own fate. Once settled, it probably does not leave its burrow until it is collected by a fisherman, or by one of the wading birds which feed on the sandflats, or else dies a more natural death (probably after a life span of about two years).

[*This article is based on work in conjunction with Professor W. Stephenson, of the Zoology Department, University of Queensland.*]

An adult male tuatara, with crest raised, foraging for ground insects at night.

Photo.—M. D. King.

The Tuatara, New Zealand's Ancient Reptile

By W. H. DAWBIN

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COMPARED with the Australian reptile fauna, that of New Zealand is small and relatively uniform. Lizards are represented by two families only, the geckos with 12 species and skinks with 20, but collectively these are unusual in that all the endemic species produce live young and egg-laying is confined to lizards which have been introduced recently. The larger lizards—such as the Agamids or dragons, and the monitors—are quite unrepresented, and there are no terrestrial snakes, crocodiles or tortoises.

However, there is one species which many students of reptiles feel fully compensates for the small representation in the other groups. This, of course, is New Zealand's tuatara, a reptile which has become known throughout the world as the sole representative of a group that apparently became extinct elsewhere more than 100 million years ago.

The tuatara closely resembles some lizards in appearance, and there are few clues from external appearance to separate it from the Agamids or dragons. It reaches a length of about 2 ft., has a typical Agamid-shaped body with a crest of softish spines forming a mid-row along the back of the head, and a row of smaller spines along the middle of the back. The spines, the skin folds of the jowl, and the total length and weight all reach greater sizes in males than in females. Adult males weigh up to 1000 grm. (about 2¼ lb.), whereas females seldom exceed 500 grm. (about 1 lb. 2 oz.). The animal is normally of an olive-green colour, but specimens varying from slate-grey to almost brick-red have been found and all have the background colour broken by numerous small dots, usually of a lighter colour.

The tuatara was known to the earliest Maoris (Moa hunters), who, clearly, sometimes used the animal for food, as shown by jaw-bone remains in their kitchen middens. However, the later Maoris appeared to be rather afraid of the animal and there is no evidence that they hunted it. Through Maori descriptions the earliest European

settlers in New Zealand became aware that a relatively large reptile existed, but it was not until 1831 that the animal first became known to science through a paper by Dr. Gray, of the British Museum. In a later description (1842) he regarded the tuatara as a member of the Agamid family, and it was not until more material was described in 1867 by Dr. Gunther, also of the British Museum, that the unique features of the animal became known to the world. Gunther found that many features of the skeleton, especially the presence of certain primitive bones in the skull, the structure of the vertebrae, the nature of the ribs and other parts of the skeleton, were unlike those of lizards and could only be matched with fossil material from the Triassic period. He proposed the name Rhynchocephalia (referring to the beak-like notch at the tip of the upper jaw) to include both the fossil material and the tuatara. Later paleontological investigations have shown that members of this group occurred in North America, Africa and the Eurasian land-mass, and some of the specimens of more than 100 million years ago are remarkably similar to the living tuatara. This is very clear evidence of the extremely static condition of the structure of this animal over a vast period of time. These findings led to a very great interest amongst students of reptiles, and some came from as far as Hamburg and Bremen to New Zealand to collect material for their institutions and to make the earliest scientific studies of the habits of the animal in its natural habitat.

Island Habitats

At the present time the tuatara is confined to small islands off shore from the mainland of New Zealand. The islands occur in two main groups, the first lying off the north-eastern part of the North Island between North Cape and East Cape, while the second group includes a number of islands in Cook Strait between the North and South Islands. There have been accounts of the occurrence of the tuatara on the mainland in early European times and it was suggested that the introduction of domestic and feral mammals, such as pigs, cats and dogs may have exterminated it from the mainland. However, it has been impossible to confirm any of the reports that it did still exist in colonies on the main islands, and it seems likely that the occasional animals which have been found on the North Island were ones which had been brought there by people who had collected them from the islands off shore. It is clear from the bone remains, however, that at the time of the early Maoris it occurred at a number of sites on both the North and South Islands as far south as Bluff. At present there is no clear evidence as to the cause of its disappearance, but it seems more likely that it has been due to some gradual climatic or vegetational changes rather than any sudden direct effect of man and his accompanying animals.

To see the tuatara in its natural habitat one must visit an off-shore island, and even on one of these there will be little evidence of its presence in day-time, as the animal comes out to forage for food during the hours of darkness and normally returns to burrows during the daylight hours. On all the islands where the tuatara occurs there are also very large concentrations of sea birds, including shearwaters and other members of the petrel family which return to land at night-time and have their nesting chambers at the end of burrows which may be yards in length. Sometimes the tuatara occurs in burrows with the sea birds, and it has often been thought that it depended on these burrows for shelter, but it is quite certain, from watching tuataras in the field, that they just as frequently excavate their own burrows and quite frequently live completely separate from the birds. During the hours of darkness tuataras forage mainly for large ground insects, especially beetles and wingless crickets, known as wetas, as well as snails and other ground organisms. At the time of the breeding of the sea birds some tuataras include occasional eggs in their diet and, despite the fact that many live in harmony with young chicks and adults of the petrels, there is clear evidence from feathers and bones in tuatara droppings to show that a number of chicks are eaten.

In late spring and early summer the tuatara breeding season commences and the females construct a depression in the ground up to six or more inches in depth, where they lay 10 to 15 eggs which are approximately $1\frac{1}{2}$ in. in length, round at both ends and covered by a parchment-like membrane instead of a hard shell. The eggs are buried by the

female and no further attention is paid to them by either sex. Incubation is surprisingly long, taking approximately 15 months, so that the young emerge in late summer of the year following egg-laying. At the time of hatching the young burrow to the surface and apparently search out small crevices or other natural cover in which they hide during day-time. They are uniformly clay-brown in colour, and retain this protective colouration for a number of years. During the first year, the pineal or "third" eye is visible in the middle of the head, but later becomes covered by scales. Some writers have attached much importance to the "third" eye as a special feature, but later work has shown that it is equally well developed in a number of other animals, including several Australian lizards. Crest development in newly-hatched young is so small that it takes very close inspection to detect any trace of the tips of spines, and these do not become conspicuous until the animal reaches at least five or six years of age. During this early period the young feed on small ground insects and land crustaceans, such as slaters and amphipods.

The growth rate of the tuatara is possibly the slowest of that for all reptiles, even including the famous Galapagos tortoises, which are often claimed to be the slowest-growing of all land animals. The growth rate in the field has been studied mainly by marking tuataras of various sizes and then comparing the measurements of the same animal several years later on recovering them during field trips. This has been carried out on more than 200 animals for periods up to nine years, and calculations from the data obtained show that growth is more or less continuous, but at a steadily declining rate, for at least 50 years. There is, as yet, no way of knowing how long the animals live after growth ceases, but it would seem very likely that a century or more would be a conservative estimate.

Breeding occurs long before growth itself ceases, and from the minimum size of animals which are sexually mature it seems likely that breeding can commence when they are approximately 20 years old. This is surprisingly different from the information available on lizards, nearly all species of whcih so far studied are capable of breeding when two or three years old. Even the slower-growing tortoises and turtles are capable of breeding at ages ranging from six to 16 years, so on present information the tuatara is the latest-developer of all known reptiles.

Despite its slow growth, the tuatara shows powers of tail regeneration comparable to those of true lizards. Quite a high number of animals in the field can be found with at least some portion of the tail showing the distinctive, relatively smooth appearance of a regenerated portion distinguished from the unbroken basal portion. Tuataras also have considerable resistance to injury, as shown by the fact that I have encountered two specimens in which an entire front limb was missing and the tiny stump had completely healed over without any evidence of marked adverse effect on the injured animal. Their activity is also considerably greater in field conditions than would be expected from the slow growth or from the reports of sluggish behaviour of the animals in captivity. An adult tuatara in the field is capable of running for 20 or 30 yards at a speed which makes it difficult to catch, and the small young animals are as active as geckos and skinks of similar size.

The special interest of the tuatara lies in the fact that it is the sole survivor of the group which, though once widespread, disappeared from the rest of the earth about 100 million years ago. In keeping with its ancient lineage, it is possibly the slowest-growing of land animals, and much more study will be required to gain a fuller understanding of the reasons for such marked difference in this respect between it and modern lizards. The New Zealand Government has maintained a very strict protection on tuataras, so that permits are required even to visit the islands on which the animals occur and the penalties for unauthorised handling are very severe. A close watch on the tuatara population is maintained by officers of the Department of Internal Affairs, and on most of the islands it appears that the existing populations are maintaining themselves satisfactorily. It is to be hoped that the continued strict protection will maintain this ancient reptile as a source of interest for zoologists and nature lovers of the future.

The Australian Museum

The Museum is open free, daily, at the following times : Tuesday to Saturday, and public holidays, 10 a.m. to 5 p.m.; Mondays, 12 noon to 5 p.m. (during school holidays 10 a.m. to 5 p.m.); Sundays, 2 to 5 p.m. It is closed on Good Friday and Christmas Day.

To students and pupils of schools and colleges special facilities for study will be afforded if the Director is previously advised of intended visits. A trained teacher is available for advice and assistance.

Gifts of even the commonest specimens of natural history (if in good condition), and specimens of minerals, fossils, and native handiwork, are always welcome.

The office is open from 9.30 a.m. to 1 p.m. and 2 to 4.30 p.m. (Monday to Friday), and visitors applying for information there will receive every attention from the Museum officials.

College St., Hyde Park, Sydney

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