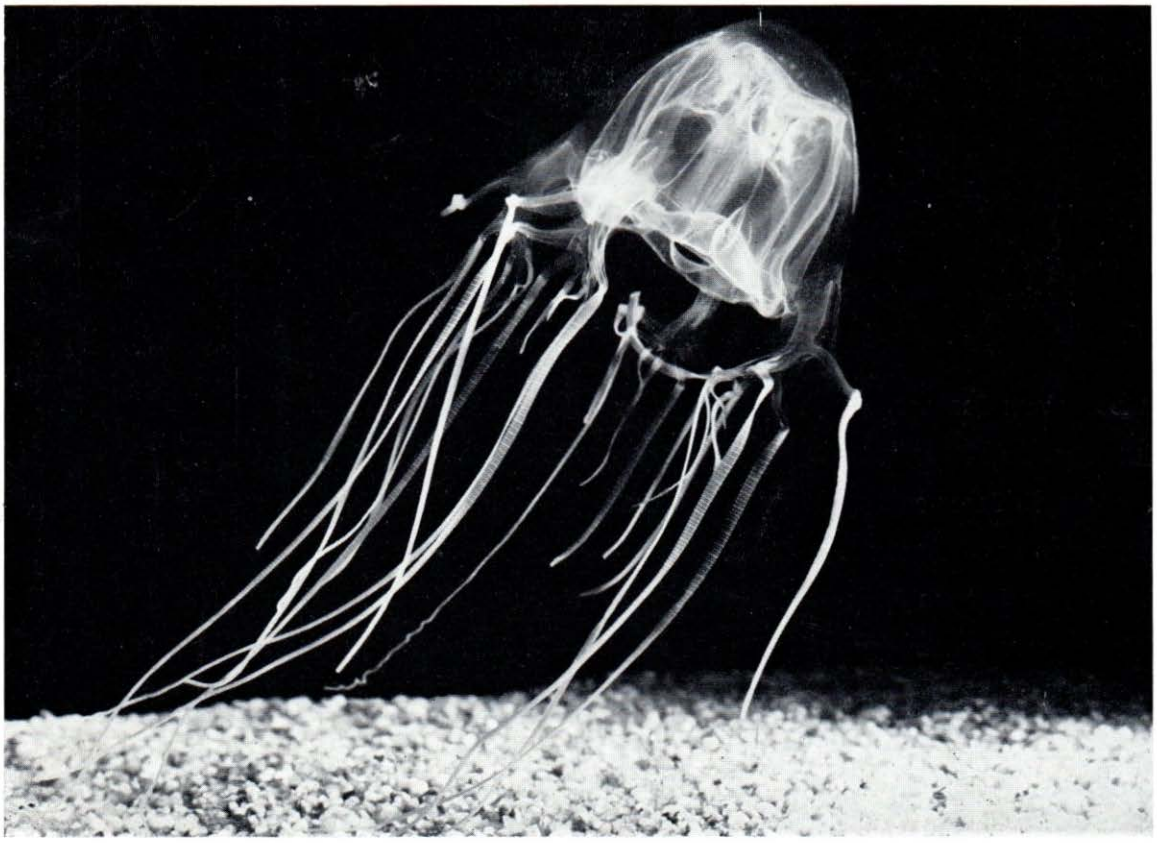
AUSTRALIAN NATURAL HISTORY



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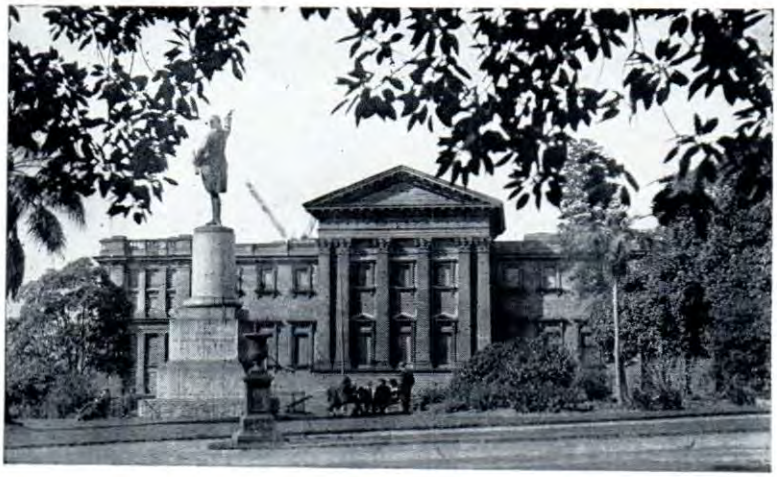

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[Photography is by Howard Hughes, unless otherwise stated]

● **FRONT COVER: The deadly "sea wasp"** *Chironex fleckeri*, **of northern Australia. The batteries of stinging cells (nematocysts) are seen as rings around the tentacles. This photo of the living cubomedusa and others on page 313 were taken specially for the Australian Museum by Keith Gillett, F.R.P.S., of Sydney.**

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Birds of the Coral Sea Isles

By K. A. HINDWOOD

Past-president of the Royal Australasian Ornithologists' Union

THE Great Barrier Reef, lying off the north-east coast of Australia, extends for more than 1,000 miles, from near Cape York to about the latitude of Rockhampton, southern Queensland. Within this shelf, varying in width from 12 to 150 miles, are many islands; some are of continental origin, others have been formed over the centuries by the breaking up of the coral reefs.

Most of these islands and cays are well known to both naturalists and tourists and have provided the inspiration for scientific papers, books and innumerable popular articles, all of which have focussed world attention on this wonderland of nature.

What of the islets beyond the outer edge of the Great Barrier Reef? Admiralty charts showed that portion of the Coral Sea to be dotted with reefs and cays about which little was known. Certainly, the bird life of Raine Island, east of Cape York, had been investigated as far back as 1843 and 1844 by J. B. Jukes and John MacGillivray, the naturalists on board H.M.S. *Fly*, and that of Willis Island, on which there is a permanently occupied weather station, by several ornithologists in more recent times. Other remote and seldom-visited cays in the Coral Sea still awaited detailed investigation, though it was known that Dr. F. M. Rayner, of the survey vessel H.M.S. *Herald*, collected on a few of the islets in 1869.

In 1960, and again in 1961, the Frigate H.M.A.S. *Gascoyne* visited the south-west Coral Sea on a survey of the isolated reefs and cays in that area. Naturalists on board the ship were able to study the bird, insect and marine life of the 46 cays on which landings were made, either by cutter or by rubber float paddled over the encircling reefs.

The Coral Sea, particularly that part between the outer Barrier Reef and New Caledonia, has been aptly named "The Graveyard of the Pacific". Here, in the days of sail, and even in recent times, disaster has overtaken many ships. Wreck Reef, comprising several islets within a

A Brown Gannet with its nestling.

coral outcrop extending over a distance of 20 miles, has been the scene of several tragedies. Bird Island, of this reef system, was exploited in the 1860s by the Anglo-Australian Guano Company, whose employees remained ashore for months on end. Here the company's schooner, *Harp*, was lost in 1861; also wrecked on the islet were the brigantine *Wolverine* in 1871, with the loss of all hands, and the schooner *Anne* in 1872.

On nearby Porpoise Cay the *Porpoise* and *Cato* were lost on August 17, 1803. The necessities of life were salvaged from the wrecks and the 94 survivors sheltered on what was, and still is, little more than a sandbank. Rescue came after the navigator Matthew Flinders, a passenger on the *Porpoise*, sailed to Sydney in a cutter for assistance.

The isolation of the cays, their relatively small size, and the absence of fresh water make them quite unsuitable for continuous occupation by man. The fate of any castaways without food or water can well be imagined and many must have been the unrecorded calamities before the days of wireless and modern navigational aids, which now bring help almost within hours.

Such was the case in May, 1962, when a Japanese fishing boat grounded on Mellish Reef, 600 miles east of Cairns. Twenty-eight members of the crew reached a small sandbank in the middle of the reef and were rescued two days later by a passing Norwegian freighter which had been alerted by wireless, the original appeal for help having been sent direct to Japan from the stricken ship, thence to Canberra. Contact with the freighter was then made from Brisbane. In the meantime, the stranded fishermen had been located by a R.A.A.F. Neptune bomber. Incidents enough to astonish the shade of the Ancient Mariner!

Three types of cays or islets are found in the Coral Sea. The most common are those formed of coral detritus and varying in size from mere sandbanks, awash at high tide, to others 2000 feet or more in length and perhaps 1000 feet wide. Some of these cays may, in the course of time, change or evolve into vegetated islets; others, because of their exposed positions, caused largely by the state of their reef systems, may never be other than unstable accumulations of sand and coral-shingle, the shape and size of which are influenced by the vagaries of the surrounding seas.

Birds nest on the bare cays but never in such numbers or variety of species as on the vegetated islets.

The second group comprises those cays on which grasses, creepers and succulents grow, the vegetation seldom exceeding a foot or so in height. These islets are the breeding grounds of large numbers of Sooty Terns, Common Noddies, Gannets, Frigate-birds and Shearwaters.

The third type includes those islands on which both low herbage and trees grow and which have, it would seem, reached the optimum of development. Because of their stability and greater range of habitats they attract more nesting sea-birds than either sand or grass cays.

In all, 14 species of sea-birds were recorded on the 46 cays visited during the 1960 and the 1961 expeditions.

The only mammals noted were House Rats, *Rattus rattus*, numerous on Coringa Island. They scampered over the recumbent forms of naturalists sleeping on the beach and even climbed the iron tripod supporting their food-box. The rats probably originated from the *Coringa*, a sailing ship that was wrecked on the island in 1845. Fortunately, all the other cays visited seem to have escaped the scourge of these destructive rodents.

Shearwaters Or Mutton-birds

Wedge-tailed Shearwaters, or Mutton-birds, *Puffinus pacificus*, frequent the vegetated cays in thousands and their nesting burrows are often up to six feet in length. A single white egg is laid late in November but it is April or May before the young bird leaves for the sea.

Overnight camps on some of the breeding islands showed that a few Shearwaters came in well before sunset, though many waited until dark before landing. It was an interesting experience to walk through the rookeries with a torch and watch the birds courting, preparing their burrows, or merely resting and sleeping, which they often did in the open. Their weird moaning calls, uttered throughout the night, provided eerie background music to the booming of the surf breaking on the edge of the reef.

A male Greater Frigate-bird.

Frigate-birds

Two kinds of Frigate-birds, the Greater, *Fregata minor*, and the Lesser, *Fregata ariel*, live on most of the vegetated cays. The Greater nests in trees while the Lesser builds its nest both in trees and on the ground: in the latter case there seems to be a tendency to form colonies, the nests being placed a couple of feet or more apart. A single white egg is laid on a nest-platform composed mainly of sticks and grass-stems.

Frigate-birds have a wing-span of up to seven feet and a body length of about three feet. The bill is long and hooked quite

A male Lesser Frigate-bird brooding its young. Another nestling is in the background.

strongly, whereas the feet are very short and poorly developed. A wide expanse of wing and a relatively light body, seldom more than three pounds in weight, enable the birds to remain in the air for hours, soaring effortlessly above their breeding grounds.

Male Frigate-birds have a bright red, distendable throat-sac or pouch which is inflated to the size of a toy balloon during courtship —a most curious sight, especially when the birds are flying. The names Frigate-bird and Man o' War Hawk are derived from the habit, general to the family, of harrying other birds in flight until they disgorge their catch, which is retrieved by the piratical Frigate-birds before it reaches the sea. Frigate-birds do, of course, frequently obtain their own food—fish, squid, young turtles and even nestling birds.

Gannets And Boobies

The names gannet and booby are more or less synonymous, though the term gannet (from the Anglo-Saxon *ganot* meaning gander) is usually applied to the larger members of the group. The word booby is derived from *bobo*, the Spanish or Portuguese for fool, used by early sailors for these seemingly stupid birds, which can be caught while resting on ships at sea. On their breeding grounds they are equally unsuspecting.

The several members of this family are relatively large birds, from two to five pounds in weight, with long wings and powerful bills having serrated cutting edges, thus enabling fish to be held securely before being swallowed. Gannets dive on their prey from a considerable height, often in excess of 100 feet, striking the water with force, the impact being cushioned by the presence of numerous air-sacs beneath the birds' skin.

Three species of gannets, or boobies—the Masked, *Sula dactylatra*, the Brown, *Sula leucogaster*, and the Red-footed, *Sula sula*—breed on the Coral Sea cays. The Masked is white, with black wing-feathers and facial skin; the bill is yellow. Females are slightly larger than males and utter deep, throaty cackles in sharp contrast to the high-pitched wheezy notes of the males. No nest is made; a mere scrape or depression in the sand holds the two eggs which form a normal clutch. The birds prefer the beaches fringing the cays for their nest-sites, which are usually placed well apart.

Often one of the two eggs in a clutch is infertile; even when both eggs hatch it is seldom that both young survive. Mostly there is a difference of a few days between the emergence of the chicks, and it would seem that the greater strength and voracity of the older bird induce its parents to feed it exclusively, thus soon eliminating the younger and weaker nestling in what is an effective, if involuntary, form of population control.

Much the same circumstances surround the breeding habits and calls of the Brown Gannet, a bird generally dark chocolate-brown in colour, with white underparts. The ground nests of this species vary a good deal: some are very skimpy, others are substantial platforms of grass, twigs and wrack. On the bare cays eggs are laid on the sand or shingle. The two eggs, as with those of other gannets, have a chalky white surface which, if scratched, reveals a greenish-blue shell. Brooding birds cover, or partly cover, their eggs with the webs of their feet and belly feathers.

On Raine Island, east of Cape York, some 2,000 pairs of Brown Gannets were breeding in November, 1961; elsewhere in the Coral Sea their numbers were fewer.

One of the most interesting and colourful birds on the coral cays is the Red-footed Gannet. In what may be termed the final adult plumage its body is white, often with a golden tinge in the feathers of the head and neck. The main wing-feathers are black, the legs coral-red and the bill a bright blue, with a lolly-pink base. Breeding birds are found in other plumages, often from dark greyish-brown with lighter heads and necks, to light-coloured bodies and dark wings. Irrespective of plumage states, all nesting birds observed had white tails and rumps.

In some parts of its distribution the Red-footed Gannet occurs only in the "white" phase. The significance of the wide plumage variation noted in the Coral Sea area, and in other colonies, has yet to be assessed. Perhaps the birds reach the breeding state before attaining the final plumage phase. The voices of the sexes are similar.

Only one egg is laid on a platform of sticks and twigs nearly always built in a tree. Very occasionally the birds will nest on the ground, but only in the absence of trees. The predilection for tree-sites governs, to a degree, the distribution of the species, which was found nesting plentifully on the cays where trees were growing. Small numbers were breeding on some of the grass cays, though ground nests are rare throughout the range of the species.

Tropic-birds

The Red-tailed Tropic-bird, *Phaethon rubricauda*, a lovely species of satin-white, rose-tinted plumage, with black feathers in the wings and face, a coral-red bill and two elongated red tail-feathers, was found on a few of the cays. Nests, with a single egg or a speckled chick, were on the ground under the shelter of trees or coral slabs. Elsewhere in its range, on islands such as Lord Howe, the Tropic-bird is common and breeds in cavities in cliff faces.

On Raine Island the population of Tropic-birds seems to have remained fairly static for more than 100 years. In 1844 John MacGillivray reported seeing about a dozen birds; seven nests (14 birds) were recorded by an observer in 1918, and six pairs in 1961. Nesting birds utter loud and discordant cries and do not hesitate to use their strong serrated bills against an intruder.

The three known species of Tropic-birds are often called Bo'sun Birds, a name bestowed by sailors because of the resemblance of the projecting central tail-feathers to a marlin-spike, the "badge-of-office" of a ship's boatswain.

The Sooty Tern

On several of the cays visited Sooty Terns, *Sterna fuscata*, occurred in what might well be termed prodigious numbers. It was estimated that the population of some colonies was well in excess of 100,000 birds. Long before a landing was made on their islets the Terns could be seen like a cloud above their nesting grounds.

Human intrusion caused extreme confusion. Screaming adults in the air, brooding birds uttering their protests, and speckled young fleeing in panic created an impression of great fecundity, heightened by the

A Red-footed Gannet, in the "white" plumage phase, at its nest.

presence of many dead fledglings. The excessive mortality noted had probably been caused by several factors—lack of shelter from the hot sun, overcrowding and the vicious attacks by adults on confused "runners" that had inadvertently wandered into forbidden nesting territory.

A single egg is laid in a sandy scrape, to which may be added shell fragments, pebbles and bits of vegetation.

Such was the scene on Cato Island in October, 1960, where the gathering of Sooty Terns was thought to total more than a quarter of a million individuals. Strangely, in November of the following year only a few birds were present, probably because most of the island was then covered with lush vegetation and quite unsuitable for nesting Sooty Terns whose chosen sites are the more open sandy parts of the vegetated cays. Small colonies sometimes breed on the bare islets.

An interesting fact about the Sooty Tern is that in many parts of its range the species has a regular annual breeding cycle. Yet, on Ascension Island, within the tropics in the Atlantic Ocean, where detailed studies have been made, nesting takes place every 9.6 months, or five times every four years.

When breeding is finished the birds apparently disperse widely over the oceans for they are then to be observed in small parties far from land, and their sharp calls, resembling the words "wide-awake" (a common name for the species) are also to be heard in the sky at night.

Other Terns And Gulls

Other Terns frequenting the Coral Sea are the Black-naped, *Sterna sumatrana,* the Crested, *Sterna bergii,* and the Little, *Sterna albifrons;* of these three species, the Black-naped is widely distributed, though nowhere numerous. Nesting colonies of 50 or more pairs were noted, the eggs, generally two or three, being laid in sandy scrapes, often with small pieces of smooth coral fragments added to the depression.

The larger Crested Tern, a bird common enough in the coastal waters of Australia, was rarely seen, while the Little Tern, a sprite having an overall length of less than a foot (its body being about six inches long), was observed only once, when a few were seen, and an egg was found on a small cay of the Lihou Reefs, 400 miles east of Queensland.

The well-known Silver Gull, *Larus novaehollandiae,* seems to prefer coastal waters and inland swamps. It was seen once during the two expeditions, when a few birds were noted on Raine Island.

Noddies

Noddies are really terns, differing only slightly from those birds in structure and habits. Three of the four recognized

species are either dark chocolate-brown or blackish, with white or pale grey crowns, long pointed bills and short legs. The fourth species, the Grey Noddy, *Procelsterna cerulea,* has greyish-white plumage.

Two kinds, the Common Noddy, *Anous stolidus,* and the White-capped Noddy, *Anous minutus,* were abundant in the Coral Sea. The Common Noddy is very adaptable in its breeding habits; the single egg may be laid on bare sand or shingle, or in a nest ranging from fragmentary gatherings of grass and twigs to bulky structures of vegetation, feathers, sponges and other debris placed either on the ground or in trees. A strong tendency to nest in association with the Sooty Tern is evident in this species.

Non-breeding adults and flying young often gather in fairly large groups on beaches close to the water, or on rocky outcrops.

The White-capped Noddy is smaller, daintier, and darker in plumage than the Common Noddy. On cays of the Coral Sea it nests only in trees, though elsewhere, in the absence of trees or shrubs, it will nest on the ground. A platform of broad leaves or grass-stems and fine twigs, cemented with excreta, holds the single egg.

Noddies do not dive for their food like many sea-terns, but are surface-feeders, dipping from a few feet above the water, sometimes making a momentary belly-landing.

A pleasant memory of an overnight camp on one of their nesting cays is the sight of thousands of these birds streaming in from the sea at dusk, circling airily above their nesting trees, and uttering their soft calls in the tropic twilight.

The aggregate population of the 14 species of sea-birds recorded breeding on the Coral Sea cays probably exceeds a million individuals. Obviously there must be an abundance of marine life to support such numbers. When being handled, these birds would often disgorge squid and flying-fish up to 14 inches in length, and smaller birds, such as Sooty Terns and noddies, would throw up lesser fry.

The only land-birds living permanently on the outer cays are Banded Landrails, *Hypotaenidia philippensis,* which are found on most of the vegetated islets. Several instances of albinism were noted in this species: this tendency towards whiteness in the plumage is probably due to long isolation and the inbreeding of populations restricted to small islands. Also apparent was the disinclination of the rails to fly: if chased, they preferred to shelter in the burrows of the mutton-birds.

Other land-birds—bee-eaters, cuckoos, kingfishers, dollar-birds and cuckoo-shrikes —are seen very occasionally on the outer cays, generally after cyclonic weather and during periods of migration.

Shore-birds

Shore-birds or waders are not at all numerous in the Coral Sea. Turnstones, *Arenaria interpres,* and Golden Plover, *Pluvialis dominica,* which often associate together, are the species most frequently observed. Godwits, tattlers, whimbrels and stints are rare.

Members of this group of birds, of which more than 20 species migrate as far south as Australia from their breeding grounds in Alaska and Siberia, seem to prefer swamps, coastlines and islands closer to continents rather than oceanic cays. However, many individuals of several species frequent islands scattered throughout the Pacific, often finding their way over 1,000 miles or more of trackless ocean.

The absence of herons was noticeable. Apart from the presence of Nankeen Night-Herons, *Nycticorax caledonicus,* on Raine Island, a breeding station of the species, the only other bird of the kind seen was a lone Reef Heron, *Demigretta sacra,* on north-east Herald Cay, some 200 miles east of Cairns.

A comprehensive survey, with detailed notes, photographs, a map and references to relevant literature, dealing with the birds of the south-west Coral Sea, has recently been published as Technical Paper No. 3, Division of Wildlife Research, C.S.I.R.O., Canberra, A.C.T.

[*The photos in this article are by the author.*]

Queensland's Deadly "Sea Wasp", Photographed Alive

THE dangerous and justly-feared "sea wasp" of northern Australia is now well established as a harmless-looking, virtually transparent, cubomedusoid jelly-fish, apparently under certain conditions deadly to young children and quite capable of killing a full-grown man. (See "A Deadly Poisonous Jellyfish", by F. A. McNeill and E. C. Pope, *Australian Museum Magazine*, VIII (4), pages 127-131, June, 1943; and "Marine Stingers", by E. C. Pope, *Australian Museum Magazine*, XI (4), pages 111-115, December, 1953.)

The cubomedusae, or box jelly-fish as they are sometimes called, are squarish coelenterates with stinging tentacles arising from each of the four corners of the box-like swimming bell. These tentacles, growing down from a short, fleshy base called a pedalium, are sometimes placed singly at each corner, as in the case of *Carybdea rastonii*, the box jelly of South Australia (see photo in F. A. McNeill's and E. C. Pope's article referred to above, and in "Some Sea Animals that Sting and Bite", by E. C. Pope, *Australian Museum Magazine*, IX (5), page 166, August, 1947). *Carybdea* can give a painful sting with its six-inch-long tentacles and will leave a weal which may blister, but it rarely causes much injury and no deaths have been attributed to it as yet. The northern "sea wasp", on the other hand, belongs to that group of the cubomedusae with many tentacles arising from the single fleshy pedalium at each corner of the bell.

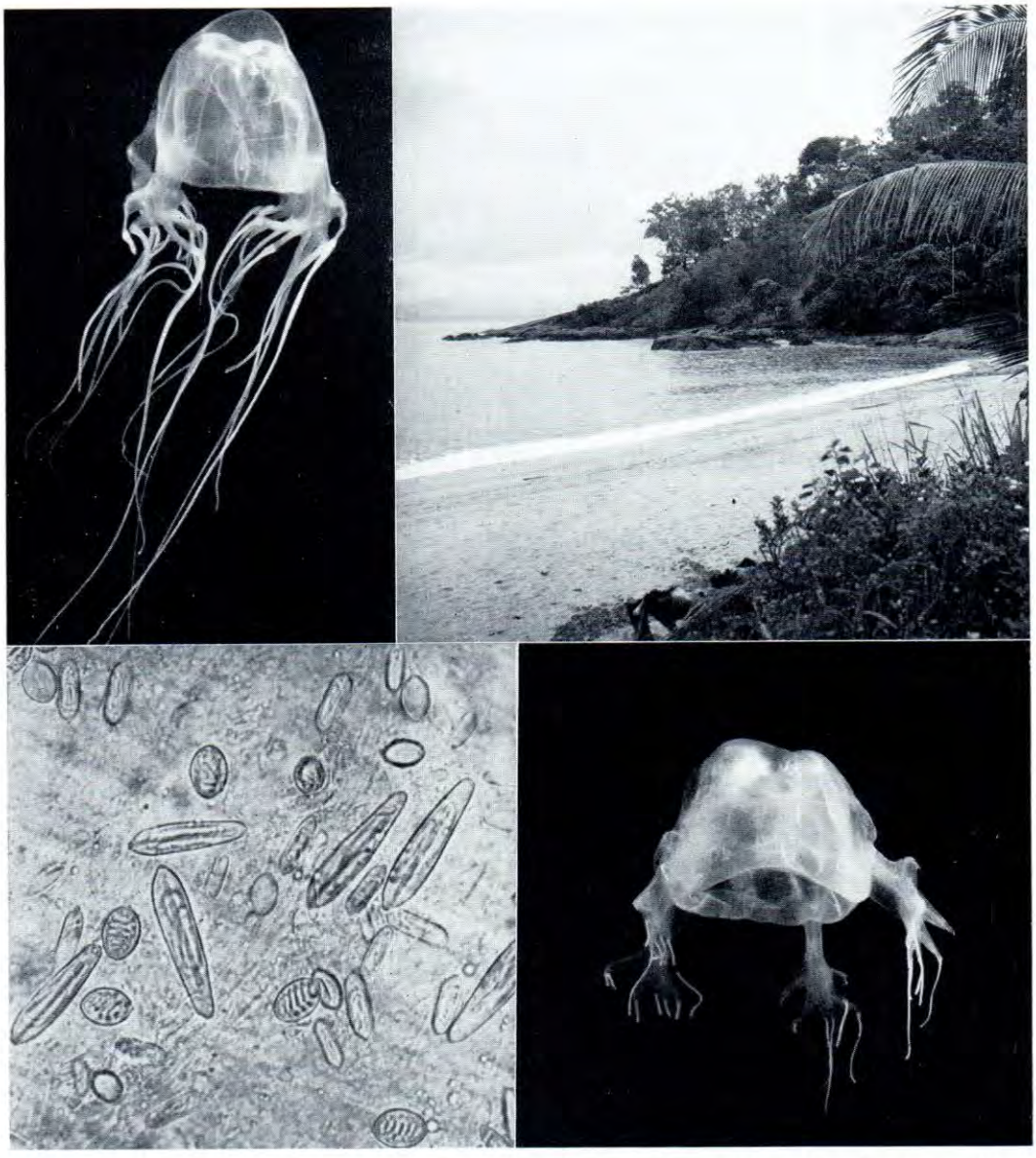
The name now applied to the northern Australian killer is *Chironex fleckeri*. This was put forward by Dr. R. V. Southcott, of South Australia, to honour the late Dr. H. Flecker, of Cairns, who many years ago had realized the danger of jelly-fish stingings in northern Queensland and had started to gather records on these occurrences, a work now ably continued in Cairns by Dr. J. H. Barnes.

There appears to be another, closely similar, multi-tentacled cubomedusa in our northern waters. This is *Chiropsalmus quadrigatus*, a well-known and deadly animal in the Philippines. The differences between *Chiropsalmus* and *Chironex* are obscure and difficult to evaluate. These differences, including the structure and position of the sex organs (gonads) within the bell, may be of less importance than we now regard them, but for the moment it is best to consider that there are at least two forms of highly dangerous cubomedusae in northern Australian waters, the principal one being known as *Chironex fleckeri*. According to Dr. Southcott, the authority on *Chironex*, this "sea wasp" grows to at least six inches across the bell and at that size would have 60 or more tentacles, many of them six feet in length or more. At a conservative estimate this gives at least 200 feet of stinging tentacle available for wrapping around, and discharge upon, a victim. Cubomedusae up to 20 inches in bell diameter with tentacles 20 to 30 feet in length have been reported by fishermen in the offshore current at Cairns but have not as yet been substantiated by specimens.

Following the death of a young girl at Palm Cove, Cairns, in January of this year, Mr. Keith Gillett, a well-known nature photographer of Sydney and an Honorary Associate of the Australian Museum, flew to northern Queensland to secure photographs in monochrome and colour of *Chironex* in life. Although Mr. Gillett was on an assignment to photograph *Chironex* for Dr. B. W. Halstead, of the World Life Research Institute, California, he was able at the same time to obtain a few black and white photographs for use in *Australian Natural History*. These unique photographs are published on the opposite page and are the first detailed illustrations of a living, northern "sea wasp" available in a scientific magazine.

In preparation for this work Mr. Gillett took over 1,000 exposures in his Sydney laboratory, using the southern stingers, the Portuguese Man-o'-war, *Physalia utriculus*, and the brown blubber *Catostylus mosaicus*, as live subjects. He found it was possible to record a transparent subject showing internal structure, using a matt black background combined with an electronic flash at a speed of approximately 1/5000th of a second. This eliminated the possibility of unsharp negatives with a strongly swimming subject. On arrival in Cairns, Mr. Gillett spent many hours with Dr. Barnes taking photographs of cubomedusae in the latter's laboratory. An animal, if left undisturbed in an aquarium, would immediately sink to the bottom of the tank and completely retract its tenacles, thus making it difficult to photograph. Both forms of cubomedusae were found to be light-sensitive and would swim quite rapidly with pulsating movements of the bell towards any light source. Both forms were not completely colourless in life, but rather a very pale shade of blue just visible to the naked eye.

The handling of these "sea wasps" did not turn out to be the problem that had been expected. Mr. Gillett was stung on the fingers while working with specimens of both forms up to four inches in diameter. The stinging was about as painful as that of *Physalia*, but lasted a little longer. There were no after-effects. He had been stung on several occasions by the hydroid coelenterate *Lytocarpus philippinus* (for photo see the "Marine Stingers" article in the *Australian Museum Magazine* referred to above) while skin-diving along the Barrier Reef and found its sting to be far more painful than those of the *Chironex* specimens described above.—*J. C. Yaldwyn.*



Top left: The cubomedusoid "sea wasp", *Chironex fleckeri*, photographed alive in an aquarium tank. Note the virtually transparent swimming bell, four inches wide, with a fleshy pedalium at each of the four corners giving rise to the long retractile tentacles armed with very numerous ring-like batteries of stinging cells (nematocysts). Top right: This typical swimming beach of the Cairns area, northern Queensland, is one of many where cubomedusae stingings have been reported in recent years. Bottom left: A photomicrograph (magnified 480 times) of undischarged nematocysts from *Chironex fleckeri*. Three distinct nematocyst types can be seen. The hollow, coiled tubes through which toxin is injected after discharge can be seen tightly spiralled within many of the smaller subspherical type. Bottom right: A live cubomedusa, identified as *Chiropsalmus* rather than *Chironex fleckeri*, with the tentacles largely retracted on each pedalium. Note the open subumbrella surface of the three-inch wide swimming bell. [Photos: Keith Gillett, F.R.P.S.]

Kangaroo Paw mingles with geranium as a highlight against a gay background of exotics. [Photo: Author.]

Australian Plants in Cultivation

By THISTLE Y. HARRIS
Author of "Australian Plants for the Garden"

THE first permanent settlers in Australia brought with them their own choice of garden plants including, to our present sorrow, such attractive but pestilent species as Lantana and blackberry. Unfamiliar with the floral beauties of the land to which they were migrating, they not unnaturally turned to the established plants which had given them pleasure in their gardens at home. Many of these plants, selected and bred over innumerable generations and tended lovingly in their new surroundings, were able to survive and sometimes to flourish under the exigencies of the weird climate and soils of the new settlement. No one thought of introducing into their gardens the hardy plants that were displaying their beauty in the untouched land around them. No doubt some of these early settlers did have "wild" gardens through sheer inability to cope. But many more took it as a first duty to eradicate all the wilderness around them and replace it with a formal design.

But now there have grown up new generations of Australians who are familiar with the remnants of our bushland and who appreciate and would like to perpetuate its bounty. To-day you will find throughout Australia quite a sprinkling of indigenous plants in gardens, parks and streets. For example, Geraldton Wax, *Chamelaucium uncinatum;*

New South Wales Christmas Bush, *Ceratopetaum gummiferum;* Bottlebrushes, *Callistemon* species, and Mint Bushes, *Prosthanthera* species, are common in Sydney gardens; many species of Eucalyptus, Moreton Bay Chestnut, *Castanospermum australe*, Brush Box, *Tristania conferta*, and a host of others are in Sydney streets and parks, while a much greater variety, including many spectacular species from Western Australia, grace the average Melbourne garden. In Perth, alas, one sees very few of the Western Australian plants in the gardens.

Dr. John Beard, Director of King's Park, Perth, which is now establishing quite an extensive native botanic garden within the park, speaks of the cultivation of native plants as "the second line of defence in conservation". I think this is very true. It is highly desirable to see as many as possible of the Australian plant species preserved in their natural habitats, but with the present big increase in population and the consequent devastation of the bushland, many species must inevitably join the ranks of those already disappearing. Cultivation can preserve some of them from this.

Australian Plants In Cultivation Overseas

The interest and beauty of many Australian plants have long been recognized in other countries. One has only to watch American films to discover this. Californians speak unashamedly (and no doubt in good faith) of "Californian Eucalyptus", the Mediterranean countries grow quantities of "Australian Mimosa" (*Acacia*) and in both north and South Africa a variety of Australian plants are to be seen in parks and gardens, nor are they uncommon on the European mainland. The great arboretums of America, such as that at Los Angeles and the Arnold Arboretum, can boast a grand collection of Australian plants.

Adaptability Of Australian Plants

One must remember, of course, that plants vary considerably in their capacity to adapt themselves to varying soils and climates and to produce hybrids and other new forms more suitable for garden cultivation. The familiar exotics which grow so readily under a variety of conditions are plants of wide adaptability in these respects, selected and developed by horticulturists over a very long period of time. This we realize if we leave gardens containing such plants untended for some time or allow our annuals to throw their own seedlings. How often are we disappointed by unpretentious weaklings or meagre flowerers!

Many Australian plants are amazingly adaptable. The Silky Oak, *Grevillea robusta*, and the White Cedar, *Melia azedarach*, both of them denizens of the coastal brush forests of high-rainfall and rich soils, are among the most successful trees for parks and streets of the arid inland areas of New South Wales, while the beautiful Black Bean, *Castanospermum australe*, which fringes the coastal rivers of New South Wales, does very well in some parts of Sydney; the lovely weeping bottlebrush, *Callistemon viminalis*, restricted naturally to the banks of inland rivers, flowers magnificently in Sydney and Perth, while the Western Australian Peppermint, *Agonis flexuosa*, which graces the sandy, windswept beaches of both the west and the south coast in that State, does very well in a variety of very differing habitats.

Others are extremely selective, demanding a very close approximation to the conditions where they normally occur. Most of the Boronias, including the lovely Native Rose, *Boronia serrulata*, of New South Wales, the Western Australian Morrison Flowers, Verticordias, and Leschenaultias are very selective and will only continue to flourish if particular conditions of soil and climate are available. On the other hand, some plants do far better in cultivation than in their natural habitats. I have never seen naturally-occurring New South Wales Waratah, *Telopea speciosissima*, to equal some garden-grown plants.

Contrary to earlier beliefs, most Australian plants respond to fertilizers just as other garden plants do. Since many of them occur naturally in rather poor, but well-drained, coarse soils, small amounts of fertilizer are all they will tolerate but they will respond to some such attention. Careful application of any of the normally-used fertilizers will determine how much is the optimum for each species on particular soils.

The common complaint that Australian plants are straggly and untidy need not apply to garden-grown forms (and it frequently does not to naturally-occurring plants). All such plants will respond to judicious pruning for shapeliness. There is one difficulty in shaping some Australian plants, more particularly those of the myrtle family, such as bottlebrushes. Such plants commence their new growth before the flowering period is over, and to obtain a shapely bush and a good flowering for the following season it is necessary to prune off the flowering heads before they are fully spent.

Plants For Every Garden

There are Australian plants suitable for every kind of garden. From the aspect of soil and climate this is not surprising when one remembers the vast continent from which we have to make our selection and the great natural variety of living conditions thereon.

From the aspect of suitability in appearance, again one has a great selection. Many gardeners—probably most—cannot withstand the temptation to grow such well-known favourites as camellias, roses, azaleas and the like. Many Australian native plants, even unselected forms, can rival these established plants and sometimes outstrip them.

At the same time, with careful selection one can have a garden mixture of Australians and exotics in complete harmony. Could anything be more flamboyantly lovely than the Mexican Jacaranda, *Jacaranda acutifolis*, flaunting its delicate blue flowers against the red waxy richness of the blossom of the native Illawarra Flame, *Brachychiton acerifolius*, or the gentle blossom of one of the mint bushes against the pink delicacy of an Oriental Weigela?

If you have a suitable site for a subtropical corner the lovely rich orange-red bells of *Rhododendron lochi*, from the Bellender Ker mountains of New South Wales, will certainly catch the eye of any visitor.

Your indoor garden section can be enhanced by many local species of Pothos, Perperomia, many suitable fern species and the Australian *Hoya australis*.

New South Wales Waratah on a formal lawn. [Photo: Quinton F. Davis.]

If you have a yen for a completely Australian garden you can have this, too, but you will need to select plants carefully to give an appearance of harmony. Just because plants come from the same continent they do not necessarily blend.

Improved Forms Among Australian Plants

As with all plants, some Australians are better adapted to cultivation than others. Many show great adaptability in nature, and careful selection and breeding by vegetative means can introduce into gardens the best forms of desirable species. There may be forms which vary in size, colour or display of flowers or which produce flowers at varying times of the year or for longer periods. The Brown Boronia, *Boronia megastigma*, of Western Australia, has been so successfully cultivated in Victoria that flowering sprays are now produced for a much longer period of time than under natural conditions. So successful has this

A pleasant blending of natives and exotics in a suburban garden—Illawarra flame tree, Christmas bush, cotoneaster, hydrangea, cypress and stringybark. [Photo: Author.]

been commercially that the flowers are now commonly offered for sale as "Melbourne Boronia".

Natural hybrids among Australian plants are not uncommon and this phenomenon is being greatly increased by the introduction of species from one part of Australia to another. In a native garden at Poorinda, near Buchan, Victoria, owned by Mr. Leo Hodge, the New South Wales *Grevillea juniperina* has successfully hybridized with the locally-occurring *Grevillea victoriae* and many of these hybrids are superior in one way or another to either of the parents. These successful hybrids have reached the market under the name of the Poorinda hybrids—Poorinda Queen, Joyce, Leane, Firebird and a number of others. Mr. George Althofer, of Dripstone, New South Wales, to whose credit must largely go the successful cultivation of native plants throughout this continent (for he was the pioneer) has produced a considerable number of such hybrid Grevilleas (Audrey, Marion, etc.), Prostantheras and others. Mr. D. Gordon, of Glen Morgan, has produced Pink Pearl, one of the hardiest and most adaptable of all Grevilleas, a hybrid arising from *Grevillea rosmarinifolia.*

A beautiful pink-flowering hybrid Brachychiton from the Illawarra Flame, *Brachychiton acerifolius,* and a related species will graft successfully on either Illawarra Flame or Kurrajong, *Brachychiton populneus,* thus providing plants which will flourish either on the coast or inland. There are several plants of this growing in Sydney, one particularly fine specimen being in the grounds of the public school at St. Ives, near Sydney. It flowers in summer.

Fairly recently a new hybrid Eucalypt has reached the market. This is a cross between two very fine Western Australians, *Eucalyptus woodwardi,* with golden flowers, and the Coral Gum, *E. torquata,* with coral pink blossom. The result, on the market as Torwood, carries unbelievable masses of orange-red blooms with the quaint long and crinkled buds of *E. torquata,* and holds its bloom for many months. Other hybrids have been artificially produced and

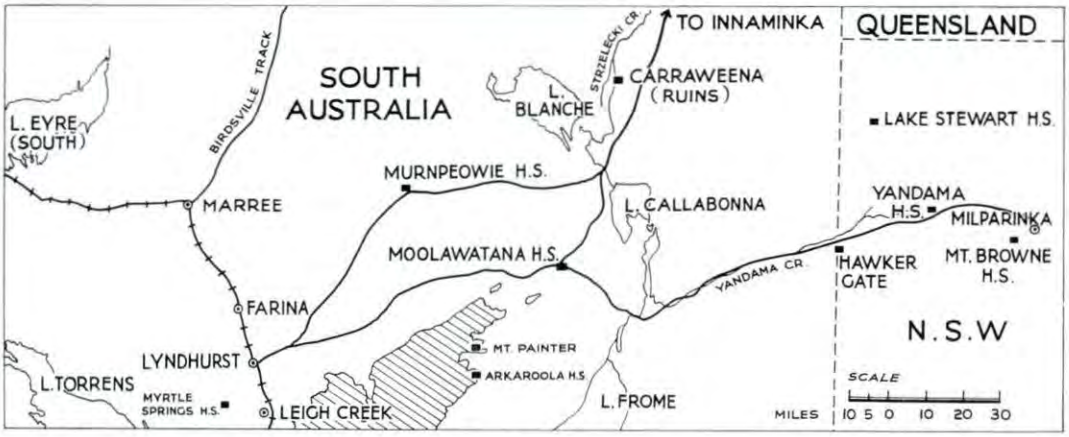
A double form of Wax Flower, *Eriostemon verrucosa*, a gem for any garden. [Photo: Author.]

there is a wonderful field here for the horticulturist.

Double forms of a number of Australian plants suitable for cultivation are receiving attention. The first one to draw the attention of horticulturists was a double form of Wax Flower, *Eriostemon verrucosa*, from the Bendigo Hills. From a single plant of this some 15 or so years ago a Melbourne nurseryman raised a number of cuttings and put the plant on the market. Since that time many more, and some better, forms of the same plant have been discovered and commercialized, particularly by Mr. W. Cane, nurseryman, of Maffra, Victoria. Several species of Boronia throw double forms. A fine double form of Sydney Boronia, *Boronia ledifolia*, occurring naturally at Dee Why, near Sydney, is to be seen growing very successfully at Stony Range Reserve in that locality. I know of other plants of this species which are natural doubles as well as one small patch of double *Boronia pinnata* and a magnificent double form of *Boronia thujona*, a species very close to *Boronia pinnata*. The flowers of the latter are like small, closely-packed roses and will be a sensation when they reach the market. A good double form of the Australian Bluebell, *Wahlenbergia gloriosa*, is being cultivated by a nurseryman, Mr. W. Cane.

Protection Laws

All the Australian States, with the exception of Tasmania, have legislation protecting certain of their native plants. Such protection covers every part of the plant, including seeds and portions suitable for cuttings. These laws are very necessary if our flora is to be preserved in its natural habitat. They need not, however, dampen the ardour of potential growers since there are now a great variety of Australian plants available at nurseries. Moreover, gardeners are notoriously generous—sometimes overpoweringly so—with the products of their own gardens and the enterprising grower will have no difficulty in obtaining a wide variety of suitable material for his own particular needs. The Society for Growing Australian Plants, with branches in every capital city in Australia and in many suburban and country centres, can put you in touch with the local growers who can introduce you to the techniques of native plant cultivation and whose overflowing generosity will fill your nurseries and greenhouses in no time.



A section of the route of the Meteorite Expedition last year. The hatched area is the northernmost part of the rugged Flinders Ranges. [Map by Elvie Brown.]

SEARCHING FOR METEORITES

By R. O. CHALMERS

[This article is being published in two parts. The second part will appear in our next issue.]

THERE are about 106 iron and stony meteorites known from Australia. Apart from the eight of these that were seen to fall none were found as a result of a planned search by geologists; they were found by people who lived, worked and travelled in the country. There are difficulties in the way of planning a systematic search for meteorites since they do not fall according to any set pattern. In fact, the statistics of meteorite falls might rather daunt any scientist embarking on such a search. The estimate is that one meteorite falls every year in every 400,000 square miles, which is about the area of South Australia. We include as a single fall any shower of meteorites which falls in the one area at the one time. This estimate is based on the number of meteorites known from countries like western Europe, India and Japan where, because of the high density of population, nearly all meteorites known have been seen to fall. Allowing for the fact that 70 per cent of the earth's surface is ocean, 150 would fall on a land surface each year.

In 1962 Dr. Brian Mason, of the American Museum of Natural History, New York, and Mr. E. P. Henderson, of the United States National Museum, Washington, D.C., both noted authorities on meteorites, fell to thinking where the best place to search for meteorites might be and they chose Australia, for the following reasons. Firstly, there are known occurrences of meteorites at four meteorite craters which can be visited and studied. This is the greatest number of meteorite craters in any one country. Secondly, a large part of inland Australia has a small average annual rainfall and is therefore waterless, arid and sparsely vegetated. Even despite the extremely low population density of the inland a surprisingly large number of iron and stony meteorites have been found in such areas because visibility is good over long distances and their appearance has usually been sufficiently distinctive to attract the attention of the Australian bushman with

his well-deserved reputation of being a good observer. Thirdly, that part of the continent of Australia south of a line joining Brisbane and Broome is noted for the occurrence of australites. Australites are varieties of tektites which are naturally occurring glassy substances that are found only in certain parts of the world. Scientists are by no means unanimous that these have come from outside the earth's atmosphere, since they differ in many respects from the stony and iron meteorites that are still seen to fall, but this makes it all the more important to acquire as many specimens as possible for scientific study in museum collections.

Expedition Travelled 12,000 Miles

Accordingly, an expedition was financed jointly by the two museums in the United States and by the National Geographic Society. The writer was a member of the party for the first two months, then returned from Alice Springs while Dr. Mason and Mr. Henderson continued on into Western Australia and returned to Sydney by the southern States. The total distance they travelled was 12,000 miles.

The itinerary was planned so that visits could be paid to as many known localities as possible where meteorites had been found or seen to fall. The prevailing opinion at present is that stony and iron meteorites break up in the air and fall as showers rather than as single fragments. It seemed not beyond the bounds of possibility that searching and making inquiries at station properties in arid regions in the general area where meteorites had fallen might yield other fragments from the same shower.

Setting out from Sydney in a four-wheel-drive vehicle on May 11, 1963, we proceeded from Bourke, through Wanaaring, Tibooburra and Milparinka to the Hawker Gate in the dog-proof fence that marks the N.S.W.-South Australian boundary. As an example of what we hoped to find, to the north-west of Wanaaring three stony meteorites have been found, two on Nardoo Station and one on Elsinora Station, 25 miles to the west. The resemblance between the Elsinora and the Nardoo stone nearest to it influenced us to search the intervening area in the hope that these might have been part of the one shower. At this stage the elements intervened. There had been unusually heavy rains in this part of the State, which has an annual average rainfall diminishing from 10 inches to eight inches as one goes westward. This impeded us in two ways. Firstly, tracks between stations and even the main highways, which in this remote part of the State are unsealed, were in bad condition, and in general the excellent growth of pastures and vegetation made visibility much more limited than it would have been after a few seasons of normal low rainfall. This was a handicap at other places in the north-west of New South Wales, where meteorites have been found, such as Nocoleche, south of Wanaaring, Mount Browne near Milparinka, where a stony meteorite was seen to fall in 1902, and the area between Yandama and Lake Stewart Station properties. This latter area is in the extreme north-western section of the State, about 50 miles west of Tibooburra.

Isolated Occurrence Of Australites

Australites were known to have been found on a property, Pindera Downs, 30 miles east of Tibooburra, and while a search didn't reveal any, Mr. Frank Nicholls, the present owner, presented us with some specimens. This seems to be an isolated occurrence. A considerable amount of searching and inquiries failed to reveal any other australite occurrence in north-western New South Wales.

Towards the South Australian border and after we passed into that State through the Hawker Gate, sand-hills made their appearance in increasing number and size. The presence of broad flat clay-pans between the sand-hills rather raised our hopes, but though numerous dark-brown rocks were seen on the clay-pans examination proved them invariably to be the characteristic hard ferruginous sandstone known as "ironstone" throughout the inland.

The road we took keeps close to Yandama Creek, which eventually joins Lake Callabonna. It would be a misnomer to say that it flows into the lake, because seldom is it other than a dry sandy creek. On the western side of Lakes Frome and Callabonna we left the sand-hills temporarily and

crossed stony flats, the outwash from the extreme north-eastern section of the rugged Flinders Ranges which we were now approaching as we headed in a north-west direction to Moolawatana Station.

1909 Find

Our next venture was to traverse the western shore of Lake Callabonna, where one of the largest and most striking iron meteorites known from Australia was found in 1909. It weighed just over a ton, and was very fresh in appearance. The surface was lustrous, black and covered with very well developed shallow cavities known as "thumb marks". These are one of the distinguishing surface features of meteorites, particularly iron ones. Though known as the Murnpeowie, it was found 53 miles east of the head station of this name. A more appropriate name would have been Callabonna, since it was found only five miles north-west of the western shore of the lake.

On the western shore of Lake Callabonna sand-hills once again made their appearance and continued on after we reached the Lyndhurst-Innaminka road. This was once literally just a track that closely followed the course of Strzelecki Creek and was a main stock route from South Australia through Innaminka on Cooper's Creek in the far north-west of that State, into western Queensland. To-day a well-graded dirt road extends from Lyndhurst on the main north line in South Australia to Innaminka and was built as part of the oil search programme which is proceeding at an ever-increasing tempo not only in this State but throughout the Commonwealth. We came on to this road right at the crossing between Lakes Blanche and Callabonna. Strzelecki Creek joins Lake Blanche and although we knew that the creek was running, a rare event, having been filled by the overflow from the Cooper due to the phenomenal rain in western Queensland earlier in 1963, the crossing was perfectly dry.

Unfortunately the new road pursues quite a different course from that of the old track and it proved impossible in the time at our disposal to find the old Carraweena ruins. Carraweena was a property near a point where the old track crossed the Strzelecki on which attempts were made to run sheep in the old days before the owners had to move out and leave the country to the dingoes which abound at the present day. In the near vicinity, three very similar stones, Carraweena, Artracoona and Accalana, were found round about 1914. This pointed to the possibility of a shower, but full investigation must await some future occasion.

A return was made to Leigh Creek, South Australia's only coal-field, on the main north line. This involved a trip of 200 miles back down the Innaminka track and through the picturesque scenery of the Flinders Ranges on to the relatively flat country stretching from the western margin of the Flinders Ranges into the sand-hills surrounding the eastern margin of Lake Torrens.

100 Australite Specimens Presented

While the state of the roads in all directions from Leigh Creek was definitely not the best because of the unseasonable rain that had fallen in this district, as in so many other parts of the so-called arid inland, we were soon proceeding post haste into the sand-hills fringing Lake Torrens. As soon as contacts had been established in Leigh Creek we received definite information that australites had been found there. Mr. Noel Smith, of Myrtle Springs Station, some 15 miles west of Leigh Creek, had collected australites and not only led us by the hand, so to speak, to the very spot where they could be picked up but also was good enough to present us with a collection of 100 specimens. Imagine the feelings of three geologists actually confronted with the spectacle of australites lying on bare claypans between the sand-hills. As with the iron and stony meteorites, australites have nearly always been found not by geologists but by people like Aborigines, policemen stationed in remote areas, property owners, station hands, boundary riders and others who live and work in the outback.

SPÖRING, OF SPORING CREEK

By Z. VRBICKY and J. KABAT

SOME 35 miles south of Cooktown, Queensland, Sporing Creek winds its course through Sporing Parish. It springs from the western side of Mount Boolbun (3,316 feet) and continues on its capricious way to join the Granite Normanby River and eventually wash into Princess Charlotte Bay.

The Queensland State Archives reveal that the name Sporing Creek was apparently first shown on a published map, "Cook District Two Mile Map", sheet 2, date 1889. A copy of this is held at the office of the State Archivist in Brisbane.

The Surveyor-General's Office in Brisbane probably chose the name "Sporing" for the parish and creek to commemorate the *Endeavour's* association with the area —the bark's sojourn in the Endeavour River from June 17 to August 3, 1770.

The parish and the creek were named after Herman Dieteric Spöring who, inter alia, immortalized the fauna of the Endeavour River with his fine drawing of an Epaulette Shark. Common in the shallow water of the Barrier Reef, *Hemiscyllium ocellatum* Bonnaterre was described by the Swedish naturalist Dr. D. C. Solander in his "Pisces Novae Hollandiae" (British Museum, Solander MS, Z2). One reads in a passage of Banks' journal entry for June 29, 1770: "The Seine was hauled to day for the first time and 150 lb. of Fish cought in it." This was mentioned in association with Spöring's drawing.

Spöring was born in 1735 on the south-western shore of Finland in the city of Abo (Turku in Finnish), which was a part of the Swedish kingdom till 1809. In 1827 the Swedish registers and documents were burned in the great fire of Abo, which destroyed the town as well as the Academy. The successor of the ancient Academy is the bilingual University of Helsinki, which celebrated its 300th anniversary in 1940. The destruction of the city accounts for some of the uncertain information concerned with Spöring's birth date in 1735. The young Spöring had been educated at the Abo Academy—founded by Queen Christina of Sweden in 1640—where his father, a well-known Professor of Medicine, was twice Rector Magnificus. As correspondent to Linnaeus, Spöring's father, Dr. Herman Diedrich (born Stockholm, 1701, died Abo, 1747), wrote an obituary of Linnaeus' father-in-law, Johannes Moraei.

In 1753 Spöring began to practise "kirurgi" (surgery) at the Kungl. Karolinska Institutets in Stockholm. However, he went to sea in 1755 and later supported himself for 11 years in England as a watchmaker (Dr. Solander's letter to Linnaeus, dated December 1, 1768, in Rio de Janeiro). In the last two years of his sojourn in England he was engaged as a writer to Dr. Solander, by whose acquaintance in 1768 he became one of the supernumeraries in Joseph Banks' retinue aboard the *Endeavour* (1768-1771).

As friend to Dr. Solander, a distinguished pupil of the great Linnaeus, Spöring was a valuable acquisition to the first voyage of the *Endeavour* round the world. He was considered a "grave thinking man" (Banks' journal entry of October 28, 1769) and useful clerk by Banks, and as assistant naturalist his sketches prove him to have been an artist of great ability. The drawings are preserved among the collections of the British Museum and some are published in J. C. Beaglehole (*The Voyage of the Endeavour* 1768-1771 and *Joseph Banks' Journal of the Endeavour*).

On the return voyage to England, between Batavia and Cape of Good Hope, Lieut. James Cook wrote a simple epitaph to Spöring in his journal (ship time, Friday, January 25, 1771): "Light Airs and Calms, hot and Sultry weather. Departed this Life Mr. Sporing a Gentleman belonging to Mr. Banks' retinue."

Banks' journal, in an entry dated January 24, 1771, mentioned his own illness and also that "In the Eve Mr. Sporing died".

The *Umitaka Maru*, one of the many ships built in Japan for research in fisheries and oceanography. Together with the *Koyo Maru*, *Oshoro Maru* and *Kagoshima Maru*, this fine ship has been exploring the eastern Indian Ocean as part of the International Indian Ocean Expedition. [Photo: *Umitaka Maru*.]

THE INTERNATIONAL INDIAN OCEAN EXPEDITION

By D. J. TRANTER
C.S.I.R.O., Division of Fisheries and Oceanography

AT the present moment, the research ships of many nations are exploring the Indian Ocean. This activity has been going on since 1959 and will continue till 1965. Previous to this, research expeditions to the Indian Ocean were few and far between. Less was known about this expanse of water than any other, not excluding the Antarctic. This is no longer the case, and the credit is due to the active encouragement of international bodies, particularly the Scientific Committee for Oceanic Research (SCOR). In fact it was this body of scientists which put forward in 1957 the proposal for an International Indian Ocean Expedition. Since then, UNESCO has become a co-sponsor and the administrative co-ordination is handled by the Intergovernmental Oceanographic Commission.

It is a tribute to the responsibility of science that the stimulus to initiate this work lay not only in the scientific merit of such a programme, but also in its economic and humanitarian implications. Around the shores of the Indian Ocean are distributed some of the most densely populated and under-nourished nations in the world. There is no doubt that these will come to depend more and more on the protein resources of the open ocean, just as Japan does today. The location of these resources, and the mechanisms by which they are formed, are now becoming apparent as the International Indian Ocean Expedition gathers momentum.

The term "Expedition" is somewhat of a misnomer, since there have already been many expeditions, and more are to follow. Early cruises were carried out by the Soviet Union, France, Australia and U.S.A., and later ones by Japan and Britain. Other cruises were made by South Africa, Pakistan, India and Indonesia.

As well as pursuing a policy of helpful encouragement, SCOR and UNESCO are making other contributions to this programme. Scholars from countries bordering the Indian Ocean are offered studentships at oceanographic laboratories throughout the world, and arrangements are made for them to participate in cruises. These are the people who will form the nucleus of oceanographic effort in this area in the years to come, and who will build upon the store of knowledge amassed during the expedition.

Unique Institution

Oceanography is a science which has developed its own methods and equipment. This is in many respects a healthy characteristic, but it has the disadvantage that where standard gear is not available a multiplicity of equivalents comes into use and it becomes difficult to compare the results obtained by different ships, even though they may be observing the same phenomena. Thus there is a pressing need to intercalibrate the observational methods. With the assistance of SCOR-UNESCO, it has been possible to gather together at Hawaii in 1961 and at Perth in 1962 the scientists and equipment from many participating countries, and to carry out a series of intercalibrations.

Out of the recognition for this need has arisen a unique institution, the Indian Ocean Biological Centre in Cochin, India. The IOBC is located within the precincts of the Oceanographic Laboratory of the University of Kerala, and is staffed and maintained by India's CSIR in co-operation with UNESCO. Its purpose is to act as a receiving centre for zooplankton samples taken with the Indian Ocean Standard net by the ships of the expedition. In charge of the international collections is a curator appointed by UNESCO, the first appointee being Dr. Vagn Hansen, of Denmark.

The Indian Ocean Standard net was agreed upon at a meeting of zooplanktologists in 1962, and was quickly put to use on many ships. It is not without fault as a sampling instrument, but these limitations are far outweighed by the fact that it has become widely used and provides the standard for the comparative zooplankton investigations of the expedition. Standard zooplankton samples are sorted at the IOBC by a team of expert technicians, and studied both at the Centre and abroad by specialists in the various fields of zooplankton systematics. By now the Centre has received a magnificent collection of samples, and will probably develop into the foremost institute for zooplankton research in our area.

Wind Systems

The Indian Ocean is unique in many respects, the chief of which are the relative disposition of land and water and the character of the wind systems in the area. The powerful influence of the wind systems upon

The Indian Ocean Standard net, adopted for general use in the expedition. This is a nylon net with a mouth area of one square metre. It is hauled vertically from 200 metres to the surface. [Photo: Commonwealth Film Unit.]

A C.S.I.R.O. scientist at work in the laboratory of one of the Australian oceanographic frigates. The bottles in the rack contain samples of sea-water from various depths. These samples are filtered through fine "millipore" membranes (in the tray) and the concentration of activity of minute phytoplankton organisms measured. [Photo: Commonwealth Film Unit.]

the productivity of the oceans is not generally realized. In the Indian Ocean it is most marked, for this is the domain of the monsoons, which change their direction from season to season and spread their influence over vast regions of the central and northern Indian Ocean. These winds exert their effect by way of ocean currents and other lateral movements of water, accompanied by upwelling of the deeper nutrient-rich waters so essential for oceanic productivity.

These are the processes which make the Arabian Sea and the Bay of Bengal so fertile, as well as the larger part of the equatorial Indian Ocean. Closer to home, similar influences are at work in the region between the north-west coast of Australia and Indonesia. This is a region which has received particular attention by our own laboratory. Among the 20 or so cruises we have made in the Indian Ocean since 1960, has been a series of six identical cruises between Fremantle and Singapore within a period of 12 months. This is a unique attempt to study the seasonal nature of oceanic productivity and to follow its effect from the point where deeper water is brought up into the lighted zone and triggers off the first phytoplankton bloom, to the stage where abundant food becomes available for populations of large migratory fish such as the tuna.

It seems to us that there may be three systems at work in this region, each with an enriching influence. North of 15° South, there is upwelling associated with the South Equatorial Current, which makes the region south of Indonesia one of the most productive in the entire Indian Ocean. South of this and north of 25° South is an entirely different system, depending for its seasonal enrichment on a deepening of the wind-induced mixed layer. Further south, in the region west of Perth, there is also periodic blooming of the plankton. This seems to be associated with the development of a large anti-clockwise gyral which may be accompanied by vertical uplift of deeper water.

The story is only now beginning to unfold. Our findings will be relevant to the expedition's work in other parts of the Indian Ocean and that work will be relevant to our own. Together, our combined results will provide not only the answers we are seeking, but also answers to problems not yet formulated.

VISITORS TO THE MUSEUM

Three overseas delegates to the conference of the Australian and New Zealand Association for the Advancement of Science, which was held in Canberra last January, later visited the Australian Museum. They were Dr. Wilhelm Solheim, of the University of Hawaii and editor of *Asian Perspectives*, who inspected the Museum's collection of Oceanic pottery; Mr. Sujono, of the National Archaelogical Bureau of Indonesia; and Professor Koentjaraningrat, Professor of Anthropology at the University of Indonesia, Djakarta.

In studies of the behaviour of rabbits, individual animals are marked with black dye and with identity discs in the ear. [Photo: E. Slater.]

Territoriality in Rabbit Populations

By R. MYKYTOWYCZ
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RECENT observations have shown the importance of territoriality among birds and mammals. (The words "territoriality" and "territory" are used broadly in this article, and not in the precise sense as understood by animal ecologists.) The nature of the territoriality varies from species to species, depending on the size of the animal, its way of feeding, reproduction, mobility, density of population, season and many other factors. In general, individual animals or groups of animals confine their activities to certain areas—home ranges—all or part of which they will protect from intrusion by other members of their own species, often by fighting.

New examples of territoriality within the animal kingdom are constantly coming to light and these are not confined only to the higher animals; territoriality has been demonstrated for some fish, lizards and frogs, as well as for a few insects, including dragon-flies.

Territoriality, which is closely interlinked with social organization, is beneficial to the individual as well as the species as a whole. This can best be illustrated by the results obtained from intensive studies of the behaviour of the wild rabbit, *Oryctolagus cuniculus* (L.), in enclosures and

under wild conditions in Australia. Similar results have been obtained with the rabbit in New Zealand and Great Britain and with the North American rabbit, *Sylvilagus* species. The behaviour of domestic breeds of rabbits has also been studied; despite domestication their behaviour does not differ basically from that of wild rabbits.

Studying The Behaviour Of Wild Rabbits In Enclosures

Until recently practically nothing was known about the social organization and territorial behaviour of the rabbit. These aspects of the biology of rabbits were difficult to observe in a predominantly nocturnal animal living under wild conditions, and were obscured when rabbits were confined under the crowded conditions of domestication.

A clearer picture has emerged, however, during studies of rabbits run under quasi-natural conditions in small enclosures of about two acres at Canberra, Australian Capital Territory, Albury, N.S.W., and in Tasmania. These studies have been made over the last few years by the author in collaboration with other members of the Division of Wildlife Research, C.S.I.R.O.: Messrs. K. Myers, W. E. Poole, I. Rowley and, more recently, Mrs. E. Stodart.

In the enclosures it was possible to record the activities during the day and night of rabbits marked individually by dyeing the fur and by attaching to the ear discs and tags marked with patterns of coloured reflective tape—patterns that could be detected by using spotlights and binoculars at night.

Rabbits were watched every day and sometimes round the clock for several days without interruption. Techniques were developed to enable rabbits to be caught at any time on the surface or in the burrows, and hence it was possible to manipulate the population experimentally by removing specific animals. The abdominal fur of each pregnant doe was dyed a distinctive colour specific to an individual animal and as this fur is plucked to line the nest the female parent of each litter could be determined from the colour of the fur in the nest.

A Hierarchy Of Dominance

During the breeding season, rabbit colonies consist of a number of discrete social groups, each of from five to eight adults, the number varying according to density of the population.

In each social group a linear hierarchy of dominance exists among the males, each dominating males below it and being dominated by males above it in the social scale. This hierarchy is established at the commencement of the breeding season by physical contests which are often violent. Among females, linear hierarchies are not universal; but females can be just as vicious fighters as males, although not so frequently. In savage fighting the rabbit uses its teeth, mainly to hold on to its opponent, while the powerful hind paws are used for ripping, usually at the abdomen. Two evenly-matched animals commonly leap at one another and crack together in mid-air while trying to secure a grip with their teeth.

In the Canberra study, when a dominant buck was removed the hierarchical system in his social group broke down temporarily. All bucks tried to improve their social position but the second-ranking individual usually succeeded in attaining dominance. When the original dominant male was returned to the group, fighting usually broke out between him and the newly-emerged leader. The result of the fight could go either way.

Territories

Within the area occupied by a group of rabbits the subordinate bucks usually confine themselves to certain sections. Does, especially during the breeding season, are even more sedentary, spending practically all their time feeding. The dominant bucks spend a great deal of time moving over the group's area, and by virtue of their wider range of movements become involved more in its defence. Intruders are repelled, or, if they offer resistance or are unable to move away, are fought and occasionally killed as a result of harassing by all the rabbits of the group; subordinates, and even half-grown rabbits, also participate in defence.

A rabbit using its chin gland to mark pegs in an experimental enclosure. [Photo: E. Slater.]

Does are particularly active in defending their breeding burrows, directing their attacks against other intruding females.

There are some males with even wider range of movement than the dominant males. These are unattached bucks which wander from one territory to another, always ready to take advantage of any existing opportunities.

Despite the existence of territories the rabbit's strong habit of exploring often takes it into strange territories, but there it behaves differently. Foreign territories are respected and even a buck, dominant in his own territory, will avoid contact and fighting with a subordinate in another territory.

Outside the breeding season territoriality weakens and almost disappears. This is the time when newcomers, usually kittens of the season, have to be integrated into new social groups. The final shaping of the social hierarchy takes place at the commencement of the new breeding season, and involves tests of strength between rabbits of a group.

Methods Used By Animals To Demarcate Their Territories

As information has accumulated about territoriality in free-living animals there has been a parallel growth in the knowledge of the methods used by different species to demarcate their own territories.

Generally four main methods are recognized—optical, acoustical, olfactory, and combinations of these.

The giraffe best exemplifies the first method. Its conspicuous marking does not appear to be related to camouflaging, as the animals can be sighted by experienced hunters miles away. On the contrary, it has been suggested that the animals space themselves in the savannah in such a way that sight contact is preserved between members of the same herd and different herds.

Special songs of birds tell their neighbours that the territories in which they sing are occupied and that "trespassers will be prosecuted." Among mammals the South American howling monkeys use their voices to demarcate their sphere of territorial influence.

Olfactory marking is the most common method among mammals. Faeces and urine are used, as well as the secretion of special glands. Dogs urinating on fence posts and walls of buildings provide the best known example of marking with urine.

Olfactory glands are found in many sites on the body, their situation in a particular species depending upon its mode of life. Several species of deer possess a gland below the eyes; the chamois uses for marking the secretion of glands situated around the base of the horns. The burrow-dwelling golden hamster and shrew have glands on the sides of the body in the intercostal region. The peccary possesses large glands in the mid-dorsal lumbar region, while the cutaneous glands on the legs of many ungulates function also for territorial marking. A number of animals, like the muskrat,

nutria, skunk and sable, use the secretion of the anal gland. The marmot and pika use glands situated under the eye and on the cheek.

Marking Of Territories By The Rabbit

The rabbit also possesses a special gland (actually a complex of glands—the superficial sub-mandibulary glands) which is used for marking territories. On the chin of a male rabbit one can often see fur matted together with the secretion from the gland; the gland may be felt under the skin. By applying gentle pressure droplets of a clear secretion can be forced out through a semi-circular row of secretory pores. The rabbit touches an object with its chin and covers it with the secretion from the gland. Objects marked by "chinning" include grass blades, posts, entrances to burrows, and also other rabbits, food, the ground, and faeces deposited by other animals.

The gland is present in does but is underdeveloped; thus, the hair on the chin of females remains smooth or only slightly contaminated with secretion. One can actually determine the sex of mature rabbits by the appearance of their chins. Females also mark with the chin gland but 10 times less frequently than the bucks and somewhat half-heartedly. The dominant bucks in one enclosure study were those which "chinned" most frequently, and on dissection their glands were found to be the largest.

Other studies suggest that the anal glands of the rabbit may also be of importance in territorial marking. The secretory ducts of these glands open into the rectum. It has been generally believed that the secretion of the anal glands facilitates the passage of hard faecal pellets, yet surgical removal of the glands does not result in any pathological disturbances. It is possible that the secretion of the anal glands coats the faecal pellets with a distinctive odour recognized by other rabbits.

Under enclosure conditions the dunghills of rabbits are formed by bucks within their home ranges at prominent points and are visited frequently. In addition, rabbits discharge faeces and urine randomly all over their home ranges, impregnating them with their own smell. Rabbits obviously recognize by smell when they have invaded foreign territories and this can be seen in their changed behaviour—cautious movements, frequent sniffing and the suspension of "chinning."

Although the hare, *Lepus europaeus*, is much larger than the rabbit, its anal gland is only one-tenth the size of that of the rabbit. The chin glands of hares are also only slightly developed. This is consistent with the wider-ranging movements of the hare as distinct from the gregariousness of the rabbit and the relatively small size of its territories.

The Pay-off Of Territoriality

Our studies of rabbits have suggested that where favourable breeding sites are limited there are definite advantages arising from the possession of territories.

The does, usually the older ones, which have free access to the better breeding sites, are the first to litter at the beginning of a breeding season. Thus, their progeny have an age advantage over other kittens and so have a greater chance of reaching dominant status in adult life.

Some nesting sites are better than others—in some places the risk of predation or of flooding is higher—and territoriality ensures that a female's unrestricted possession of a specific site is strengthened. Also, social stresses arising from territorial restrictions inhibit the breeding of some females and their embryos are totally or partly resorbed. Thus, an important result of territoriality is that all rabbits are not equally successful in breeding, and so the speed of growth of the population is retarded and is not as spectacular as might be expected, considering the breeding potential of an individual rabbit.

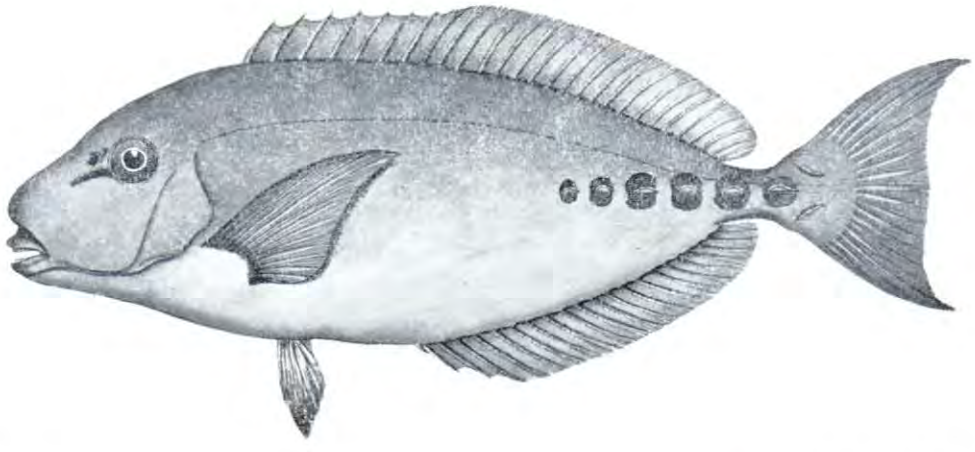
A Large Sawtail Surgeonfish

The Sawtail Surgeonfish (*Prionurus microlepidotus*) was first described by Lacépède from a specimen obtained by Baudin's expedition to "New Holland" in the earliest years of the nineteenth century. It differs from other Surgeonfishes and from the Unicorn Fishes in having more than three blades or spines on each side of the butt of the tail. Until recently this fish was known only from New South Wales and southern Queensland and from examples up to about 18 inches in length. All of them were of a normal fish shape and without any horn or bump on the head as in Unicorn Fishes. However, Mr. George Coates, of Townsville, northern Queensland, recently obtained from a spearfisherman an example 27 inches long, one of several hundreds seen at the same time on Keeper Reef, 45 miles north-east of Townsville. This specimen (registered No. IB.6366 in the Australian Museum) has a pronounced bump on the snout and an elongate oval shape, and is much larger than any hitherto reported. I am grateful to Mr. Coates for his drawing of this specimen, here reproduced, and for the loan of his painting, which shows the original colouring as dark greenish-grey on most of the fish, shading to greenish-silver on the lower third of the body; the eye is brown with a yellow ring around the pupil and the blades on the butt of the tail are dark greyish-brown.

E. P. Ramsay (in MS dating from about the 1870's) noted: "Specimens of this fish are occasionally taken in Port Jackson. When alive they are of a deep sooty-black, the eye yellowish, fins black, the laminae on the tail and their bases are whitish, or transparent." I have noted some with dark-blue eyes, blackish marks around their blades and bluish fins. Some have been reported to have had blue or white blotches or semi-albino markings here and there on their sides. The Australian Museum has several specimens from Port Jackson and other inlets in New South Wales into which this species swims in February, April to June, and August to December at various sizes, from a few inches long to 15½ or even 18 inches and a weight of about 2 lb. These occurrences may be due to an influx from large schools working along the coastline in seasonal searches of the algae upon which this fish feeds. Spearfishermen as well as line-fishermen catch the species.

The eggs and larvae are unknown. *Prionurus microlepidotus* is now known from Port Hacking, New South Wales, northwards to the Townsville district. A close relative, *P. scalprum* Cuv. and Val., is found in the Riu Kiu Islands, southern Japan and Korea.—*G. P. Whitley.*

The young or half-grown Sawtail Surgeonfish (right) is of the normal fish shape, but the record-sized Queensland specimen (below) is elongated and has a pronounced bump on the snout as in some Unicorn Fishes. Both have characteristic offensive blades on each side of the body before the tail. [Illustrations: right, after Cuvier and Valenciennes; below, drawn by George Coates.]



The Funeral Rites of the Ngadju Dayaks of Central Borneo

By D. J. MILES

FIELDWORK and bibliographic research recently carried out by Köln (West Germany) and Sarawak (British Borneo) Museums into rites associated with death in Dayak societies have stimulated considerable interest in the practice of such rites by Ngadju Dayaks. The Ngadju Dayaks are a Proto-Malay people who inhabit the upper reaches of the southward-flowing rivers of Indonesian Borneo or Kalimantan. They were described as savages practising human sacrifice and head-hunting by missionaries and colonial officers who first penetrated the interior of southern Borneo in the mid-nineteenth century. Today nearly half of the Ngadju are literate and the grandchildren of the renowned head-hunters own outboard motors, radios and sewing machines.

However, even more striking than this contemporary contradiction to the general conception of the life of "the wild man from Borneo" is the survival of certain aspects of his culture where others have undergone considerable change. The Ngadju still live in the same type of villages as those they occupied a century ago; today they are as dependent as ever on their traditional techniques of rice cultivation; many of the ceremonies which I witnessed while living in Ngadju communities in 1961-62 are almost identical to those described in nineteenth century reports.

One Ngadju ceremony which has gone almost completely undescribed in both recent and past ethnographic publications is that of the first phase of the rites performed on the demise of a Ngadju individual, the funeral. An epidemic of dysentery provided me with the opportunity to witness Ngadju funerals on numerous occasions whilst in the field and the following account is a summary based on these observations.

The sounding of a gong is the usual announcement that an ailing individual appears to be on the point of death. Relatives

A mask worn by a dancer at a wake to personify an evil spirit.

and friends gather around the sleeping mat on which he lies, while elders attempt to drive evil spirits from the body of the sufferer by various magical techniques. Concoctions of herbs and water are sprayed from the mouth onto his face and body or the toe and finger nails are prised upwards to allow an exit for the spirits. The gongs can be heard throughout the village and the farm hamlets which surround it. People who reside in the farms make inquiries from travellers as to the identity of the ill person so that all those who have responsibilities to fulfill if death occurs are usually aware some time in advance that their services may be called upon.

Death, which is announced by the beating out of a particular tune on the gongs, marks

the beginning of a great amount of activity on the part of survivors. It is considered undesirable for the immediate kin of the deceased themselves to have to organize the practical duties associated with preparations for the funeral and its performance. In this regard they are dependent on the assistance of fellow villagers and relatives. The first need is for the corpse to be washed and dressed in the finest garments available. Next a coffin must be manufactured. A tree of suitable softwood is selected in nearby jungle, felled and roughly trimmed before being carried back to the village. Here it is carved in the shape of a canoe. Cracks and fissures are sealed with resins and a bamboo pipe is inserted into the base. This conducts fluids of the decomposing corpse from the interior of the coffin and through a hole in the floor of the house. A canopy of brightly coloured cloth is erected above the coffin. The corpse may lie on view for several days before being swathed in white cloth and placed in the coffin.

After the closing of the coffin a continuous watch is kept on it until burial takes place for it is believed that the corpse is subject to the attacks of evil spirits who are bent on interfering with it in various ways. The wake may last from a few days to more than a month. Its duration is largely dependent on the wealth of the household of the deceased, for those who come to participate must be served with food and rice wine. Only the wealthiest households have supplies of food sufficiently in excess of their own needs to support a wake of long duration; on the other hand a poor household may be dependent on voluntary contributions of food from fellow villagers in order that any funerary rites may be performed.

During the period of the wake the immediate kin of the deceased sit or lie beside the coffin replenishing bowls of burning incense and awaiting the attacks of evil spirits. In the hours of dark the rhythmic clacking of split bamboos announces the arrival of the "bukungs" or dancers who personify the evil spirits. The dancers wear masks and body decorations of leaves, mud and nets. Villagers compete in order to produce the most elaborate of masks and decorations and dancers attempt to conceal as far as possible individual identity. The masks come in many shapes but usually take the form of human faces with zoomorphic appendages, such as horns and trunks. Attached to the masks are coins, bank-notes, bottles of Chinese wine and even live chickens.

The clacking of the dancer's bamboo acts as a signal for gong players and drummers within the house to begin beating their instruments which accompany the "bukung's" dance in front of the coffin.

After the dance the "bukung" is usually invited to be seated on the floor, where he is served with food and rice wine by representatives of the deceased's family. Lavish hospitality is the keynote of the reception. It is in such an atmoshpere that an exchange of verbal courtesies occurs during which the "bukung" subtly puts forward reasons as to why he should be given access to the corpse; the bereaved attempt to parry his arguments without seeming to infringe the ethic of hospitality towards guests. The argument of one "bukung" went as follows. Glancing towards the coffin, he explained that he and his friends urgently needed a canoe in order to undertake an important voyage. The canoe which was in the centre of the house would be eminently suitable. Knowing of the widely renowned kindness of the members of the household he had come to beg assistance. The bereaved replied that they felt honoured by the request and were anxious to give every possible assistance, for they regarded the success of the guest's voyage as their own responsibility. Because of this they could not tolerate the possibility of any risks to their guest's safety such as those entailed by use of such a leaky and undersized craft as that which had been requested with such commendable humility. This type of debate continues for an hour or more until the "bukung" finally submits to the superior oratorical skill of the bereaved. He requests permission to leave and in a final dance before rushing from the house tears the mask from his face and throws it at the foot of the coffin. The "evil spirit" is defeated.

Between the entries of various "bukungs" a different rite takes place in which females play the dominant role. Worn reed and rattan mats are gathered, rolled into cylinders and set on fire. These blazing torches are then beaten against the feet and legs of all visitors. Women mix ash, rotting rice

and fluid from the corpse and try to plaster the mixture on the bodies of men as they dart about the house in an attempt to evade the onslaught.

Such rites are performed every evening between the closing of the coffin and the actual burial. Those performed on the eve of the burial continue into the following day when the most elaborate and finely carved masks are used by dancers. The gongs and drums continue without cessation. Women bring gifts of rice to the house as a contribution to the funeral feast. A portion of each basket of rice is sprinkled on the coffin. Having made this contribution each woman rests her head and arms against the wall of the house and wails loudly for several minutes. The wailing continues as men fetch bamboos and gourds of river water which they splash over the floor of the whole house. The canopy above the coffin is removed. The carved head and tail of either a water snake or a bird is attached to the ends of the coffin; the former is used when the deceased is male, the latter when the deceased is female. Poles are tied to the sides to provide handles for pallbearers. An axe blade is bitten by the close relatives of the deceased and then tapped on the coffin.

The tapping and a loud shout announce that the coffin is about to be moved. It is carried by mud-covered men to the river bank where it is placed in a canoe and transported downstream. Gongs continue to be beaten in the other canoes accompanying the floating hearse to the burial site.

As the grave is dug elders scatter wine and rice in the nearby jungle, begging the jungle spirits not to harass the deceased. Mourners pelt one another with earth from the excavation as the coffin is lowered and the grave is filled in. In some cases the grave is completely lined with hardwood planks which form a wooden tomb and facilitate recovery of the remains for secondary ceremonies that may be performed some years after the burial.

On their return to the village all mourners participate in ablution rites. The members of the household of the deceased sit in a canoe which is deliberately capsized, immersing them in the river. All other participants bathe and then partake of the funeral feast.

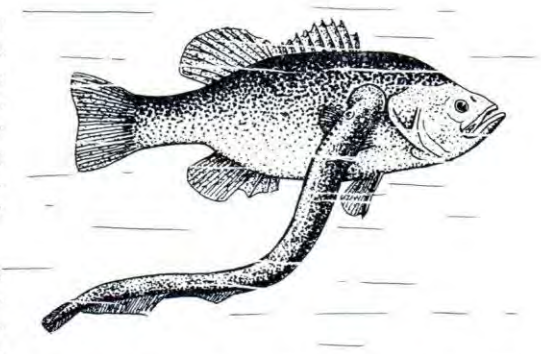
LAMPREYS IN AUSTRALIA

By RONALD STRAHAN

School of Biological Sciences, University of New South Wales

EACH year, in the late spring or early summer, large numbers of lampreys leave the sea and swim up into most of the rivers of southern Australia. These eel-shaped creatures are from one foot to over two feet long and are brightly coloured, yet they are hardly ever seen, even by fishermen who are well acquainted with their home rivers.

Lampreys are reasonably familiar animals in the northern hemisphere. In the Scandinavian and Baltic countries they are in demand as delicacies, and some Governments prevent over-fishing by placing a limit on the fishing season or restricting the catch. In contrast to this attitude, the Canadian and United States Governments are spending millions of dollars to eradicate lampreys from the Great Lakes, where they have ruined the lake trout fishery. A brief account of the natural history of a typical northern lamprey helps to show what we do not yet know about the southern forms.



Petromyzon marinus, a large lamprey found in the North Atlantic Ocean and its major rivers, sucking onto a bass.

Not True Fish

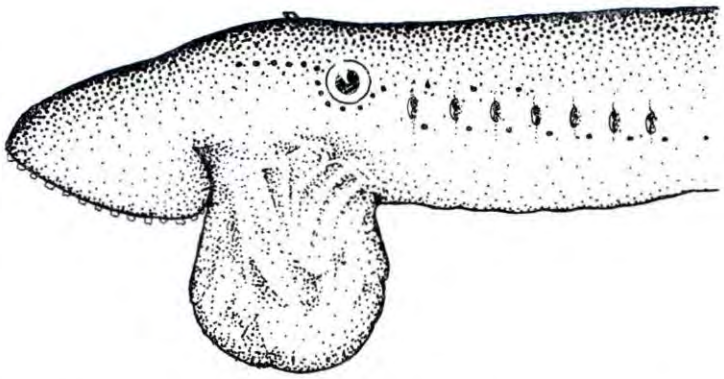
Lampreys are eel-like creatures, but they are not true fish. They are survivors of a primitive group of backboned animals that lived in the seas some 400 million years ago. Like fishes, they had tails, but they lacked paired fins and had no jaws. The nostrils were fused together as a single opening on the top of the head. Most of these early forms (known as the Agnatha, or "jawless fishes") probably fed by filtering food particles from water or mud taken in through a mouth that was little more than a hole, but the lampreys have developed a way of feeding on animals larger than themselves. The mouth is expanded into a circular, tooth-studded sucker with which the lamprey attaches itself to the flank of a fish. A tongue-like organ, also armoured with teeth, rasps into the body of the fish and the lamprey sucks up blood and fragments of flesh.

Typical lampreys, such as *Petromyzon marinus*, a large species found on both sides of the North Atlantic, spend their adult lives at sea, and are seldom caught or observed in the act of feeding. We know most of this habit from observations on the lampreys which quite recently—within the last 25 years—have changed from feeding in the sea to a life in the fresh water of the Great Lakes of North America.

When they reach maturity, lampreys migrate into rivers to spawn. They cease feeding and thereafter live on food stored in the body tissues. Consequently they shrink as they grow older. Spawning takes place in gravel beds in the clear shallow headwaters of rivers, and this may entail an upstream migration of as much as several hundred miles. The male excavates a rough nest by carrying away stones held in his sucker; the name *Petromyzon* (stone-sucker) recalls this habit.

Fertilization takes place with the female holding on by her sucker to a large rock upstream of the nest and with the male similarly attached to her head. Vigorous movements of their tails stir up sand which is carried with the eggs into the interstices of the nest, burying them. After spawning, the spent parents drift downstream and die.

The young, when they hatch, burrow into the stream bed and begin a larval life of up to five years. These larvae, known as



A sexually-mature male of the Pouched Lamprey, *Geotria australis*. The large pouch has no connection with any of the body cavities, but is an enormous "blister" in the skin. The seven gill-slits plus the eye and the median nostril of lampreys led to their German name *Neunauge* (nine-eyes). The median nostril is seen as a projection above and just in front of the eye.

ammocoetes, make temporary U-shaped burrows in sand or mud, particularly in small backwaters or eddies where fresh silt is being continuously deposited. The ammocoete pumps a current of water into its mouth and out through the seven gill-pores on each side of the head, and feeds on microscopic plants which are filtered from the water by a net of slime strands in the throat. Possibly the fossil jawless fishes had a similar method of feeding.

Ammocoetes are pallid and rather worm-like in shape, although their bodies are quite firm and muscular. The paired eyes are rudimentary and lie below the skin, but there is a well-developed pineal eye on the top of the head. This "middle eye" is an ancient characteristic of backboned animals, but in most modern forms it is a solid body lying below the skull and quite insensitive to light. The pineal eye of the ammocoete does not "see", but it can sense the degree of illumination above the animal.

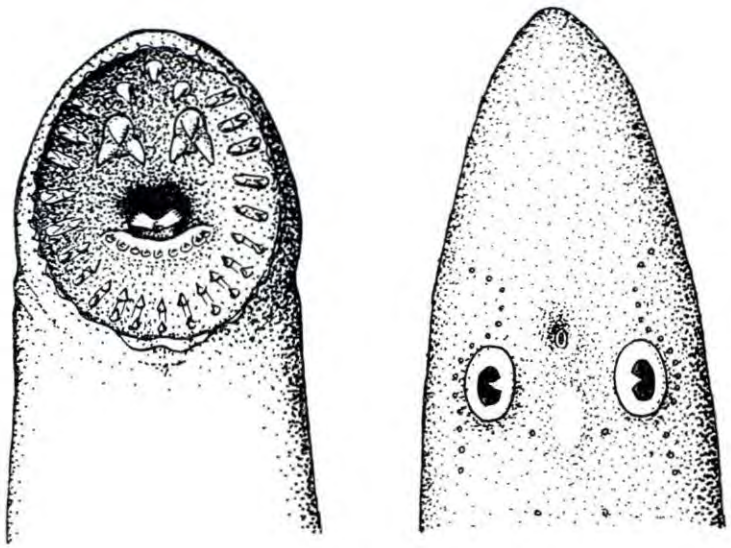
At the end of larval life, the ammocoete metamorphoses into a small adult. The paired eyes complete their development and emerge to the surface, the fins become larger, and the overhanging upper lip of the larva is transformed into a sucking funnel around the mouth. The young adult, not more than about six inches in length, swims down to the sea and begins the parasitic phase of its life, lasting from one to several years. It grows larger and develops sexually to the point where it is ready to make the upstream spawning migration that is the culmination of its life.

That is a typical life-history. In many of the larger river systems of the northern hemisphere, we find species of lampreys that do not go to sea. The young adults, which become sexually mature a few months after metamorphosis, mate and then die without having fed. These are known as "non-parasitic" lampreys.

So far as is known, there are only two species of Australian lampreys. The Short-headed Lamprey, *Mordacia mordax*, predominates on the eastern side of Australia and overlaps in the southern rivers with the Pouched Lamprey, *Geotria australis*, which is predominantly western in its distribution. Both species are found in Tasmania.

The adult *Mordacia* is bright blue and approximately 18 inches long. It is remarkable among lampreys in two features: its eyes lie on the top of the head instead of at the sides, and it burrows in sand or mud quite like an ammocoete. How it breathes when it is under the bottom is a mystery. Ammocoetes of this species are found in reasonable abundance in most of the rivers of south-eastern Australia, but the adults are rarely seen. This is probably due to their habit of burrowing during the day. In recent years, Baltic immigrants have found adults in large numbers in several small rivers around Melbourne where

Ammocoete larva of the Short-headed Lamprey, *Mordacia mordax*.



The Short-headed Lamprey, *Mordacia mordax*. Left, head seen from below, showing sucker and teeth. Right, head seen from above. The funnel-like depression is the single nostril. The clear area behind it marks the pineal eye. The small pores are sense organs of the lateral-line system. The head is more pointed in this view because the sides of the sucker are folded inwards, closing the mouth.

low weirs hinder the upstream migration. They have been caught by the thousands, leaving virtually no survivors. We do not know to what extent lampreys return to their home rivers, but if they do the populations in these rivers are doomed.

Geotria is a larger lamprey, reaching over two feet in Western Australia, but not much more than 18 inches in eastern rivers. The newly-metamorphosed adult is a brilliant creature with silvery flanks, a black stripe running down the middle of the back, and a turquoise stripe on either side of this. The paired eyes are relatively large, and this stage in the life-history was earlier described as a new genus, *Macrophthalmia*. When the adults enter the streams on the spawning run, the stripes are still quite distinct and this has led to the popular name, Bandera Argentina (Argentine flag), in South American waters. As they swim further upstream, the skin becomes dull and opaque, and the stripes disappear. This stage has been described as a separate genus, *Velasia*, for it differs from the quite mature adult in its body proportions and in possessing a sucking funnel which is not much wider than the body. On the last stages of the migration, the sucker becomes immense, about twice the diameter of the body, and a pouch of skin develops below the throat. This is particularly marked in the males.

Like *Mordacia*, *Geotria* is seldom seen except where the run is held back by a dam or weir. They are a fairly regular sight at Pemberton, in Western Australia, where they are active in daylight.

The life-histories of *Mordacia* and *Geotria* appear to be the same as the typical parasitic lampreys of the northern hemisphere. One might have expected, in view of the length of the Murray-Darling system, that Australia would provide a home also for non-parasitic lampreys which have given up the hazardous marine phase of the life-history. These have not been found but they may well exist.

Nothing is known of the mating habits of Australian lampreys. We do not know how or where they breed, and we can only guess that they mate in the summer. We do not know what sort of nests they build —or even whether nests are built at all. This is a serious handicap to the study of these forms for we cannot investigate their embryology or early development. There is scope here for valuable work by amateur naturalists who have access to the headwaters of clear shallow streams, particularly in south-eastern Australia. Careful observation of sandbanks and gravel beds during the summer months, particularly at night, might solve this little mystery.

[*The drawings in this article are by the author.*]

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