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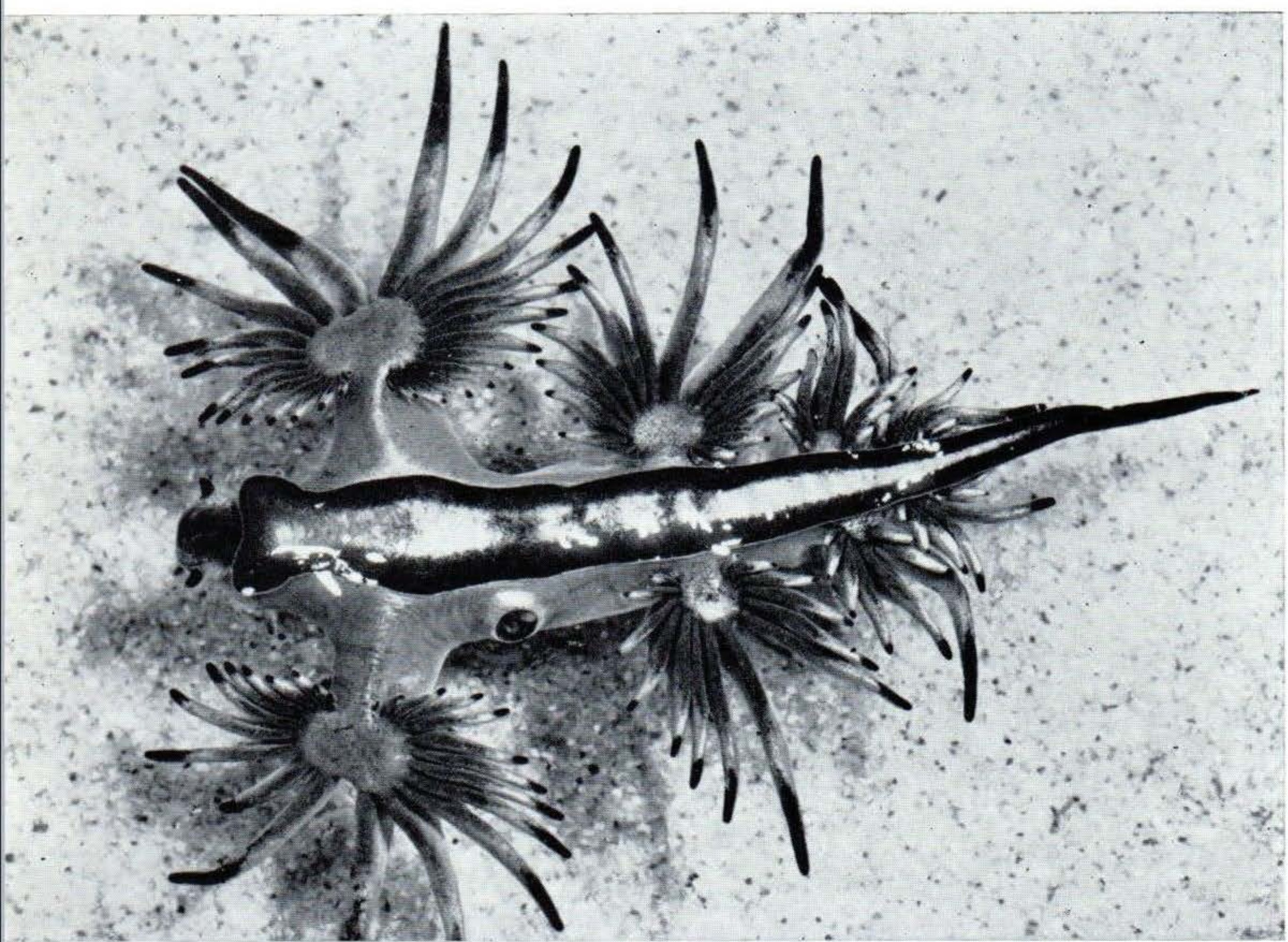

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CONTENTS

● **FRONT COVER:** *Glaucus atlanticus*, **a blue and silver-grey marine animal often washed ashore in thousands during the summer. It is a nudibranch, one of the "naked-gilled" sea-slugs, related to the sea-snails and other members of the phylum Mollusca. Most nudibranchs are found crawling under stones and among seaweed, but** *Glaucus* **has adopted a planktonic mode of life, drifting at the ocean surface together with such animals as the bluebottle and the violet-snail. It swims actively, and has numerous finger-like projections. These are often thrown off when the animal is disturbed or dying. This specimen was found on Cronulla Beach, New South Wales. [Photo: Howard Hughes.]**

VOL. 15, No. 11 SEPTEMBER, 15, 1967

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VOL. 15, No. 11 SEPTEMBER 15, 1967

The Portuguese Man-of-war or Bluebottle

By RONALD V. SOUTHCOTT
Honorary Zoologist, South Australian Museum

THE survival of primitive animals and plants in the modern world has excited the curiosity of naturalists at least since the time of Darwin. One large primitive group of animals is the coelenterates or cnidarians—the jelly-fish, sea anemones, corals and their allies. Anyone who reflects on the survival and success of this group in the marine world—the great habitat of predators both in the past and the present—may well wonder how a group of fleshy animals, frequently completely exposed to their environment and usually not very motile, can have survived in such numbers and in so many different kinds.

Some coelenterates are so numerous as to force their presence quite painfully upon man when he attempts to become "*Homo aquaticus*", the man of the marine and other aquatic environment. This article deals with a colonial organism mostly known in the English tongue as the Portuguese man-of-war, but generally referred to along the eastern Australian coastline as the bluebottle. Its scientific name is *Physalia physalis* (L.), and according to the most recent studies (by Totton) there is only one species of *Physalia* over all the oceans.

There is certainly no doubt of the success of this floating creature. Thus a newspaper item of 9th January, 1967, records:

> Thousands of surfers at Sydney beaches were treated yesterday for stings by bluebottles. Large numbers of bluebottles—some with stingers more than six feet long—were reported for the third successive day . . . Children seemed to be crying and yelling all day . . . At Manly lifesavers closed the beach . . . when they sighted a mass of bluebottles drifting towards the shore . . .

An accompanying photograph shows a similar occurrence at Bronte Beach, New South Wales, where large numbers of *Physalia* were stranded along the shore.

Yet despite the fact that this animal is well-known and occurs in vast numbers at times—appearing in plague proportions every few years for a few days—there still remain large gaps in our knowledge of its habits and life-history. This makes attempts to predict

Stranded Portuguese man-of-war (bluebottles) washed-up on Bronte Beach, New South Wales, in rough weather. The floats of these specimens were about 6 inches long. [Photo: Keith Gillett.]

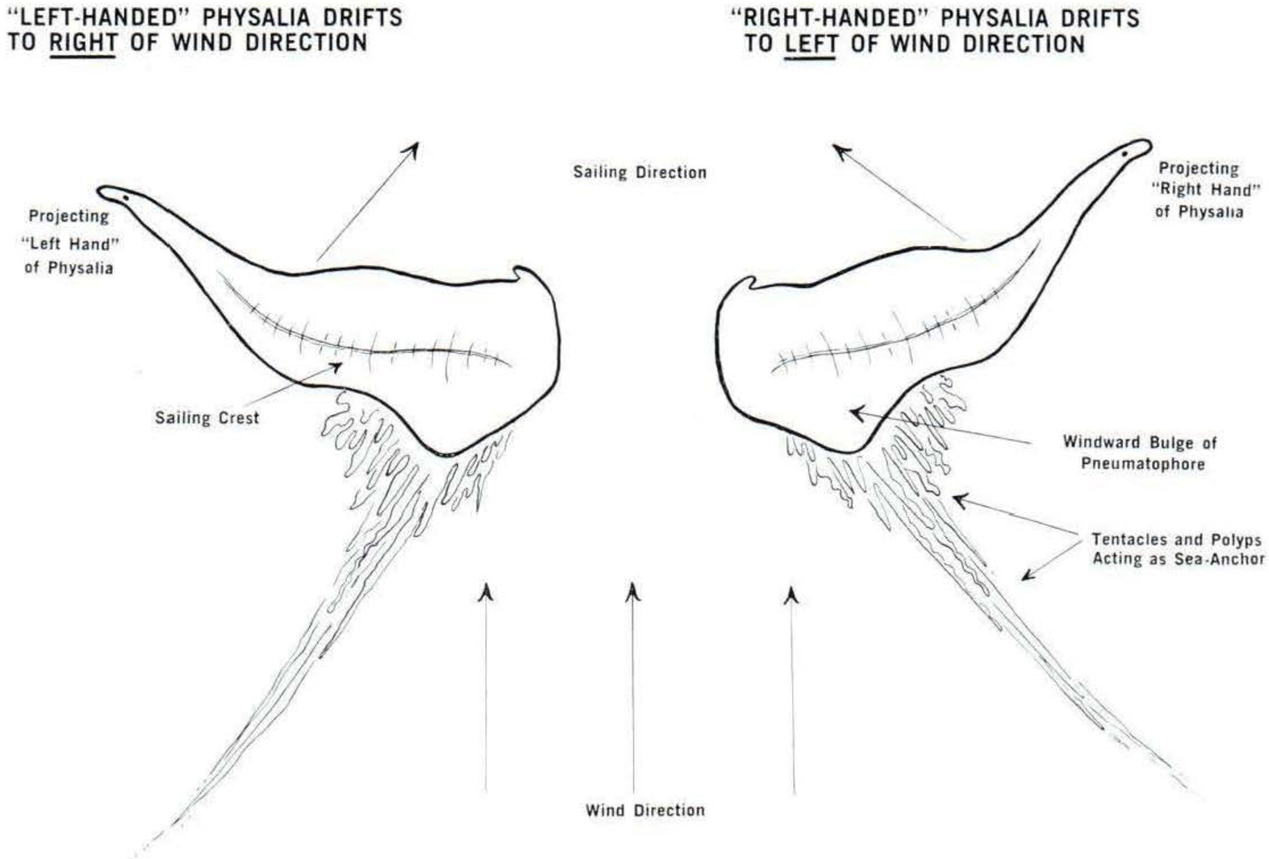
its numbers and the hazard involved unreliable, and efforts to prevent such plagues at present impossible.

Ecology—the bluebottle's place in nature

The air-water interface of the open sea has been considered by some authors as an ecological niche, and is clearly one with very distinct features. A number of animals live there permanently, or spend much of their lives there, and these may have special adaptations. Among the inhabitants of this niche are the bubble snail, the paper nautilus, various crustaceans and various siphonophores, but not all of these are permanent inhabitants. *Physalia* is one of the floating siphonophores, a specialized group of coelenterates, which includes also *Velella*, the by-the-wind sailor, and *Porpita*, a disc-like colonial form the size of a penny. The floating wind-directed fauna has been named the "pleuston" by the Russian ecologist Savilov. This ecological "niche" is certainly a hazardous one, as its inhabitants are exposed not only to predation from above and below, but also to the battering of the waves and the dangers of stranding along shores. It is this stranding which makes *Physalia* such a pest to "*Homo aquaticus*" from its considerable stinging abilities, but cannot be of any survival value to the *Physalia* itself.

Natural enemies and associations

Very few animals use coelenterates as a principal food source, possibly because of their unpleasant stinging powers, together with their low food-value. Coelenterates also appear to be remarkably free from parasites. However, in a number of instances there is a distinct fauna, mostly fish, associated with a species of jellyfish. Other coelenterates also have distinct associated organisms, probably among the best-known being some of the larger sea anemones and the fish which live among their tentacles. Why some fish can do this, while others are instantly killed by the stinging apparatus of the tentacles, remains still largely unclarified. In some cases the situation is utilized by the coelenterate's associate for shelter, as far as can be determined, but in other cases the relationship is more complex. The associate of the coelenterate is usually a fish, but in one recorded Australian instance the large jellyfish *Pseudorhiza haeckeli* had



Sailing characteristics of "left-handed" and "right-handed" specimens of the Portuguese man-of-war. [Diagram by the author, after Totton.]

sheltering underneath it a number of small clear hydroid jellyfish, *Eirene menoni*.

The classic case of jellyfish-fish symbiosis (living together) is that of *Physalia* with *Nomeus gronovii*, a small pelagic fish which swims among the tentacles of its siphonophore "host". The question of the degree of, and possible mechanisms for, immunity is too long a subject to be discussed here, but can be studied further in other publications. The situation is, however, a complex one, as *Nomeus* does feed upon the tentacles of *Physalia*, and in its turn *Physalia* can sting *Nomeus* fatally and digest it.

Turtles appear to be among the more important natural enemies of coelenterates, as there are records of turtles eating *Physalia*, and also the lethal box-jelly or sea-wasp *Chironex fleckeri*. More observations on this predation by turtles in the Indo-Pacific region are, however, required.

Sailing habits and other movements

For many years sailors have noted the peculiar habit of *Physalia* of sailing at an angle to the wind, and in fact the name Portuguese man-of-war is believed to have been given because of the resemblance of the float or pneumatophore to the lateen sail of the caravel, a fast and successful light ship introduced by the Portuguese in the reign of Henry the Navigator.

Specimens of *Physalia* have this float, a medusoid form which has been inflated by a gas-gland, projecting to either the left (left-handed) or the right (right-handed) when the animal is under the influence of the wind, and in different areas the stranded "navies" of the man-of-war carry different proportions of the right-handed and left-handed forms. (Another siphonophore, *Velella*, also occurs in mirror-image forms with opposite sailing characteristics.) The left-handed *Physalia* sails to the *right* of the wind direction, and vice-versa (see diagram). In the laboratory, or in beach-stranded specimens, the left- or right-handedness of a specimen can be recognized from the fact that the bulge of the specimen, with its various polyp-forms and tentacles, drags to the rear, serving in fact as a drogue or sea-anchor.

Another motion seen in *Physalia* under aquarium or other still conditions is that of rolling or somersaulting. This is possibly due to the animal being unstable if there is no breeze. Some authors do not accept the old sailors' explanation that the animal is "tacking". Whatever its explanation, it certainly has the effect of keeping the float wetted.

Feeding habits

The feeding habits of the Portuguese man-of-war have been studied more particularly in the Atlantic, and there it has been found that it feeds mainly on flying fish, mackerel and other surface-swimming fish which collide with it. Immediately this occurs the fish succumbs to the injection of poison by the thousands of nematocysts, the tentacle contracts (this is the main tentacle or "fishing-tentacle", of which there is usually only one in the Pacific forms of *Physalia*, but several in the Atlantic form) and the fish is drawn up towards the float. The mouths of the hundreds of feeding polyps then open upon the prey and digestion begins. In the laboratory it has been found that in the presence of glutathione, a simplified amino-acid derivative, the mouths of the feeding polyps open widely.

Nature of the animal—a composite organism

Each specimen of *Physalia* is not a single animal in the ordinary sense; it is, instead,

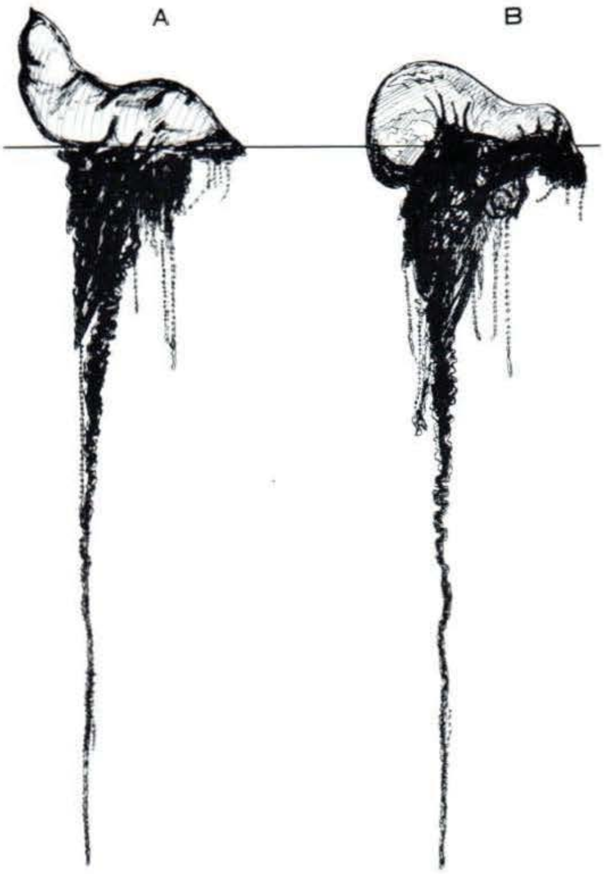
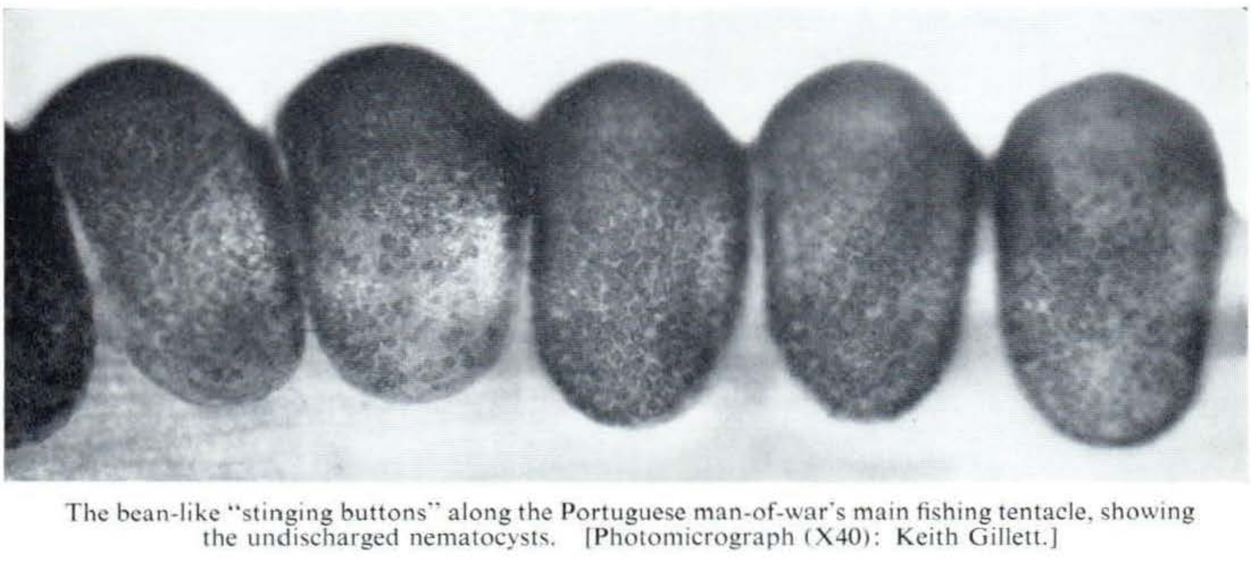
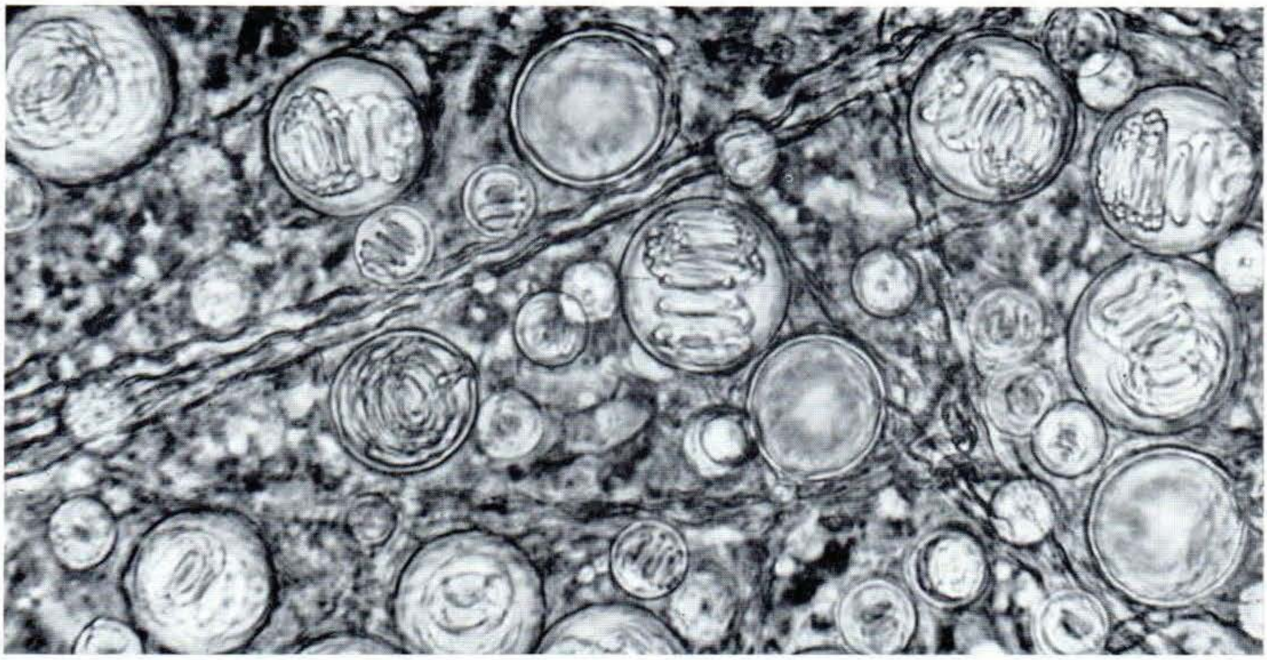


Figure A shows the normal posture of a Portuguese man-of-war. Note that, as the Portuguese man-of-war is not under the action of wind, its sailing crest is not erected. Figure B shows the roll-over or somersault in progress. [Drawn by the author from photos by D. J. Lee of a specimen from Sydney in an aquarium.]



The bean-like "stinging buttons" along the Portuguese man-of-war's main fishing tentacle, showing the undischarged nematocysts. [Photomicrograph (X40): Keith Gillett.]



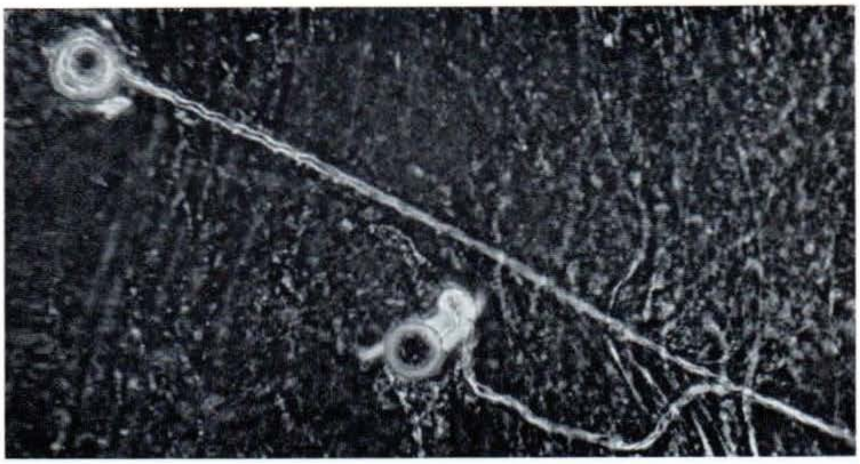
The nematocysts of a Portuguese man-of-war, from a tentacle. The spheres which contain a coiled thread are undischarged nematocysts. The empty spheres have discharged their injector threads, which are the slightly wavy tubes across the photo. Note the two sizes of nematocyst capsules (X475). [Photomicrograph: Keith Gillett.]

a group of organisms which has developed from a single egg and is living a colonial existence. One member of the group is expanded by the gas-gland to a float, which then bears beneath it not only tentacles, but polyps specialized for feeding, the gastrozooids, others specialized for reproduction, the gonozooids, which are actually adult forms, as well as dactylozooids bearing the tentacles, etc. Despite a number of careful studies, there are a number of morphological features of the Portuguese man-of-war still remaining to be elucidated. The structure of an adult *Physalia* is exceedingly complex, and in addition there are many features of its behaviour and physiology which need clarification. Although each specimen of *Physalia* is made up of a number of adult and larval forms, each specimen is either male or female, and the two sexes are separate. The shedding of eggs and sperm has not as yet been observed, and so far specimens below 1 mm in length have not been described.

Stinging powers

The stinging abilities of *Physalia* have been known for centuries, and an early account of them is mentioned in Hakluyt's Voyages, for 1579. During the period of European exploration of the oceans *Physalia* became well-known to sailors, and in fact this was why deaths from the little-known box-jellies (sea wasps) in the tropical Indo-West Pacific zone came to be attributed by many authors to *Physalia*. Despite its considerable stinging power, no human fatality has with certainty been attributed to stinging by *Physalia*. Earlier claims of deaths from *Physalia* of swimmers in New South Wales have not been substantiated on critical examination.

Among early studies on the stings of *Physalia* are two by naturalists with Australian connections. Sir Joseph Banks made observations on the stinging powers of *Physalia*, being the first to observe the "millions of fine white threads" which pierced the skin, arising out of "little knobbs or beads" which were in fact the tentacular nematocyst capsules. Photographs with this article show the spherical capsules and the threads they shoot out when in contact with suitable prey material. Banks also made observations on the sailing character of *Physalia*, and in addition recorded that an albatross he shot disgorged large amounts of *Physalia* it had consumed. Dr George Bennett, a century later, also made observations on the stinging powers of *Physalia*.



Two discharged nematocysts of a Portuguese man-of-war. [Photomicrograph by dark field phase contrast (X165): Keith Gillett.]

The nematocysts in *Physalia* occur in different sites of the various appendages, but the ones of interest to swimmers occur only on the main fishing tentacles, where they are grouped in bean-like packets strung consecutively along. The nematocysts occur in two different sizes, but their action is fundamentally the same. On appropriate stimulation the internally coiled threads turn inside-out like a sock, and, on full evagination, discharge their venom. This poison is still under study by various laboratories, and appears to be a protein complex with added factors, but its full nature is not yet known. One of the major problems has been to get enough purified venom, free from contaminants, corresponding to the actual contents of the capsule. Possibly the differing sizes and kinds of nematocysts in these coelenterates contain fundamentally different types of toxins, as their differing effects appear to indicate; this is a subject still being explored.

The best first-aid treatment for the sting victim is alcohol (methylated spirits) rubbed on. This has the effect of preventing further nematocyst discharge. If the sting is a severe one, however, medical attention should be sought.

CURATOR TO STUDY IN LONDON

Mr David McAlpine, Assistant Curator of Insects at the Australian Museum, leaves this month for a period of study at the Imperial Institute of Science and Technology, University of London, and at the British Museum (Natural History). While there he will make a special study of the flies of the family Platystomatidae, with special reference to the Australian fauna.

FLATBACK TURTLE

Miss Robyn Spalwitt, assistant in the Australian Museum's Department of Reptiles, with an adult female Flatback Turtle (*Chelonia depressa*) from the Cobourg Peninsula, Arnhem Land. This turtle is the only adult of its species in the Museum's collection, and possibly in any collection in the world. It was collected by Mr David Lindner, the ranger in the Cobourg Peninsula Faunal Reserve. The Flatback Turtle is known only from coastal areas in northern Australia, and such a restricted distribution makes this large sea-going reptile of special interest to herpetologists. [Photo: C. V. Turner.]

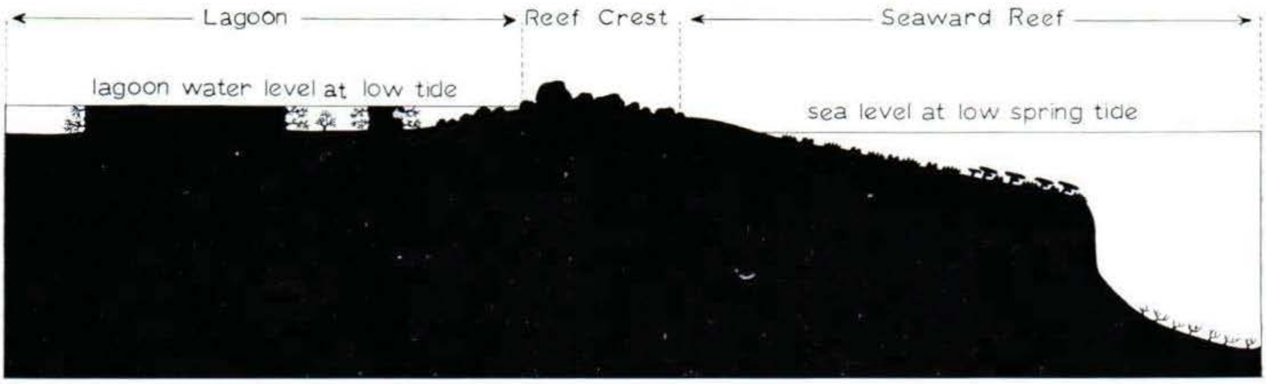
Large schools of fishes at the edge of a steep cliff on the seaward coral reef slope at One Tree Island. [Photo: Victor Springer.]

Expedition to One Tree Island

By FRANK HAMILTON TALBOT
Director, Australian Museum

J. BEETE JUKES, naturalist on Her Majesty's vessel *Fly*, who named and landed on One Tree Island on the Great Barrier Reef in January, 1843, would have been astounded if he could have repeated his visit a few months ago. When he stepped ashore on the island (probably the first man ever to do so), he found its sole inhabitants were "multitudes of young terns". He wrote: "In the single tree (which was in fact a small clump of the common pandanus of those seas, with its roots exposed above ground) was a large rude mass of old sticks, the nest of some bird of prey, probably the osprey".

One hundred and twenty-four years later the picture had changed, although the nest was still there, by this time very large, and still occupied by a pair of ospreys. Five tents were grouped together above the little sheltered bay in the lagoon, one tent providing a dining area and laboratory, while the others were for sleeping. In the bay lay three aluminium work boats with outboard motors. A little way from the camp was a small compressor surrounded by piles of aqualung bottles; half hidden under a *Messerschmidtia* bush was a small laboratory with pipettes and reagents for measuring the oxygen and salinity of sea-water. Odd electronic gear, underwater cameras, perspex domes for trapping oxygen bubbles produced from coral heads, fluorescent die for marking water masses, a toddler's paddling pool filled with fishes being marked before return to the water, and much other gear stood



A diagrammatic cross-section of the coral reef at One Tree Island. The coral of the lagoon has a flat surface at the level at which water is kept by the surrounding reef crest at low tide. The lagoon has mainly branching and staghorn Acropore corals. Below low spring tides in the area of strong wave action on the seaward reef low and sturdy Acropore corals grow. Platform (or tabulate) corals are common near the steep drop-off. Sparse corals grow at deeper levels, but most coral is absent at 100 feet. In this diagram vertical distances have been greatly exaggerated. [Diagram by Sondra Beresford.]

around the tents. On one side was a small wooden structure made of driftwood, built by the one American on the island, Dr Victor Springer, from the U.S. National Museum, Smithsonian Institution. This was dubbed "the Smithsonian Sorting Centre" and was filled with baby-baths of carefully preserved fishes. All this material, some 4 tons of it, was the gear of a party of scientists from the Australian Museum, the Smithsonian Institution, and the Heron Island Marine Station, working on One Tree Island Reef, and aided with grants from the Smithsonian Institution, Caltex, and Imperial Chemical Industries.

One Tree is a lonely island on the outer edge of the Capricorn Group, off Gladstone. Unlike its neighbour Heron Island, it lacks sand and shady trees and is merely a rubble bank thrown up by violent storms at the windward edge of the 4-mile-long One Tree Island lagoon. A true coral island bordering on the open Pacific, One Tree bakes in the afternoon sun and at least one of the party was heard to mutter that the island was rather like purgatory.

The final puzzle to Jukes would have been a row of sunburnt men in bathing costumes sitting on a long strip of plastic solemly breaking dead coral into smaller and smaller pieces and picking out the minute animals they found in it.

Unsolved mysteries

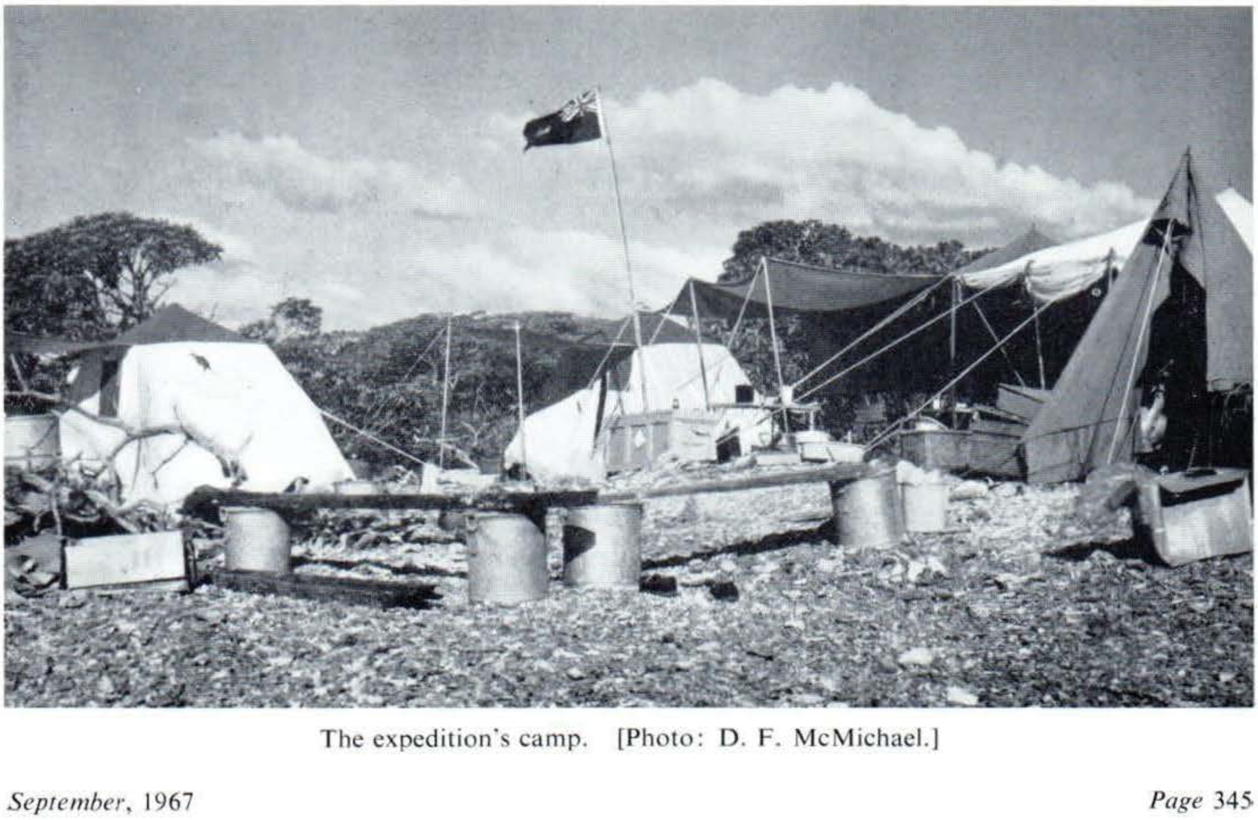
Although coral reefs have fascinated scientists from before Darwin's time, and much research work has unfolded some of the intriguing mysteries and natural-history wonders of these huge structures, a great deal remains unknown. They have a rich mass of colourful fishes with such a number of species living close together that the mind of anything but a computer boggles at the complexity of inter-action between them. Who competes with whom for the same food organisms? Who feeds on whom? Who nips off whose parasites? How in dickens' name do they identify their own females to breed with in this veritable soup of fishes?

The coral itself is a colonial animal which has a thin outer layer of living tissue, with many thousands of small mouths collecting food from water flowing over it. Below it and supporting it, this living layer builds its skeleton, intricate or simple, delicate or massive. The coral derives much of its food from the plankton of the open sea, filtering it out as it drifts helplessly over the reef. But the reef is exceedingly rich, although the surrounding ocean, blue and lovely though it is, does not carry a heavy load of food. The bluest waters are the deserts of the ocean and it is the temperate areas that are rich in plankton, the masses of tiny creatures giving the water its green colour. Yet how does it happen that the coral reefs, set in blue sea deserts, are rich in both numbers and weight of animals? Could all this richness just be supported by the thin plankton soup? Many scientists believe that this is impossible, and that minute single-celled and filamentous algae on the reef, although not seeming to be abundant, are providing much of the total food of a coral reef. American workers have done research in the Marshall Islands and other places to attempt to prove this. In all cases strong wave action has forced them to work on more or less sheltered back reefs—a reef leading into a lagoon, or on a reef flat leading to the shore. It seems very likely from their work that the reef is in part self-supporting and produces much of its own food.

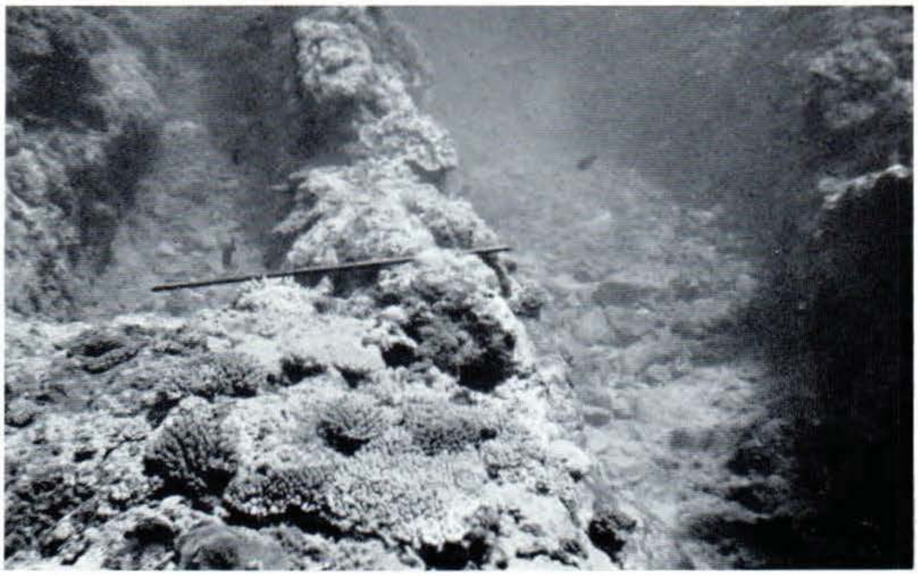
Reefs compared

The Australian Museum team and its collaborators were working on both the lagoon reef and the seaward reef of One Tree Island (see diagram). The latter, facing the open ocean, is at times hammered by tremendous surf, but is often calm enough to work on. An attempt is being made to compare these two different areas. The constrast in the degree of wave action results in major differences between the exposed open reef and the sheltered lagoon reef. The exposed reef has a hard rock slope seaward from the reef crest, covered in some areas by a veneer of calcarious algae as hard as cement. Seaward of this, just below low tide level, begin the corals of the seaward slopes, mostly strong Acropores, growing vigorously in the oceanic breakers. As one goes deeper, more delicate platform-shaped Acropores appear, but on the slope, down to about 40 feet, the corals are not strikingly large; they are probably often broken in storms and the fragments are then fused by the cementing coralline algae to add a little more to the massive reef. Here and there on this seaward face are deep gullies or surge channels running seaward (see photo) and thought to be a response to the battering the shore takes from the waves—a method, in fact, of easing the shock of great wave action. We can sink down into these surge channels with our aqualungs, and see myriads of small colourful fishes, and perhaps a school of 5-pound parrot fishes bumping rhythmically against the walls of the channel as they scrape off the fuzz of minute algal plants with their strong beaks.

The back reef, or slope from the crest of the reef into the lagoon, is very different. The hard rock slope is absent, loose boulders lie about and the corals may be delicate, forming spreading masses. Because there is no gap in the reef, the water in One Tree lagoon drops till the reef is exposed, and then is retained at a fixed level by the saucer-shaped rim of reef. Corals therefore grow



The expedition's camp. [Photo: D. F. McMichael.]



Deep surge channels run at right angles to the reef crest in areas of great surf. [Photo: Victor Springer.]

upward in the lagoon and stop abruptly at this level, and then spread outwards horizontally. The flat surface, formed by the ever-widening growth, was called "piecrust" and disliked by Museum staff because the dead coral in the centre would often suddenly break when walked on, and a leg would shoot through the crust, sometimes resulting in nasty cuts or grazes to a shin.

The work has shown, as might be expected, that the fish populations living in the crumbly piecrust area of the reef differ from those on the seaward reef. Many species are found in one area and not in the other. The seaward reef also seems to have a greater fish bulk (some 2,000 pounds/acre) than the back reef (1,000 pounds/acre).

Laboratory work

Back in the laboratory in Sydney the slow process of going through the stomach contents of the samples of fishes, and coding the results into punch cards, begins. We feel that the sources of food in the two areas are fundamentally different, and this work will prove us right or wrong. The questions we ask ourselves are many: Do we get more algal feeders on the back reef, or more on the seaward reef? Do we get a greater quantity of plankton feeders on the back reef (where we have made rich plankton hauls) or more on the seaward reef, which is continually washed by wave action and ocean currrents? Do we find more animals in the coral of the seaward slope, or the lagoon slope? To get satisfactory answers to these questions is unfortunately not a quick process.

Working in the fish world has its excitement—the scientists do not do all the investigating, for sometimes the fishes investigate back! The party had to put up with an occasional inspection by a cold-eyed shark, and one member of it, Mr P. M. J. Woodhead, Scientific Director of the Great Barrier Reef Committee's Heron Island Marine Station, was subjected to a brief but painful experiment performed by a groper. Searching in a surge channel for a coral he had seen previously, he was swimming underwater with his hands behind his back when a groper grabbed his left hand and viciously shook it, trying to pull off what he clearly considered to be a tasty morsel. Mr Woodhead tried to punch him, and he left, but the many sharp teeth had made punctures over much of the hand, and nasty lacerations at the base of the thumb. Luckily there was no permanent damage, although Mr Woodhead was out of action for some weeks. The sharks have never worried us, although Jukes said of the area: "Sharks were very numerous here, and bit the fly [rotator] of the patent-log as it trailed overboard".

THE NOISY SCRUB-BIRD

By VINCENT SERVENTY
President of the Wildlife Preservation Society of Australia

"*When I first heard its extraordinary loud notes, many of which are sweet and melodious, I was perfectly convinced it was a new bird, and watched and waited about for it for hours together without so much as seeing it, for several days, its notes are exceedingly loud and shrill, as to produce a ringing sensation in the ears. Precisely the effect produced when a shrill whistle is blown in a small room.*"

So wrote John Gilbert on 3rd November, 1842, when he obtained the first specimen of the Noisy Scrub-bird. Gilbert collected his bird on the banks of a brook which modern research indicates was in the valley of the Drakesbrook, near Waroona, Western Australia. For this early naturalist this was a kind of bristle-bird without bristles. So John Gould named it *Atrichornis clamosus*—in other words, "without bristles" and "noisy".

John Gilbert and later workers extended the range of the bird from this spot south and eastwards to the country around Albany.

Last specimen collected

Then 47 years later, in early October, 1889, A. J. Campbell collected another specimen of the Noisy Scrub-bird. After that all was silence. Naturalists searched in vain for another 70 years.

The Noisy Scrub-bird has a close relative, the Rufous Scrub-bird (*Atrichornis rufescens*). This is a bird of thick rainforest in north-eastern New South Wales and southern Queensland. Alec Chisholm had gathered a great deal of information about this species, and he wrote:

> Its habitat is the most impenetrable part of the scrub, among the jungle tangle, vines and fallen debris under which it creeps and runs on the ground never going up into a bush. It very rarely flies . . .

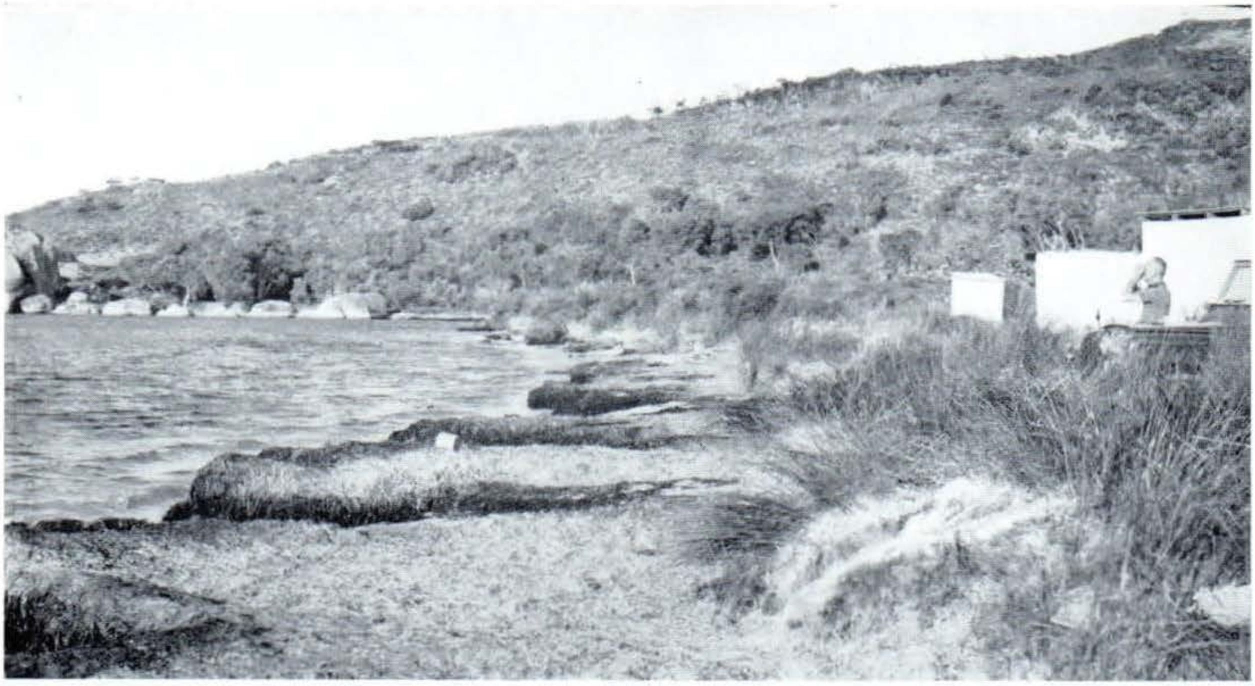
It had long been known that the scrub-birds lacked "wishbones" since the clavicles survive only as splints. Ernst Mayr and Dean Amadon put the scrub-birds and the lyrebirds together as being primitive families associated with the true songbirds. They also said the birds were probably nearer to each other than either is to any other group.

The Noisy Scrub-bird, banded and ready for release.

It is interesting that, like the lyrebirds, the scrub-bird is an accomplished mimic. Also, there is a similarity in their movements along the ground as they stride through thick bush.

Bird seen again

However, this is running ahead of the story. Eventually, with no success in the search for the Noisy Scrub-bird, some naturalists decided it was extinct. Others were more hopeful. Among these was an Albany schoolteacher, Harley Webster. On 17th December, 1961, at Two People Bay, about 20 miles to the east of Albany, he heard and saw a Noisy Scrub-bird.



Two People Bay. It was a few yards from here that schoolteacher Harley Webster, seen at right, heard the Noisy Scrub-bird for the first time.

In the last 5 years a great deal has been done. This small area was quickly declared a sanctuary and the authorities forbade the taking of any fauna within a radius of 4 miles from Mount Gardner, the centre of the colony. Possibly there are less than 100 Noisy Scrub-birds still living, so here is a species dangerously close to the abyss.

Harley Webster is hard at work studying the behaviour of these birds, and soon a lot more may be known. An occupied nest still eludes the searchers but one unfinished nest was found. This was a globular shape made of the coastal cut rush with, inside, a lining of smooth material, very similar to the grey papier mache used for egg cartons. Had the nest been complete it may possibly have been similar to that described by Alec Chisholm for the Rufous Scrub-bird.

Another specimen caught

However, in 1963 we had the chance to see a bird at close quarters. At the suggestion of Graham Pizzey, a Victorian naturalist, it was decided to attempt to catch a bird in a mist net. Harley Webster selected a territory which was long and narrow, so it was practicable to cut a narrow corridor across it where we could string our mist net. Then it was a matter of a line of beaters driving the bird into the net. It was an exciting moment. The bird which had called when we first arrived was now silent. Twice we drove to the net with no success. Then there came a cry from Harley Webster, who was stationed on the net. Bob Stranger, a young naturalist, plunged through the thick scrub, ignoring all obstacles, and seized the struggling bird; then came his triumphant shout, "Atrichornis!"

It was an exciting moment, and during the next half-hour the scientists were busy measuring, noting the colour of the soft parts, and finally weighing and banding the bird. All this time movie films were being made for posterity. Then, in slow motion, I filmed the bird as it scurried back to the safety of the bushes, not jauntily as I had seen it before, but in mouse-like fashion.

Saving bird is urgent task

Is the bird now safe?

There is no certain answer. The State Government has created a large enough

Setting up the mist net in a suitable territory.

reserve and even shifted a planned town-site to safeguard the bird. The major danger is fire. I believe the more regular firings carried out by white settlers were the cause of the scrub-birds' disappearance. To establish new colonies I feel more birds should be caught alive and released in suitable habitats, in much the same manner as koalas were taken from islands where they were in too large numbers and released in depleted areas. The obvious sanctuaries are islands, and a survey should be made of southern coastal islands to see which could sustain scrub-birds. If none of these prove suitable, then national parks west of Albany and south of Perth should have birds released in them. A vigorous search should be made for more colonies in case some have escaped the eyes and ears of amateur naturalists.

The task is urgent, and perhaps this is a job where the newly-formed Australian Conservation Foundation may be able to assist. It is vitally important that this bird, which came back from the dead and is still trembling on the abyss, should be saved.

[*Photos in this article are by the author.*]

ARCHAEOLOGICAL PROJECT

Having completed a series of excavations in the Upper Hunter Valley, the Curator of Anthropology at the Australian Museum, Mr D. R. Moore, has been surveying and excavating on the western side of the Great Dividing Range, in the Mudgee–Ulan–Cassilis area. The object of this stage in the project was to obtain material for comparison with the industry already excavated in the Sandy Hollow–Singleton region. In May, 1967, a small party carried out a week's intensive survey, during which many interesting Aboriginal sites were discovered. These included camp areas, workshop sites, painted caves, and occupied rock shelters. After a number of trial excavations, it was decided to concentrate on a small shelter on private property near Ulan. This had not been interfered with in any way since the last Aborigines used it, and proved to contain a very prolific industry of the Bondaian period. The excavation was completed during three short field trips and provided a number of interesting and puzzling features. A great quantity of implements, waste flakes, bones, and cooking debris was obtained from a stratified context, and this will give a very satisfactory comparison with the Upper Hunter material, which covers the same period. Plenty of charcoal for carbon dating was found, so that a time sequence for the occupation may be constructed. During the latter half of 1967, attention will be concentrated on the Middle Hunter, around Maitland and Cessnock, and the next stage of the Hunter Valley project will be carried out in that area.

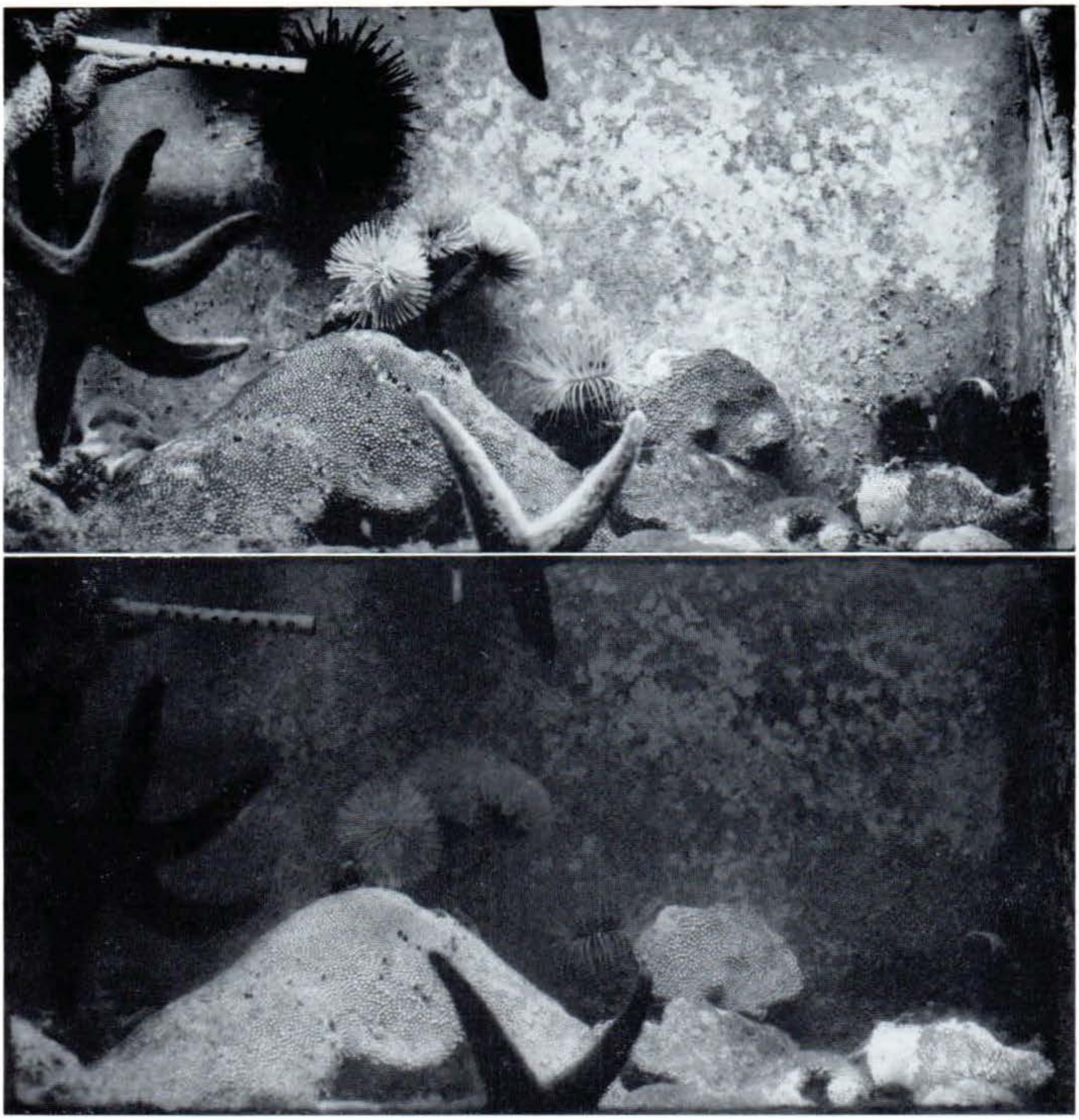
FLUORESCENT CORAL FROM SYDNEY HARBOUR

By J. C. YALDWYN
Curator of Crustaceans and Coelenterates, Australian Museum

Although reported previously, it was not until 1957 that René Catala first demonstrated on a large scale the unexpectedly varied and bright fluorescent colours of certain deep-water corals at the Noumea Aquarium, New Caledonia (see "The Aquarium of Noumea", by Dr R. Catala in *Australian Natural History*, Vol. 15, No. 5, March, 1966). *Fluorescence* is the ability to glow visibly under ultra-violet light, which itself is invisible to the human eye, and contrasts with *luminescence*, or phosphorescence as it is sometimes called, which is the ability to glow, or produce light, quite independently of any external illumination or irradiation. Dr Catala obtained his many species of fluorescent corals from depths of about 70 to 150 feet, both within the lagoon and on the outer slope of the New Caledonian barrier reef. In his book *Carnival Under the Sea*, and film with the same title, Dr Catala provides many colour photographs of these corals and makes several general comments on this phenomenon. He found that only a limited number of species respond to ultra-violet radiation; that all the individual coral polyps of a colony, with few exceptions, show the same fluorescent colour, or pattern of colours; that the colours observed in order of frequency were various shades of green, orange, yellow, blue, red, brown and grey, though colours could change after prolonged exposure to ultra-violet rays or for other reasons; that only the living flesh of the coral could fluoresce, not the calcareous skeleton; that the fluorescence was independent of the symbiotic zooxanthellae algae within the coral tissue, and that over-exposure to ultra-violet rays brought about a decrease in the intensity of fluorescence in the majority of corals, or even death in certain sensitive species. Several different fluorescent pigments have been identified from these corals (compounds related to flavines, urobilines and pterines), but as yet no satisfactory physiological reason for this fluorescence, or any possible use of this phenomenon by the corals themselves, has been put forward.

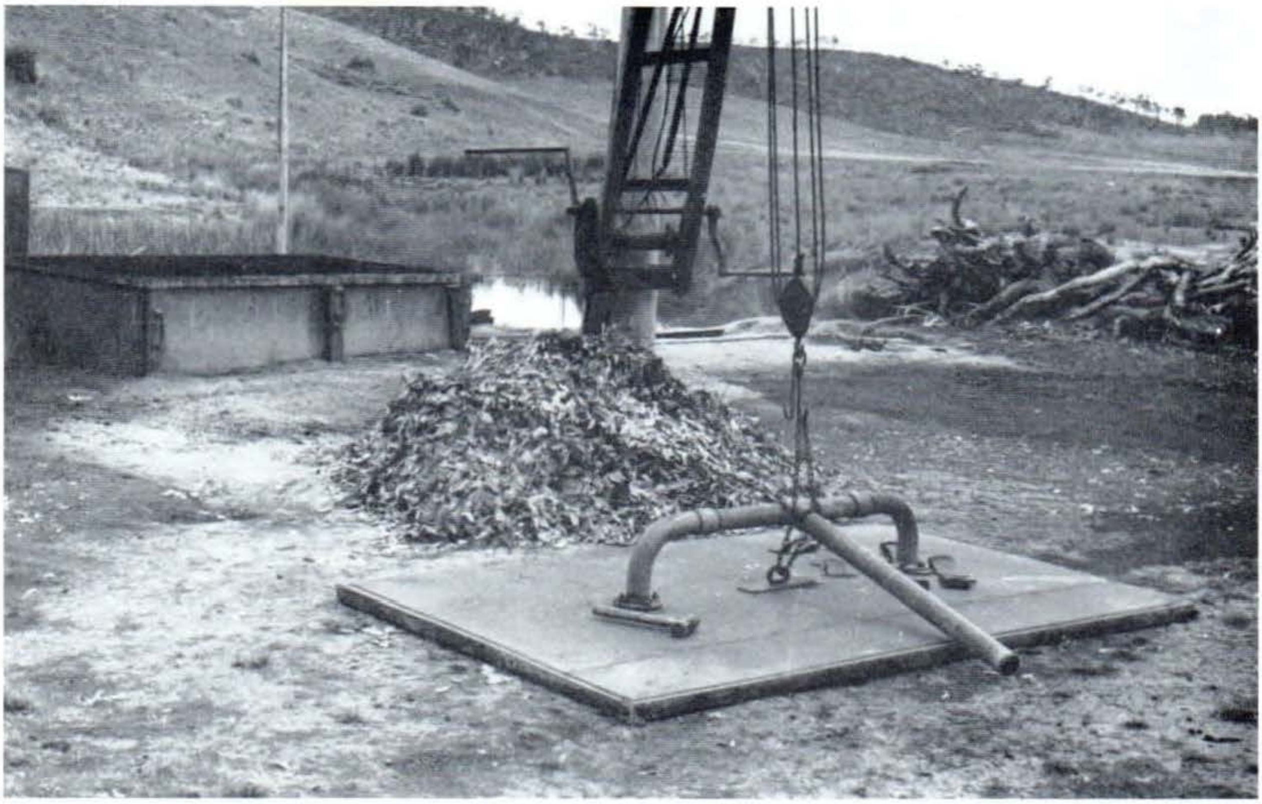
During the latter half of 1966 one of the two species of reef-type scleractinian corals known from Sydney Harbour was found to be fluorescent. Mr G. Goadby, manager of Marineland, Manly, and divers A. Robeson and D. Smith, brought specimens of the pale slate-green *Plesiastrea urvillei* up from about 60 feet and found that they glowed blue under ultra-violet radiation. Though not as intense as many of the species at the Noumea Aquarium, the blue fluorescence is relatively bright and provides a fine display in a wall aquarium tank in Marineland, where the ultra-violet illumination can be switched on and off by the visitor. The other reef-type coral found quite widely in the Sydney area, the brown *Coscinaraea mcneilli*, is apparently not fluorescent.

The two photographs opposite were taken by Bill Payne, of the *Australian Women's Weekly*, and were originally reproduced in colour in their issue of 14th December, 1966. Published here with their permission, the upper view shows the coral tank at Marineland under normal artificial light, while the lower shows the tank under ultra-violet illumination with the various specimens of living colonial *Plesiastrea* along the bottom glowing with their own fluorescence. The starfish in the tank are the common intertidal and shallow-water *Coscinasterias calamaria* on the left wall and two *Nectria ocellata* on the front glass. The latter is a fairly common, subtidal, temperate-water species. The dark urchin on the back wall, partly under the perforated metal outlet tube, is the common southern New South Wales subtidal *Centrostephanus rodgersii*. Three feather-duster polychaete tube-worms, *Sabellastarte indica*, can be seen expanded in the centre of the tank, above the large dome-like *Plesiastrea* coral, and contrast with the two long-tentacled anemones, *Cerianthus* species, one towards the centre (between the arms of



The coral tank at Marineland, Manly, under normal artificial light (above) and ultra-violet illumination (below). In the lower photo the living corals *Plesiastrea urvillei* on the bottom of the tank are glowing with their own fluorescence

the lowest starfish) and one in the extreme right back-corner of the tank. The latter, with its drooping tentacles, is surrounded by numerous small, dark, feathery "heads" of the unusual unsegmented tube-worm *Phoronis australis*. The special relationship of *Phoronis* with *Cerianthus*, in which the worm lives in the thick, tough, slimy, mucous tube of the anemone, has been described by Isobel Bennett in *Australian Natural History*, Vol. 14, No. 5, March, 1963.



A distillation plant used for the production of *Eucalyptus dives* oil in the Braidwood district, New South Wales. A heap of leaves may be seen, ready for charging into the still. When the still is full the heavy lid in the foreground will be lifted into position by the crane. The stream behind the still cools the condenser. At right is a heap of firewood to fire the still. [Photo: J. L. Willis.]

Volatile Plant Oils in Australia

By H. H. G. McKERN
Deputy Director, Museum of Applied Arts and Sciences, Sydney

THE natural vegetation of Australia shows in general a strong contrast to that of other continents. There are, of course, restricted areas which do not display much difference from similar vegetation types elsewhere: for example, the mangrove swamps of northern Australia are much the same as those of Malaysia, and the Australian rainforests show features similar to those in other parts of the world. Nevertheless, this country by and large presents a scenery whose vegetation is regarded as typically "Australian", and the correctness of this view is supported by botanical research which shows a large, typically Australian component of the flora. Dominant in the higher rainfall regions, of course, is the genus *Eucalyptus* (commonly referred to as eucalypts or gum-trees), whilst the wattles, belonging to the genus *Acacia*, are typical of the more arid regions.

Further, most travellers have observed that the Australian vegetation is distinctively aromatic. If we walk through the bush on a warm summer day we are usually aware of a distinctive fragrance; this may become most pronounced in certain areas—for example, in the alpine ash forests (*Eucalyptus delegatensis*) of the higher elevations (3,000 to 5,000 feet) of southeastern New South Wales and of northeastern Victoria.

Cause of bush aroma

This aroma of the vegetation is due to the fact that many plant species synthesize volatile or essential oils (note that the word "essential" as used here is the adjective derived from the noun "essence", and has nothing to do with "necessary"). Volatile oils are distinguished from the fatty or "fixed" plant oils (such as olive oil, peanut oil, linseed oil, etc.) by their volatility. This may be shown by the simple experiment of allowing a drop of a fatty oil to fall on a piece of blotting paper, and, at the same time, adjacent to the fatty oil, placing a drop of an essential or volatile oil such as eucalyptus oil or peppermint oil. If the blotting paper is freely exposed to the air, it will be seen that the drop of essential oil soon evaporates or vaporizes, whilst the fatty oil remains as a translucent stain indefinitely; that is, it is non-volatile.

Volatile oils may be secreted by plants in any organ—the leaf, the flower, the bark, the wood and so on. In many plants of the Australian bush, the oil is to be found in the leaves; if you hold a *Eucalyptus* leaf up to the light you will see a multitude of translucent dots, each being an oil storage reservoir, and you may smell the oil if you crush the leaf between the fingers, so liberating the volatile oil from the enclosing tissue. In the case of the genus *Callitris*, the cypress pines, an oil is contained not only in the foliage, but also in the wood, and the odour of the freshly-sawn timber is most pleasant and distinctive.

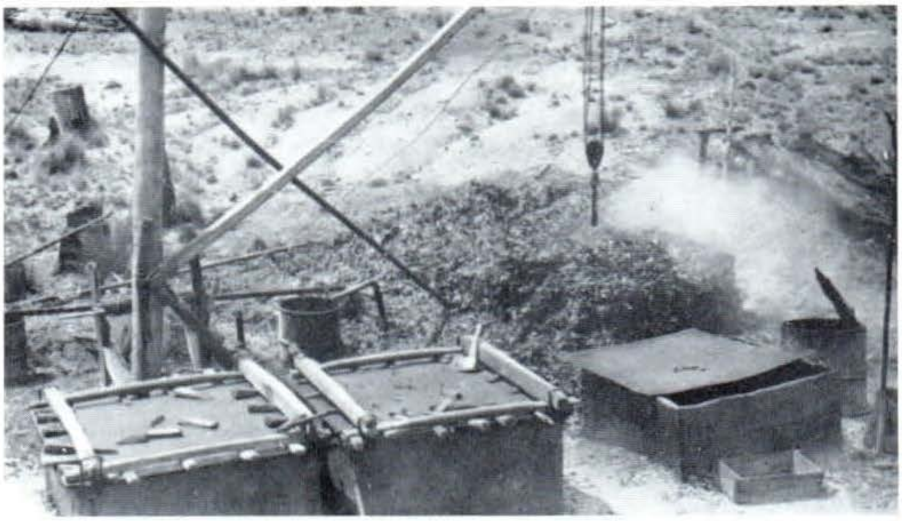
Volatile oils of commerce

Volatile or essential oils have been articles of trade for a long time, and when the first English settlers arrived in Australia they were familiar with European oils such as lavender, peppermint or lemon oil. In one of the earliest books on Australia, White's *Journal of a Voyage to New South Wales*, published in London in 1790, there is recorded the distillation of oil from the leaves of a species of *Eucalyptus* (*E. piperita*) found growing on the sandstone shores of Port Jackson, and which had proved an efficacious substitute for oil of peppermint for medical use as a carminative. Although the chemistry of the volatile oils was quite unknown at that time, it so happened that White chanced upon an oil whose chief constituent (piperitone) is now known to be chemically closely-related to the main components of oil of peppermint obtained from *Mentha piperita*. However, apart from this early essay in this field, we hear nothing more of the extraction of volatile oils in this country until the decade 1850–1860. Presumably the sturdy pioneers were too busy establishing a foothold in a rather hard land, and found little time or inclination for scientific experiment, and in any case there was lacking a knowledge of organic chemistry, a science which did not arise until the middle of the nineteenth century.

The history of the Australian essential oil industry may be said to have begun in Melbourne in 1852 with the first experiments of Joseph Bosisto, a pharmacist, encouraged by the famous botanist Ferdinand von Mueller, who had also studied pharmacy and who became Government Botanist of Victoria. By the sixties Bosisto was producing eucalyptus oils commercially, and the Australian essential oil industry has thus now been in existence for over a century. During this period many thousands of tons of oil have been produced from many different parts of the country, and for many different purposes, for local use as well as for export.

What are the different kinds of oil produced, and what are they used for? The greatest tonnage of oil has undoubtedly been won from the genus *Eucalyptus* (family Myrtaceae), the familiar gum-trees earlier referred to as dominating the Australian rural scene. The term gum-tree, by the way, is a misnomer as the eucalypts do not produce gum. The sticky red exudation which caused the early settlers (quite innocent of any chemistry) to confer upon them this name is not a gum, but a kino, and is related to the tannins. Nearly every species of *Eucalyptus*, however, contains a volatile oil in the leaves in greater or lesser amount, and this oil varies in chemical composition with the species.

By a technique known as steam-distillation, it is possible to extract the oil from the foliage, using a fairly simple apparatus. Foliage from the selected species is packed into a vessel known as a still, into which steam may be admitted at the bottom. The vessel is closed by a tightly-fitting lid, and the steam rises through the mass of



A *Eucalyptus* oil distillation plant with three stills, partly embedded in the earth, two of which have their lids closed during a "boil". The crane is used to discharge the heavy, wet, spent leaves, a heap of which is seen still steaming from a previous operation. [Photo: J. L. Willis.]

leaves. As it does so, it vaporizes the oil, and both oil vapour and steam escape through an outlet pipe towards the top of the still. The outlet pipe leads to a condenser, usually an extension of the outlet pipe, but laid under water so that both oil vapour and steam are cooled and condensed back to oil and water. The oil, being lighter than water and immiscible with it, rises to the surface as an upper layer in a receiving vessel designed to retain the oil layer but to permit the condensed water to discharge continually to waste.

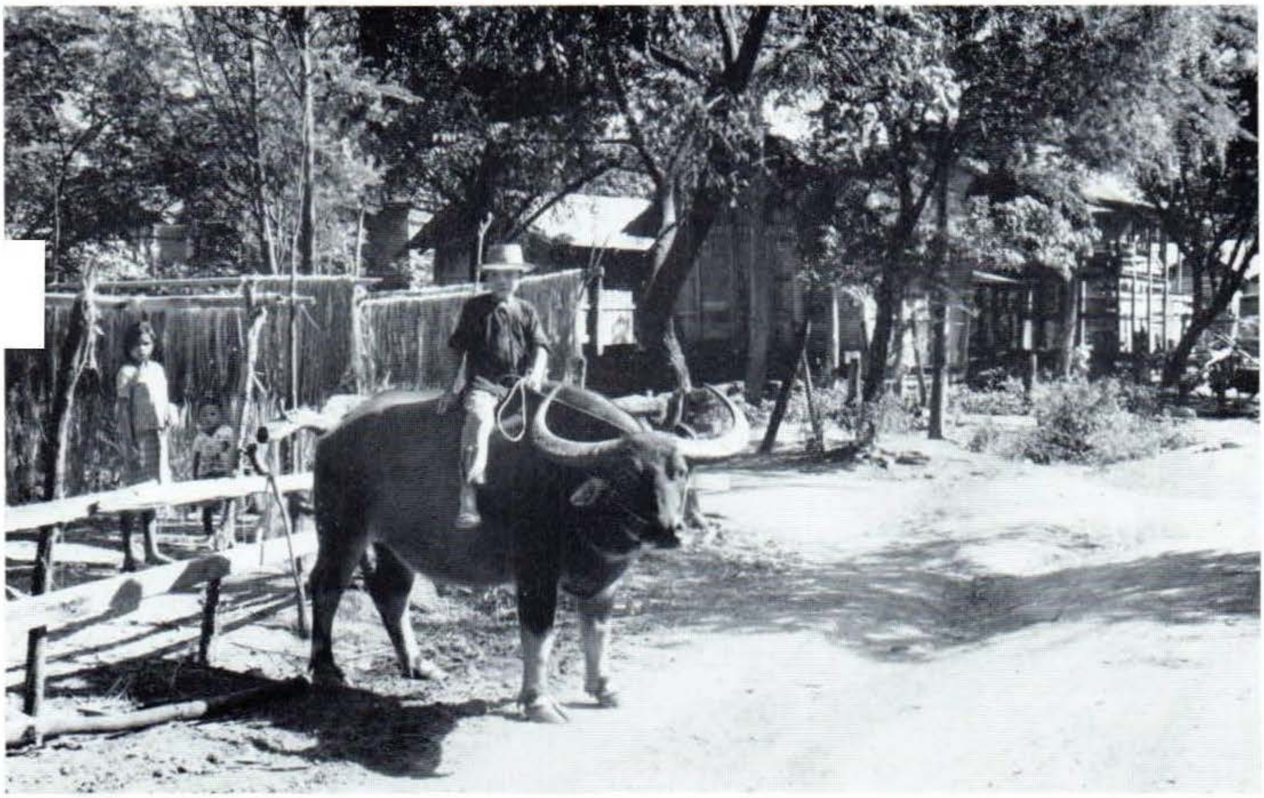
Actual details of design of eucalyptus oil distillation equipment vary considerably, but they are basically of two types—one in which the steam is generated in a boiler and led to the still by a pipe, and another in which the steam is generated from a shallow layer of boiling water at the bottom of the still which is heated by a direct fire. In this latter case, the charge of leaves is supported above the water-level by a grid. An indicator must be attached to such a direct-fired still to permit the operator to control the water-level to prevent the still boiling dry and burning the charge. The distilleries employing steam generated in a separate boiler are usually relatively large establishments, with perhaps two or three cylindrical underground stills 12–14 feet or so deep and 6 to 8 feet in diameter. Such stills are capable of taking several tons of foliage at a charge. They are found typically in areas of flatter terrain (e.g., the Wyalong district of N.S.W. and in central and north-western Victoria).

Uses of eucalyptus oils

What are eucalyptus oils used for? This is governed by their chemical composition: the broad-leaved peppermint (*E. dives*) in the Braidwood district and elsewhere in N.S.W. yields an oil rich in the substance known as *piperitone*, which is used in chemical industry for the synthesis of menthol. Such a species as *E. fruticetorum*, or the blue mallee, is a hardy plant of the 15–18 inch rainfall regions in N.S.W. and Victoria whose leaves yield an oil rich in *cineole;* oils of this class are used in pharmaceutical formulations. Certain populations of *E. radiata* in southern N.S.W. yield an oil that is of value in the manufacture of disinfectant preparations.

The genus *Eucalyptus* is not the only plant group in Australia to be utilized for essential oils. On the far north coast of N.S.W. a species of *Melaleuca*, *M. alternifolia*, yields "tea tree" oil of commerce, used in medicinal preparations, whilst in Western Australia sandalwood oil for perfumery is extracted from the wood of *Santalum spicatum*.

Finally, although Australians are naturally interested in these natural products from the indigenous flora, we should remember that volatile oils are also produced on a limited scale in this country from some exotic plants. *Citrus* oils are expressed or distilled from lemons and oranges and are used as flavouring agents. Further, a very efficient lavender oil industry has been established in north-eastern Tasmania, and a high-quality French type of lavender oil is regularly marketed in successful competition with oils of overseas origin.



Children of villagers between Khonkaen and Chompae, central Thailand, who gave the author tektites. [Photo: Author.]

THE TEKTITE PROBLEM

By R. O. CHALMERS
Curator of Minerals and Rocks, Australian Museum

IN the sandhill country of the arid Australian inland australites are found mainly lying on the surface of the bare low areas between the sandhills known as claypans. The surface of the claypans consists of sand grains cemented by clay, calcium carbonate and iron compounds to form a semi-consolidated soil, usually of a reddish tint.

The sandhills of inland Australia originated when dry conditions set in during the late Pleistocene. Vast quantities of sediments had been brought by rivers into Australia's inland drainage systems, particularly the Lake Eyre basin. Long periods of high winds concentrated the sand content of these sediments into sandhills. These events took place in very recent times, geologically speaking, probably within the last three-quarters of a million years. So far it has been impossible to obtain geological evidence of the age of fall of the australites in the arid regions.

One has a strong feeling that, in the arid inland, australites are now lying close to where they originally fell. There has been some slight movement and distribution of australites on the claypans by rain which, though it falls infrequently, may fall in large quantities in a short time. If australites are found embedded in the claypans due to the action of running water it is to a depth of no more than a few millimetres and the greater part of the australite is exposed above the claypan surface.

Since the period of intensive oil search began a few years ago australites have been found by exploration teams in a number of areas in the sandhills of the Simpson Desert. Since 1963 field trips by the writer in conjunction with staff from other scientific institutions, such as the United States National Museum in Washington and the Australian National University in Canberra, have revealed important new areas in the Lake Torrens, Lake Eyre and Birdsville Track regions. Not only are the australites reasonably abundant in all these regions, but a remarkably high proportion of them show regular shapes, such as flanged buttons, dumb-bells, elongated shapes and "bungs". This is clear evidence that in all these places the australites have suffered little movement, otherwise so many perfect shapes would not have been retained.

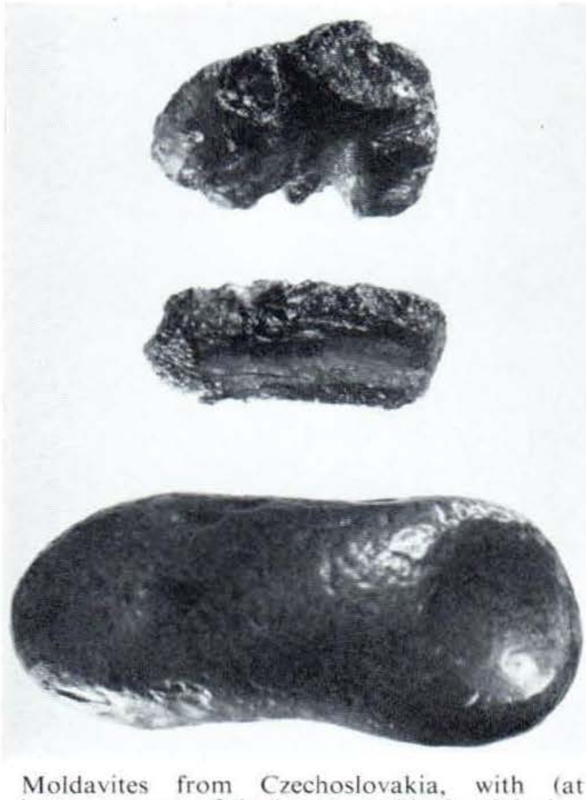
Age of australites

It is generally agreed that all tektites were formed from the melting of surface rocks by the impact of giant meteorites either on the surface of the earth or the moon. Dating by one of the most modern procedures, the potassium-argon method, shows that the original formation of australites took place 700,000 years ago. Regardless of the place of origin, it is certain that the unique regular shapes of australites are caused by the secondary melting of the surface layers due to heat generated by friction with the atmosphere during their fall to earth. The "flange", one of the most unique features of the perfectly-shaped "button" type of australite, is caused by this second period of melting. Age determinations on the flange material should therefore give the age of fall. Although the findings cannot be regarded as entirely conclusive, some determinations show the age of the flange to be the same as the age of the centre portion, namely 700,000 years. The inference from this is that the flight of the australites through the atmosphere took place immediately after the initial formation by meteorite impact and that australites have been lying on the surface of Australia for 700,000 years, which, it should be noted, is not incompatible with the age of formation of the sandhills.

On the other hand, a carefully controlled archaeological-type excavation was recently carried out in an australite area at Port Campbell, on the western coast of Victoria. Here the australites show a more perfect state of preservation and less signs of abrasion than in any other locality. From the association of australites and carbonized plant stems, the age of which has been determined by the carbon dating method, it is concluded that the australites fell no more than about 7,000 years ago. The problem posed by the contradictory evidence of 700,000 and 7,000 years for the age of fall remains to be solved.

Tektites in Czechoslovakia and Thailand

During an overseas visit in 1966 I was able to visit two other countries where tektites are found, Czechoslovakia and Thailand. Czechoslovakian tektites are known as moldavites (Czech, vltaviny). They were so named because they were first found in Southern Bohemia near the Moldau (Vltava) River. The first scientific description appeared in 1788. The tektite area lies to the west of a sizable town, Ceske



Moldavites from Czechoslovakia, with (at bottom) a cast of the largest moldavite (3 inches long) ever found in Southern Bohemia, Czechoslovakia. [Photo: C. V. Turner.]

Tektites from Thailand. The natural size of the specimen at bottom left is 4 inches long. The tektite at top left is the layered Muong Nong type. [Photo: C. V. Turner.]

Budejovice, about 70 miles south of Prague. Another group of tektite localities lies about 100 miles to the west in the vicinity of Brno, in the province of Moravia.

The South Bohemian localities are in agricultural country. The moldavites are found mainly in fields under cultivation and are usually discovered by ploughing. They also are found in present-day stream gravels and in high-level sands and gravel beds, which form deposits up to 30 feet thick on the tops of low well-wooded hills about 200 to 400 feet above the level of the present streams. One could hardly imagine a greater contrast between this pleasant, green countryside, dotted with picturesque Czech villages, and the australite localities of the sandhill country to which I was accustomed.

Moldavites are older than australites. The moldavite-bearing high-level sand and gravel beds were deposited anything from 1 to 6 million years ago in middle to upper Pliocene time. Potassium-argon age determinations give an age of formation of 15 million years for moldavites.

South Bohemian moldavites are much more translucent than australites and are light green. Specimens of regular shape and smooth surface have been found, but, due to the corrosive effects of chemical solutions in the form of groundwater, moldavites are mostly markedly pitted and grooved.

Time did not permit a visit to the Moravian localities. There the moldavites are larger and much smoother because they are found mainly in present-day stream deposits and have suffered considerable abrasion. They are greenish-yellow or brown, resembling the colour of australites.

Evidence of a terrestrial origin for moldavites has been adduced from the Ries Kessel (Giant Kettle), a cauldron-like area, 17 miles in diameter, which lies in southern Germany about 160 miles west of the southern Bohemian moldavite localities. Because of the presence of glassy fragmental rock in the Ries Kessel, and also scattered around it up to a distance of 6 miles, it is considered that it was formed by the impact of a giant meteorite. The heat generated by impact melted the country rock to form glass. It is a very old crater. No fragments of iron meteorites are found associated with it, and small towns have been built within the rim. It is sometimes known as Nordlingen Ries after one of these towns. It is, of course, much larger than even the largest of recently formed meteorite craters, the Canon Diablo (Barringer) in Arizona. Potassium age determinations show that the age of formation of the crater glass is the same as that for moldavites. However, the crater glass differs considerably in appearance and in chemical composition from moldavites. Geological study of the sedimentary rocks in the crater and the depth to which the effects of the impact extended supports the age of 15 million years for the formation of the crater.

However, as already mentioned, the geological age of the high-level sands and gravels, the oldest formation of Teritary age in which moldavites are found, is only about 6 million years. The consensus of evidence would seem to support a cosmic origin for the moldavites, but, as with the australites, the discrepancy between the age of formation and the age of fall remains to be explained.

Age determinations on the Thai tektites show the age of formation to be the same as that of australites. Indeed, it is now firmly established that the tektites of south-east Asia, including southern China, Vietnam, Laos, Cambodia, Thailand, the Philippines, Malaya, Borneo and Indonesia, originated at the same time as australites. There is no reason to doubt that these all fell at the one time, even if the age of fall remains to be discovered. This, together with the absence of evidence of impact craters of such dimensions as would cause a scatter of tektites over such a large section of the earth, would seem to favour a cosmic origin. Not even the most confirmed terrestrialist has ever suggested that the four known meteorite craters in Australia were the source of australites.

In Thailand I spent 2 days in the area between Khonkaen and Chompae. Khonkaen is a small town 250 miles north-east of Bangkok on a railway that terminates at Vientiane, the capital of Laos, on the Mekong River.

This region is on a plateau at a much higher elevation than Bangkok. The climate is therefore much more temperate. In fact, the general scenery reminded me of much of the eastern part of New South Wales.

The tektites are found in the reddish-brown lateritic soil. They are mostly partly buried in small watercourses. They have the same black lustrous appearance as australites, but in general are much larger. Many show regular shapes, though not so perfect as australites, and due to the solvent action of groundwater they are much more pitted than australites.

On this field trip tektites were collected and many were generously given to me by local villagers, all of whom had contact with field parties of the Department of Mineral Resources of Thailand and realized that tektites were objects of interest to geologists.

Tektites are much more plentiful in Thailand than in Australia. In a lapidary shop in Bangkok I saw many pounds weight of tektites for sale and there seems to be an almost continuous supply sent down from the tektite-bearing localities to the capital.

These field trips were made possible by the generous co-operation in Prague of Dr K. Tucek and Dr J. Svenek, of the National Museum, and Dr V. Bouska, of the Charles University, and in Bangkok of Dr Kaset Pitakpaivan, Chief of the Geology Section of the Department of Mineral Resources. Their help is gratefully acknowledged.

The excavation of a large Aboriginal shell midden at West Point, on the west coast of Tasmania. [Photo: Author.]

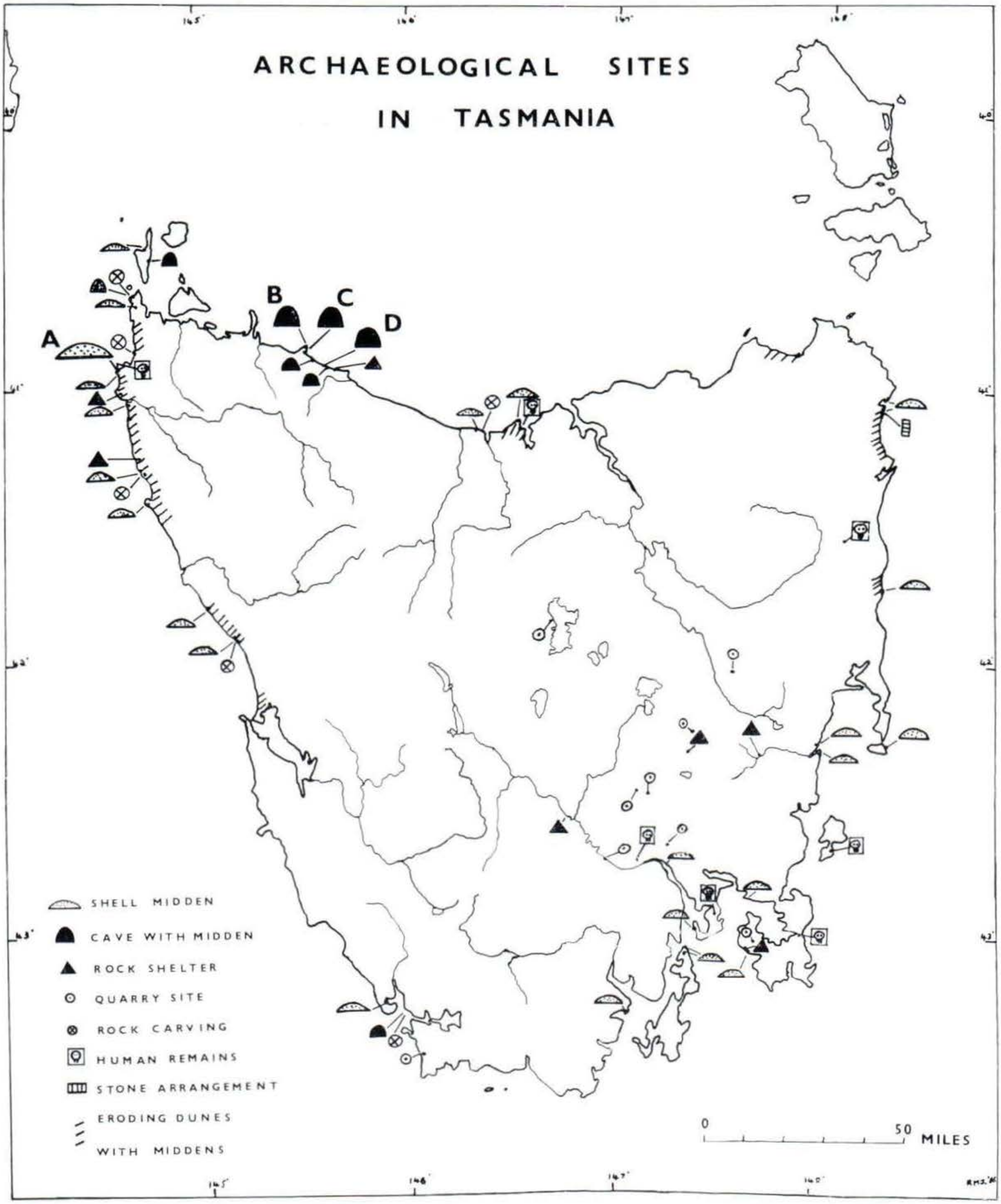
Middens and Man in Tasmania

By RHYS JONES
Department of Anthropology, University of Sydney

THE Tasmanian Aborigines are dead. In their brief period of contact with European culture some records of them were made but these, regrettably, have only given us a limited picture of their way of life. The Aborigines themselves, however, have left their own mark on the Tasmanian landscape. The farmer following his plough, or the walker on the seashore, can, if he is lucky, see evidence of past human activity. The archaeologist looking at the countryside is obsessed with certain features. A ridge of sandstone may contain rock shelters, a patch of loose sand may have stone tools lying on its surface, or an eroding dune may reveal a prehistoric skeleton. In his mind's eye he sees women eating shellfish in the shelter of some dunes, or a group of hunters travelling slowly across a marsh and setting fire to the reeds and low bush as they go, or a small cave with the half-gnawed bones of a wallaby scattered around a fireplace, with the ashes still warm. From a study of the physical manifestations of past human culture, the archaeologist attempts to write history, and in the case of Tasmania before the arrival of literate Europeans he has to rely completely on the resources of his own discipline.

Field archaeology

Tasmania has a varied coastline, and archaeological sites are common along it. These are middens, consisting mostly of shells and containing animal bones, charcoal and stone tools. Middens are sometimes found on the shores of an estuary, or on a rocky headland close to a rich source of food, but often their presence or absence is dictated by the uncertain chances of conservation. A small midden may be preserved by a protective covering of sand for thousands of years, while a neighbouring large site may be destroyed by a couple of heavy winter storms.



Archaeological sites in Tasmania. This does not include localities of surface collections. A, West Point; B, north cave, Rocky Cape; C, south cave, Rocky Cape; D, Sister's Creek. [Reproduced by courtesy of the Queen Victoria Museum, Launceston, Tasmania.]

Some sites consist of thin bands of shells representing a single meal; others are huge piles of shells covering an acre of ground and up to 8 feet thick, laid down by large groups of people who regularly came there to exploit a particular food source, year after year, for thousands of years.

In many places on the west coast the wind is eroding the dunes, thus exposing and eventually destroying the middens contained in them. This is especially true in the northwest between Cape Grim and Sandy Cape, where, after a gale, tens of thousands of artefacts and bones are exposed on the sand. The Aborigines often took advantage of the natural shelter afforded by overhanging rocks or caves, and many coastal caves contain large shell middens, On the north coast, between Table Cape and Rocky Cape, are several old sea caves formed by a past high sea-level, and I have excavated three of them. Many of the offshore islands, such as Hunter, Bruni and Maria Islands, have shell middens on them, showing that they were often visited in prehistoric times. The watercraft of the Aborigines were efficient enough for them to travel across often treacherous coastal waters, but the lack of sites on the large Bass Strait islands, such as King and Flinders Islands, shows that longer journeys were not successful, or were not made in recent prehistoric times.

Collections of stone artefacts have been made in Tasmania for over 60 years, and, by plotting the distribution of these surface finds, we can make a fair guess as to the parts of the country occupied by the prehistoric Aborigines. Such a map was published by Mrs Belleau Kemp in the December, 1963, issue of *Australian Natural History*, and from it we can see that in the west the occupation was restricted to the narrow coastal plain, whereas in the east there was occupation not only along the coast but also inland in the midland plains and in the river valleys such as that of the Derwent. The absence of surface artefacts corresponds closely with the distribution of the temperate rainforest, and it is likely that this dense vegetation formed a considerable barrier to communications.

Some botanists have put forward a theory that the present floristic distribution in Tasmania has been greatly affected by past burning activities of the Aborigines. The extensive areas of sedgeland and mixed *Eucalypt-Notofagus* forest in the west are believed to have been enlarged by intensive burning by the Aborigines over thousands of years. Now that the Aborigines have gone, the rainforest has crept back, and Mr W. F. Ellis tells me that he found great difficulty in cutting his way through coastal scrub on the southwest coast in areas described by Robinson in 1830 as being fairly open country. Similarly, open grassy plains noted by Hellyer and others at Surrey Hills, in the northwest highlands, are now covered by dense rainforest. It is likely that the Aborigines, using fire, kept open the western coastal plain and there are accounts of fire-maintained routes penetrating the rainforest. Travel through the *Eucalypt* forests in the eastern part of the island would have been much easier, not only because of the ease in setting fire to them, but also because of the richness of game there.

An Aboriginal stone quarry in the eastern highlands, near Lake Leake. The ground is covered with cores and flakes. [Photo: B. Hiatt.]

The majority of stone artefacts in the museums have come from surface collections, but it is also possible to find stratified sites inland as well as on the coast. I have seen several rock shelters with signs of occupation in them in the sandstone country in south-east Tasmania, but none of these had large depths of deposit. A future rich source of sites in the midlands may be associated with the inland sand dunes, believed to have been formed in a drier post-glacial period. Modern erosive "blowouts" uncover stone tools, and I have made collections in such sites at Grimes Lagoon, Crown Lagoon, and on the shore of Lake Dulverton. Some artefacts in situ show that these, at least, date from the end of the period of sand deposition and immediately prior to the formation of the topsoil horizon. The Aborigines carefully selected the raw materials for their stone tools and usually exploited limited outcrops of suitable rock. Many of these quarries have been found, and, where the outcrop itself occurs, the ground is covered for hundreds of yards with large quantities of smashed boulders, cores and flakes. In the midlands, near Ross and at St Peter's Pass, for example, the raw material is a metamorphosed mudstone or hornfels. On the northwest coast, a sponge chert was used, the exact source of which has not yet been found, but tools of this material have been discovered up to 100 miles away along the north and west coasts.

I have described industrial and habitation sites, but there are also the remains of intellectual activities. On the west coast there are several places where the designs of circles and lines have been carved on the faces of rocks. The most complex group is at Mount Cameron West, where the designs have been engraved in a soft sandstone. Near Anson's Bay I found a row of flat stones arranged in a straight line on the surface of a midden, and there was a second row stratified about a foot below the top one. Perhaps these marked a site which was important to the Aborigines for ceremonial or other reasons. When a person died, there was a variety of burial procedures. Sometimes he might have died alone, his skeleton covered by drifting sand, but often elaborate burial practices would have been carried out. Bodies were placed in a flexed position on a pyre and burnt, the bones then being broken and placed in little pits. Some such pits have been found.

These prehistoric remains could be any age between the time of the arrival of the Tasmanians and the time of their extinction. If we wish to place them in a chronological order we have to excavate sites under controlled conditions and date the deposits, using radio-carbon dating techniques.

Excavations at Rocky Cape

The three caves which I have excavated at Rocky Cape and Sisters' Creek contained shell middens, and in each case beneath the shells there were sand and decayed rock completely sterile of cultural remains. I think that the deposition of the basal layers of middens in the caves marks the beginning of their human occupation, and perhaps the first arrival of man in the immediate locality.

The first phase of occupation began at about 7,500 to 8,000 years ago. In the basal layers of the South Cave at Rocky Cape, the majority of the bones are of seal, but parrot fish bones are also common. Those of sea birds and land animals are present but rare. The bones of animals associated with the sea constitute 95 per cent of the total weight of dry bone, and if we add the contribution of the shellfish to the diet, which would have been at least as great as the total meat from the vertebrate animals, we see the almost complete dependence on the sea and its littoral as a hunting area for meat. In the case of seal, the high preponderance of flipper bones and jaws suggests that these choice bits were cut off the carcases, perhaps on the shore, and carried up the steep cliff to be eaten in the cave. The stone tools were made from local materials, such as pebbles on the shore or the quartzite of the cliffs, and consist of rough unsophisticated retouched flakes and utilized cores and pebbles. We found thirty-five bone tools, most of which were sharp points made from the fibulae of wallabies.

Later on, at about 4,000 years before the present, we see essentially the same protein diet with perhaps an increase in the importance of fish. Most of the stone tools are crude flakes made from local materials as before, but we also get well made tools manufactured from raw materials which are foreign to the area. This reliance on exotic raw materials increases as time goes on, so that in the top layers of the North Cave at Rocky Cape, dated to about 450 years ago, most of the finished tools were manufactured from cherts and silicified breccias which had been carried over a long distance to the site. The tools consist of well made concave and steep straight scrapers and alternate-flaked cores. In these levels I found no bone tools, and I suggest that they were no longer being made here. There are some marked differences between the diet of this latest phase and that of the preceding ones. Parrot fish were no longer eaten, and there was a decline in the relative importance of seals. Conversely, sea birds and marsupials became more important. In the top levels of the North Cave at Rocky Cape the weight of bones of land animals constitutes 30 per cent of the total dry bone weight, and those of sea birds up to 40 per cent in some spits.

West Point

As a contrast to these caves, which are situated on cliffs overlooking the relatively sheltered Bass Strait, I also excavated a large open shell midden on the exposed west coast near the West Point lighthouse. This site, with a basal date of 1,850 ± 80 B.P., and a top one of 1,330 ± 80 B.P., corresponds in general to the latest prehistoric phase of the cave sequence, and its contents are similar in many respects.

The midden contains a large quantity of flaked stone, and the profusion of cores and unretouched flakes shows that stone tool manufacturing activities were carried out at the site. The raw material used in the top half of the deposit was almost exclusively a fine sponge chert, which was probably quarried locally. The tools consist of scrapers with both concave and convex working edges on them, finely retouched flakes and utilized cores. There were also many small pebbles with heavy battering around their periphery, and these seem to occur commonly on the western coast of Tasmania. The shells of the midden were mostly *Subninella undulata* and the Abalone *Notohaliotis ruber*, but a wide variety of other littoral shellfish were also collected. There was a large quantity of animal bones in the site, most of the meat being provided by seals. These have been identified by the Curator of Mammals at the Australian Museum, Mr Basil Marlow, as Southern Elephant Seals (*Mirounga leonina*). Most of the animals killed were young and it is probable that the site was occupied during summer at least, when the seals were breeding and moulting. Land animals such as wallabies, bandicoots, possums, native cats and Tasmanian Devils were eaten and sea birds also provided a major source of food. A curious absence is that of fish, and this corresponds with the contemporary deposits at Rocky Cape.

We found several small pits filled with burnt and smashed fragments of human bone. Several individuals are represented, and it is probable that, after they had died, they were cremated in the same way as described by Robinson in 1832. In one pit, the bones were accompanied by several dozen small shells with holes in them, and these may be the remains of some sort of necklace.

Sequence for northwest Tasmania

Thus, for northwest Tasmania we have a cultural sequence from about 8,000 to 500 years ago, with some elements showing change and others conservatism. On the one hand, the eating of fish and the making of bone tools were discontinued, and, on the other hand, there was a gradual improvement in the selection of the raw materials for stone tools and in the technique of their manufacture. The complete dietary dependence on the sea in the early phase became supplemented by the killing of land animals later on, and it is likely that rich sources of food such as the Elephant Seals would have been intensively exploited whenever they were available.

I do not think that this sequence will hold in its details for the whole of Tasmania; in particular, I do not think that the relatively crude stone tools from the basal levels represent the standard of workmanship all over the island at that time. In the early phase, northwest Tasmania may have been a peripheral area to the main zone of occupation, and we require parallel sequences in the midlands and southeast Tasmania to test this.

Mainland archaeology

How does this fit in with the archaeological picture on the mainland? The oldest dates for occupation so far found on the mainland

Pierced shells and a duck's bill which accompanied burnt human fragments in a pit at the West Point midden. The vertical shell at the right is 3 inches long. [Photo: R. French.]

range from 24,000 to 18,000 years ago in northern and western Australia. In southeast Australia, a date of 11,000 years B.P. has been obtained in eastern New South Wales, and near Melbourne stone tools have been found in a deposit older than 8,000 years. It is reasonable to assume, therefore, that about 12,000 to 10,000 years ago man had arrived in southeast Australia. The sea-level was over 200 feet below its present level and this meant that the island we now call Tasmania formed part of a mountainous southward-pointing peninsula, with the coast in places up to 40 miles out to sea from the present shore. The warmest summer month was some 9° F lower than at present and the high mountains in Tasmania and the Southern Alps contained glacial and periglacial zones. As the climate became warmer and the ice-covered and treeless areas in the highlands contracted, the sea-level rose until Tasmania became an island. If we assume that in this inhospitable country—especially in the west, which may have had a dense rainforest cover—the first human settlements were closely tied to the coast, then these would have been covered by the rising sea. The inhabitants, if there were any, would have been forced back onto higher and perhaps unfamiliar ground. This is surmise, but what is clear is that, as soon as the sea arrived at its present coastline, men with a strongly littoral economy first occupied the old sea caves on what was again the north coast of Tasmania.

Some 30 years ago, N. B. Tindale pointed out the similarity between Tasmanian stone tools and certain ancient assemblages on the mainland, and this has been demonstrated stratigraphically by D. J. Mulvaney at Kenniff Cave in south Queensland. In the lower levels, dated from 16,000 years to about 5,000 years ago, were steep retouched cores, and a variety of convex and concave scrapers which in general terms are similar to tools found in Tasmania. Above these, dating from 5,000 years until the present, were unifacial points, backed blades, adze flakes and ground edged axes, none of which have been found in Tasmania. Sequences similar to this have been found in Cape York, the Northern Territory, eastern N.S.W., and South Australia, with the new and diverse industries replacing the old ones around about the third millenium B.C. (In this brief report, I have not taken account of Mrs C. White's very old dates for ground edged axes in Arnhem Land.)

Man arrived on the continent over 20,000 years ago, making certain kinds of stone tools, and he was occupying Tasmania when it became an island. In Tasmania the style of stone technology continued relatively unchanged until European contact. On the mainland, however, new cultural elements appeared, probably derived from Asia, which swamped the old culture, at least in the sphere of stone toolmaking. These new influences never reached Tasmania, however, because of the barrier of Bass Strait. At the period of contact, Tasmanian Aboriginal culture had retained (through isolation for over 8,000 years) technological elements which had once been widespread over the continent several thousands of years ago.

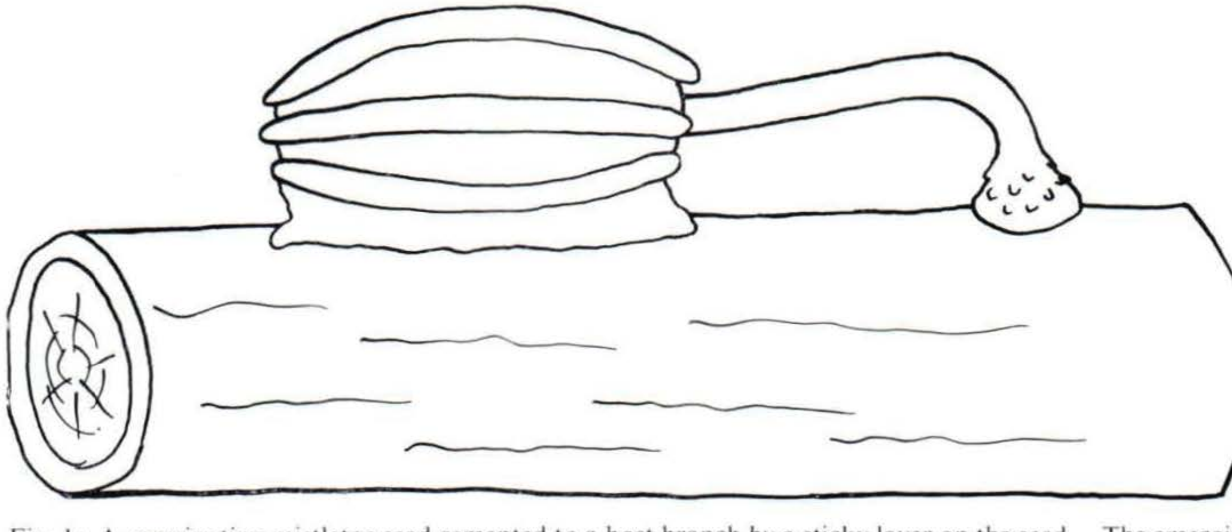


Fig. 1: A germinating mistletoe seed cemented to a host branch by a sticky layer on the seed. The emerging root, in the form of a sucker pad that becomes attached to the host, develops an hautorium which penetrates to the host's xylem tissue.

Parasitic Flowering Plants

By B. A. BARLOW
Senior Lecturer in Biological Sciences, Flinders University of South Australia

WE usually think of flowering plants as one of the foundations of our food web—as an aggregation of attractive free-living organisms which quietly and unselfishly manufacture the basic food materials which support all animal life, including man. It is sometimes surprising, then, to learn that a large number of flowering plants can be broadly classed as parasites.

Most flowering plants which fall into this category are actually *partial* parasites; their nutrition is normal except for some modification they have developed to overcome a particular nutritional deficiency in their environment, such as water or nitrogen. *Total* parasites, obtaining all of their food materials from an organic source, are rare.

The diversity of parasitic flowering plants is also noteworthy. Some belong to large groups which are exclusively parasitic. Others belong to diverse families in which parasitism is rare or otherwise absent. Flowering plants have evolved nutrition by parasitism on numerous independent occasions, and in the process there has accumulated a wide range of modifications for parasitic life.

The adoption of parasitism has a distinct effect on the future history of the species. Further evolution becomes channelled; the modifications of most selective value are those which increase the plant's efficiency as a parasite. The species often becomes more and more specialized for life on a particular host species, and less likely to live on others. There are frequently reduction and elimination of structures (sometimes, for example, leaves or roots) which no longer carry out their original functions. Highly specialized parasites are thus often highly host-specific, much reduced plants with no evolutionary escape if the normal host becomes unavailable.

Evolution for increased efficiency as a parasite often involves reduction in the degree of disturbance caused to the host, since the survival and vigour of the parasite usually depend on the survival and vigour of the host.

Root parasites

Root parasites are plants which have absorbing connections (haustoria) between their roots and those of neighbouring plants. Above the ground, then, there is no evidence of their parasitic nature. They often have connections only with the water-conducting tissues (xylem) of the host, so that they only obtain water and mineral salts parasitically, and manufacture their own food materials in the usual way. As would be expected, such root parasites develop very little host specificity, and appear to be able to parasitize a wide range of neighbouring plants.

Root parasites may be small herbs or large trees; some species of *Gaiadendron* in South America are described as reaching 80 feet. Well-known root parasites in Australia are members of the family Santalaceae (e.g., *Santalum*, *Exocarpos*), some Olacaceae (*Olax*) and two species of the mistletoe family Loranthaceae (*Nuytsia floribunda*, the Western Australian Christmas Tree, and *Atkinsonia ligustrina*, a small shrub of the Blue Mountains, New South Wales).

Some root parasites lack chlorophyll, and are therefore complete parasites, obtaining both water and food materials from the host. These include several genera of the broomrape family Orobanchaceae (one species in Australia). Probably one of the most unusual of flowering plants is *Rafflesia*, a Malesian genus of Aristolochiaceae, which parasitizes grape roots. The vegetative parts of the plant grow entirely within the host tissues, and have become so reduced that they resemble fungal threads. The only parts visible above ground are the foul-smelling flowers, which reach 3 feet in diameter in one species.

Stem parasites

Stem parasites are more obvious parasites in that they develop haustorial connections with the stems of their hosts. Some stem parasites start life as free-living terrestrial plants, but quickly develop into vine-like plants and become attached to other plants. When the basal part of the parasite dies off the plant remains as a completely aerial parasite deriving some or all of its materials from the host. Plants in this category include Devil's Twine (*Cassytha*, family Lauraceae), a leafless plant with green stems, which obtains only water parasitically, and Dodder (*Cuscuta*, family Convolvalaceae), also leafless, which has yellow stems and is a total parasite.

The more highly specialized stem parasites are those in which the seeds are modified so that they germinate on tree branches, and the plant never has a direct connection with the ground. Most parasites of this type belong to the family Santalaceae or to one of the mistletoe families Loranthaceae and Viscaceae. There are about seventy-five species of mistletoe in Australia.

The seeds of most mistletoe species are bird-distributed, and some birds, such as the Mistletoe Bird (*Dicaeum hirundinaceum*), live in close association with the mistletoe plant, feeding on the fruits. This bird defaecates in such a way that the undigested seeds fall not to the ground but on the branch on which it is perched. A sticky layer on the seed cements it to the branch, where it germinates spontaneously. The emerging root is highly modified in the form of a sucker pad, which becomes attached to the host, and develops an haustorium, which quickly penetrates to the xylem tissue of the host (fig. 1). Parasitism is thus established in the early seedling stage, and the mistletoe eventually becomes a woody shrub.

Since the more primitive species of mistletoe and Santalaceae are root parasites, it is presumed that the aerial parasites evolved from terrestrial root parasites, not from non-parasitic epiphytes (plants which grow perched on others). The major step in the

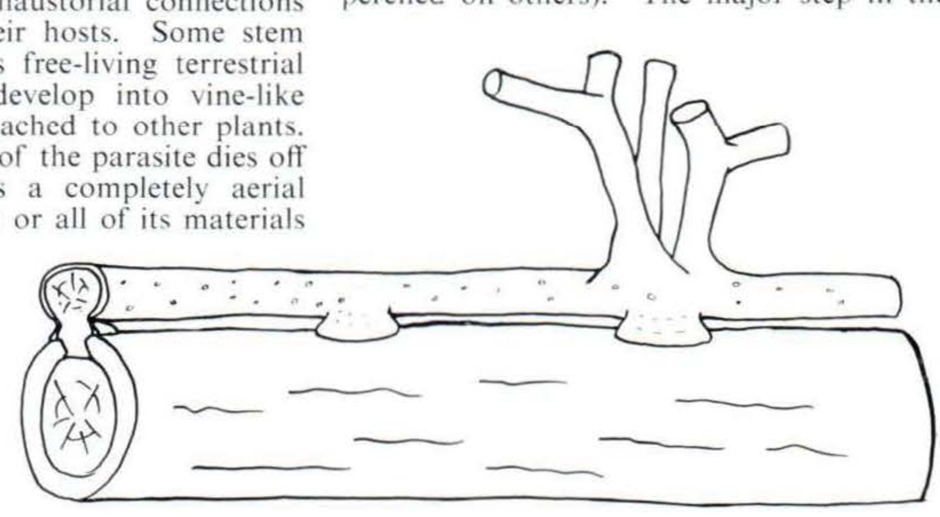


Fig. 2: Portion of a mistletoe runner, showing secondary haustoria.

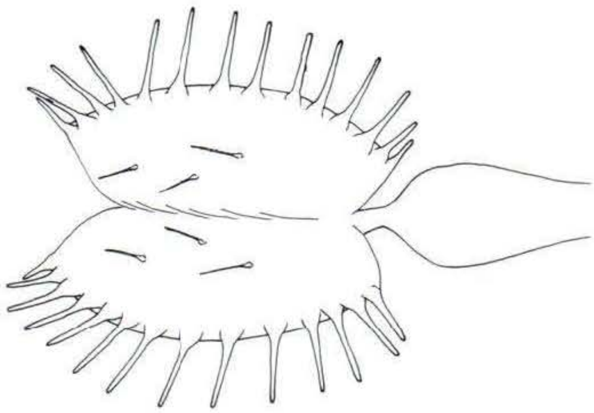
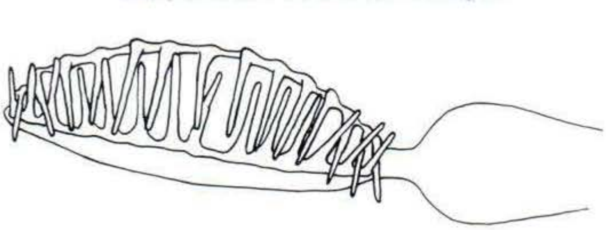


Fig. 3 (above): The open leaf of the Venus Flytrap, showing the sensitive hairs on the inner surface. Fig. 4 (below): The leaf-trap closed, showing the interlocking of the needle-like processes on the leaf margin.



sequence must have been the modification of the embryo or very young seedling for rapid haustorial attachment to the host, thereby eliminating the need for a normal root system in the soil.

Many aerial mistletoes have "runners", which are roots that spread along the host branch, producing new haustoria at regular intervals (fig. 2). These structures are probably homologous with the root system of a terrestrial root parasite. Evolution in the mistletoe has favoured greater efficiency of the primary haustorium; the runners with their secondary haustoria have disappeared in the more advanced species, which have only a single highly efficient absorbing connection with the host.

Further evolution in the mistletoes has resulted in increased host specificity; some species only grow on one or a few related host species, to which they are closely adapted. The adaptation in the Australian species has often involved the development of a close mimicry in the foliage of the mistletoe of that of its host, so that the parasite is well camouflaged. The function of the mimicry may be to conceal the plant from animals which might feed on it without effectively dispersing the seeds.

All mistletoes and most other aerial parasites are partial parasites only, taking up water and mineral salts from the host's xylem.

Insectivorous plants

Insectivorous plants grow mostly in nitrogen-deficient soils. They supplement their nitrogen uptake by trapping insects and digesting the nitrogen-rich exoskeleton. The nutrition of the plants is otherwise normal. The mechanisms for trapping insects are many and varied. Some involve the luring of insects into non-moving traps; others catch insects by movements which in some cases are quite rapid.

There are many species of sundew (*Drosera*) in Australia, all with the same kind of trapping mechanism. The leaves are covered with long hairs, each with a gland at the tip which secretes a sticky, sugary liquid. Insects attracted to the leaf are caught in the sticky secretion, enclosed by many of

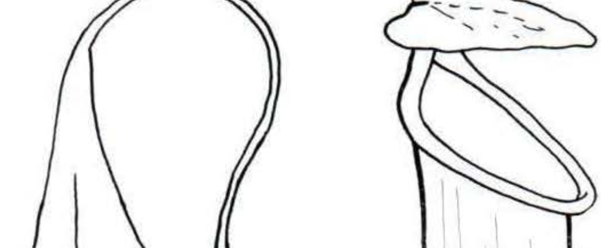


Fig. 5: The leaf of the Pitcher Plant *Nepenthes*.

the hairs and digested by enzymes contained in the sticky secretion. The bending of the hairs over the insect is a chemical response, since it does not occur if the leaf is irritated with a grain of sand. In the same family is the Venus Flytrap (*Dionaea*), in which insects are caught by a rapid movement. The leaf blade is folded, and on each margin is a row of needle-like processes (fig. 3). When an insect stimulates one of the sensitive hairs on the inner leaf surface the leaf closes quickly and the needle-like processes fold over and interlock, trapping the insect (fig. 4). The mechanism of the stimulus transmission and movement is not fully understood, but the folding is due to the sudden loss of water from certain cells at the base of each process and along the fold of the leaf.

In some genera (*Sarracenia*, *Nepenthes*, *Cephalotus*) there is a remarkable development of the end of the leaf into a pitcher, sometimes provided with a lid (fig. 5). (The lid does *not* open and shut in order to catch insects; it is fixed in an open position and probably serves to keep rain out.) Insects which fall into the pitcher are prevented from escaping by downward-directed hairs on the inside of the pitcher, drown in liquid at the bottom of the pitcher and are digested.

Species of bladderwort (*Utricularia*) trap insects in bladder-like modified leaves, which have a trapdoor that prevents the victims' escape. Some *Utricularia* species are aquatic, and it is thought that the bladders pump out water, causing a reduced pressure inside. The insect is carried into the trap by a sudden inrush of water when it stimulates sensitive hairs and breaks a surface tension barrier at the entrance.

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

NEW POST FOR CURATOR

Dr D. F. McMichael, Deputy-Director and Curator of Molluscs at the Australian Museum, has resigned to become Director of the Australian Conservation Foundation. He will take up his new duties in October. Dr McMichael joined the staff of the Museum in 1948 as a science trainee in malacology. He studied at Sydney University and, later, at Harvard University, where he obtained his Ph.D. He was Assistant Curator of Molluscs under Joyce Allan and, after her retirement, became Curator in 1957. He was appointed Deputy-Director last February.

BOOK REVIEW

THE COLLECTION AND PRESERVATION OF INSECTS. K. R. Norris. Handbook No. 1, Australian Entomological Society, University of Queensland, Brisbane. 34 pp., 8 figs. 1966. Price, $1.00.

This small book describes briefly the more usual time-tested methods used in assembling, preparing, preserving, and caring for an insect collection. Here the interested amateur and the professional entomologist engaged in fields requiring collecting as an adjunct to other studies will find described methods which, in most cases, require relatively little capital outlay and which usually do not require materials that are difficult for untrained or unqualified persons to acquire and handle. In fact, for the person who thinks "I would like to make an insect collection" or "I must keep these insect specimens for future reference" but has had no instruction in the matter, this booklet is a good starting point in the search for information on how best to set about it. The methods and techniques included are usually easy and of general application; with experience a collector may wish to modify them to suit himself or his particular interest but they are the basic, "traditional" ones. This is not to infer that they are in any way unsatisfactorily "old-fashioned"; in any case, if a method is "old fashioned" but still in use it usually means that it is good enough to have stood the practical tests of time. Collecting, trapping, and transporting specimens are subjects dealt with in adequate detail. Dry and wet preservation methods are described and a brief section is included on each of the subjects of microscope slide preparation and field preservation of material to be used for chromosome studies. An appendix indicates the usual methods of preserving specimens of each order of insects. The short list of references will be a lead for those wishing to look up more detailed or more specialized techniques.

Much energy and time are spent by collectors, especially in their first enthusiastic efforts; quite often these efforts, although satisfying initially, are found to be largely wasted because of faulty techniques due to ignorance. In some cases attention to a detail would have made the difference between a useless specimen and a worthwhile contribution to knowledge. This can be avoided simply by knowing the correct basic technique and requirements before setting out. These are described in this booklet.

The Australian Entomological Society is a young society and it is to be congratulated for setting off on the right road with this, its first, publication attending to first things first, namely, to instruction on the making of an insect collection. It is to be hoped that in the future it will provide the more advanced works which will be needed by those who make use of its first publication wisely and well.—*C. N. Smithers.*

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