Vol. 17 No. 7 SEPTEMBER 1972

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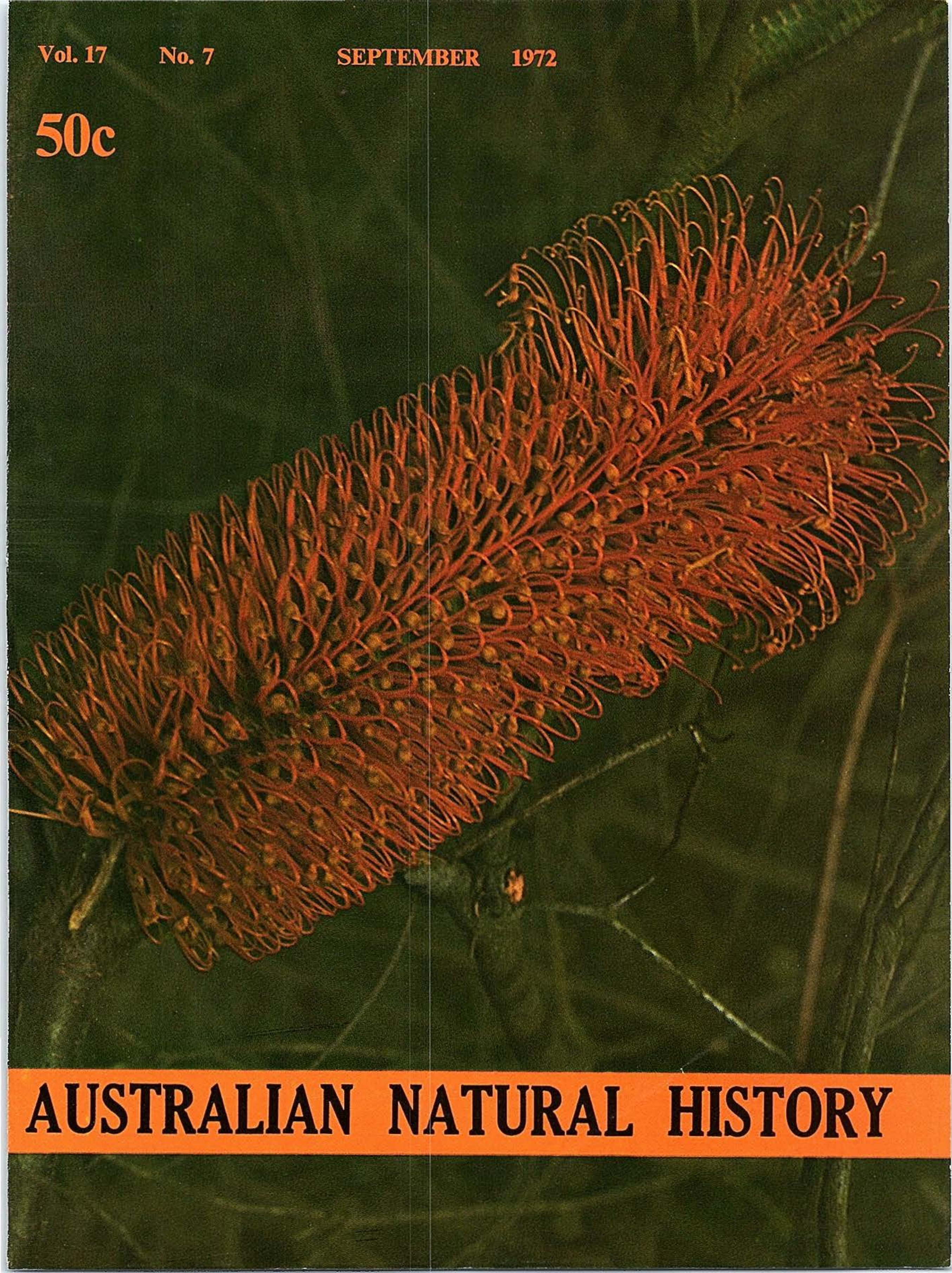

AUSTRALIAN NATURAL HISTORY

AUSTRALIAN NATURAL HISTORY

Published Quarterly by the Australian Museum, College Street, Sydney

Editor: F. H. TALBOT, Ph.D., F.L.S. Annual subscription, $2.50 posted

Assistant Editor: P. F. COLLIS Single copy, 50c (62c posted)

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● **FRONT COVER: The Heath-leafed Banksia (*Banksia ericifolia*) is the largest-flowered and most colourful of the eastern Australian banksias. From mid-autumn to late spring, its foot-long brushes, bronze to bright orange-gold, blaze like fiery torches amid the fine, heath-like foliage. The flowers, unlike those of most banksias, usually open at the top of the spike first. The tiny, rigid, dark-green leaves are carried in crowded whorls around slender branches. A shapely large shrub or densely-crowned small tree, this banksia is a native of the sandy coastal areas of New South Wales. It is common on the Hawkesbury sandstone around Sydney and extends to the Blue Mountains. The photo was taken at West Head, Broken Bay, N.S.W., by Douglass Baglin. An article on Australia's banksias appears on the opposite page. BACK COVER: An adult Double-drummer Cicada (*Thopha saccata*) resting on the empty nymphal skin from which it has just emerged. It has to wait for the soft, limp wings to harden in the appropriate position before it can go about its normal activities. This is a male, as can be seen from the pouch-like covering of the sound-producing organs on each side of the abdomen. The length of the head and body is $1\frac{3}{4}$ inches (45 millimetres). This cicada is common in New South Wales, southern Queensland, Victoria, and South Australia. It is varying shades of brown when fully developed. [Photo: Howard Hughes.]**

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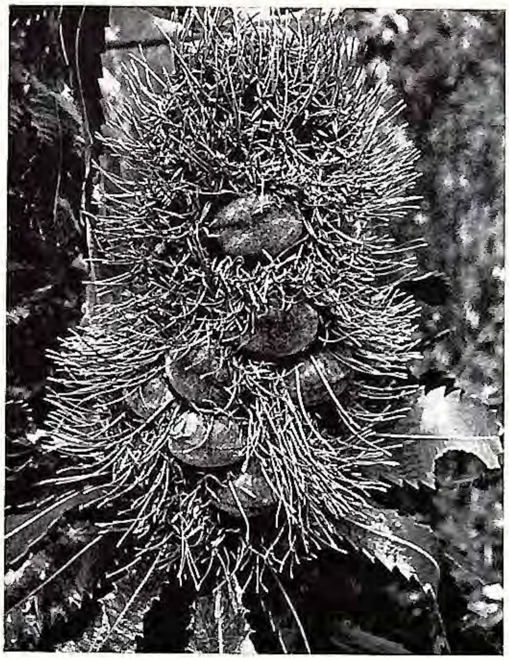
AUSTRALIA'S BANKSIAS

By BARBARA MULLINS
Sydney Author of Books on Australian Native Plants

BANKSIAS are unique to Australia, if one excepts the tropical *Banksia dentata*, which extends to New Guinea. They are found in all States, growing in peaty swamps and in salt sea-spray, leaning gnarled and resolute from the bare stone of arid rocky escarpments and hung with lichen in the moist valleys of the high country.

As is the case with some wattles (such as mulga and brigalow) and some eucalypts (for example, the mallee), banksias have lent their name to areas of country where they form the dominant growth, so that southern Queensland's sandy coastal strip of lakes and dunes is called the wallum, an Aboriginal word once used by the local tribes to describe *B. serratifolia* (syn. *B. aemula*), a small spreading tree or large shrub which binds the hind dunes of Australia's eastern coast from the Sydney district of New South Wales to the threshold of the tropics.

It is appropriate that banksias should commemorate the name of Joseph Banks, Captain Cook's botanist and "father of Australia". Banksias were among the first specimens of Australia's native flora he collected from the shores of the bay Cook later called Botany, a reference to the "great number of New Plants" which the scientists found growing there.



The Saw Banksia (*Banksia serrata*) is a native of Queensland, New South Wales, Victoria, and the islands of Bass Strait. These are the "old man" banksia trees of eastern Australia. They grow as high as 50 feet, with stout, gnarled, knobbly trunk and dark, furrowed bark. The hairy cones seen in this photo are the traditional "banksia men". They are covered with a dense, wiry fuzz of dead flowers from which protrude isolated large seed capsules, the size and shape of a pullet's egg and clothed with soft, short, dove-grey to rusty-red fur.

Great diversity

Banksias belong to the Proteaceae, a large family almost wholly confined to the Southern Hemisphere and with its greatest development in Australia. This family includes the spectacular waratah and the spider-flowered grevilleas; the name is derived from Proteus, the Greek god of the sea, who could change his form at will, and alludes to the remarkable diversity found among members of the family, even within the same genus. Banksias, for example, range from prostrate shrubs with stems creeping underground and even leaves often protectively buried beneath the surface of the sand-plains, so that the flower spikes appear to be squatting directly on the soil, to trees up to 50 or more feet high, with gnarled and furrowed butts 2 or more feet across. Leaves may be needle-fine and heathlike, large and leathery, or long and toothed like a crosscut saw. Flower spikes, in some cases a foot or more long, range in colour from glowing orange in *B. ericifolia* to the sombre, black-tipped green of the swamp-dwelling *B. robur*.

Flowers of *Banksia* are stalkless, borne in dense terminal spikes or heads containing a thousand or more individual blooms embedded in velvety brown bracts and crowded in spiralling rows around a thick woody axis. Floral parts are in fours; the perianth (petals and sepals) is tubular and slender, and the segments are petal-like,

The Acorn Banksia (*Banksia prionotes*) is a native of southwestern Western Australia. The flower-spikes are up to 6 inches long and the bright orange styles are released from the bottom first, contrasting sharply with the soft, silvery-white buds and giving the whole inflorescence its acorn-like appearance.

silken-haired and very narrow, each with a spoon-shaped lobe at the top in which an anther is seated. The style is prominent, long, and wiry; it protrudes from a slit in the floral tube to form a characteristic loop while the stigma at the tip is still held captive. When the stigma is set free, the style is either finally straight or permanently hooked, and this is a characteristic by which the various species of *Banksia* can be roughly differentiated.

"Banksia-men"

The floral spikes develop into thick, woody, fruiting cones, on which numerous colourful, withered, barren flowers persist for some time as a dry bristly fuzz. Fruit is a large, woody, two-valved capsule containing two paper-thin winged seeds. In the majority of species, curiously few of the fruits develop to maturity; those that do protrude at scattered intervals like heavy-lidded eyes among the bristles of the withered flowers—the quaint, hairy "banksia-men" of children's tales. Usually, these seed capsules remain closed until the cone is broken off or is seared by the heat of passing bushfires. An exception is the Coast Banksia (*B. integrifolia*); it spits out its seeds when they are ripe, releasing them without warning.

All banksias produce nectar in abundance—they are commonly called "native honeysuckle" for this reason—and some are valuable honey plants. Nomadic Aborigines suck the blossoms to extract nectar, or steep the spikes in water to make a honey drink. In country areas children often collect the nectar by banging the heavily-laden flower-heads against a dish.

Honey-eating birds and bees abound when banksias are in bloom. The bees push their way up the crowded rows, collecting nectar as they go from storage places at the base of each flower. Birds and tiny pigmy possums find a foothold on the wiry, arched styles, and probe for honey with furred tongues and long, curved beaks or narrow snouts. Sometimes they seek, instead, the tiny insects which scurry deep among the spiralling rows of flowers; in either case, pollen is brushed off onto plumage or fur and transferred from flower to flower.

Handsome garden specimens

The highly decorative banksias make attractive garden specimens, and should be retained wherever possible in newly-developed building lots. They were cultivated overseas as early as the beginning of last century. Joseph Knight (*On Cultivation of Plants Belonging to the Natural Order Proteaceae*, published 1809) recorded the successful propagation of several eastern Australian species. *B. spinulosa*, he wrote, could be raised from seed, which should be sown without delay, or from well-ripened shoots cut at the node. Nowadays most enthusiasts prefer to propagate from seed, preferably sown in permanent positions as many species resent transplanting. Fruiting cones should be gathered (where permissible) when the woody seed capsules are well developed. In most species these are tightly sealed until severed from the parent plant, and may have to be forced open with a screwdriver, warmed in an oven to simulate the heat of bushfires, or left for some time in the sun. Spring is the best time to sow seed, in a mixture of sand, peat, and leaf mould, covered lightly with bush soil (preferably gathered from their natural habitat). Banksias like a well-drained position, and most can stand plenty of water. As germination is uncertain, two to four seeds should be sown in each position, spaced a few inches apart, or else the whole cone can be partly buried, or placed between damp sacks until the valves open and the seeds germinate. Growth is relatively slow.

There are over fifty species of *Banksia*, more than forty of which are confined to the west. Of these, the vast majority are found only in the Southwest Province, that ancient corner of Western Australia which has remained segregated by sea and sand for countless millions of years, developing in isolation a unique and lovely flora. Only

The Waratah Banksia (*Banksia coccinea*) has squat flower-heads about 2 inches in diameter. The floral tubes are softly furred and dove-grey, and the long styles are vivid scarlet, tipped with a golden stigma. A native of the southwestern corner of Western Australia, it is common on the exposed coastal sand-plains around King George Sound, and also occurs in the Porongorup and Stirling Ranges.

The Holly-leafed Banksia (*Banksia ilicifolia*) is an exception among banksias in that its flowers are borne in dense terminal heads rather than spikes. The holly-like leaves from which this banksia derives its common name are dark glossy green, and surround the small flower-heads in prickly rosettes. The flowers, yellow when first open, turn orange-red with age, giving the tree a two-toned effect. This banksia is found in Western Australia, from the region of King George Sound to the Swan River district.

The Silver Banksia (*Banksia marginata*) ranges from South Australia and Tasmania northward almost to the Queensland border. Its popular name refers to the silvery undersurface of the small narrow leaves. Flowers, pale lemon-yellow in colour, are borne profusely from spring to early winter. The flower spikes are rarely more than 3 inches long. In the buds in this photo the typical spiral arrangement of *Banksia* flowers can be seen. The Silver Banksia is a dense shrub or small tree. It has a varied habitat, growing on the 90-mile desert of South Australia and the sea-lashed islands of Bass Strait, on the heathlands and gorges of the Hawkesbury sandstone country around Sydney, and on the high slopes and valleys of the Australian Alps.

one Western Australian species extends from that State—*B. dentata*, which grows right across tropical Australia and in New Guinea. The remaining species are largely confined to the eastern States, only two—*B. marginata* and *B. ornata*—extending westward as far as South Australia.

[*The photos in this article are by Douglass Baglin.*]

FURTHER READING

Anderson, R. H.: *Trees of New South Wales.*

Beadle, N. C. W., Evans, O. D., and Carolin, R. C.: *Handbook of the Vascular Plants of the Sydney District and the Blue Mountains.*

Beard, J. S.: *West Australian Plants.*

Black, J. M.: *Flora of South Australia* (second edition, 1943–57).

Gardner, C. A.: *Wildflowers of Western Australia.*

Mullins, B. G., and Baglin, D.: *Australian Banksias.*

Willis, J. H.: *A Handbook to Plants in Victoria.*

BOOK REVIEW

MINERALS, ROCKS AND GEMS. A HANDBOOK FOR AUSTRALIA, by J. A. Talent; Jacaranda Press, Brisbane, 1970, $10.95.

Australian amateur mineralogists and mineral prospectors (especially the former) are fortunate to have two excellent modern reference works of a popular nature. The first is the well-known *Australian Rocks, Minerals and Gemstones*, by R. O. Chalmers (Angus and Robertson, 1967), and now we have *Minerals, Rocks and Gems, A Handbook for Australia*, by John A. Talent (Jacaranda Press, 1970). These books are obvious competitors, as both are well prepared, well illustrated, written by capable men, and tend to be more comprehensive than is usual in popular works. Both can be highly recommended.

The book under review begins with a short section on the ways rocks and minerals are formed. As a student of rocks, I feel that this section is too short, and favour the lengthier treatment of Chalmers. But as Dr Talent says: "Since the main theme is mineral determination, description of the origin of rocks and mineral deposits is kept brief", and there is some justification for this viewpoint. Readers with some chemical knowledge will appreciate the section on the atomic structure of minerals (especially silicates), and the treatment of crystallography attains first-year university level. Chapters on the physical and chemical testing of minerals are provided, as well as keys to the identification of minerals and rocks, the latter being most ingenious.

The properties of minerals also are categorized under alphabetical listing of mineral names, and the book is indexed on the basis of subject and of locality. A section on gemstones deals with cutting, polishing, detection of imitations, and artificial stones. A glossary of words commonly used in geology, mineralogy, and mining will be particularly useful. There is also a section on prospecting and Australian mineral provinces, though this is not as extensive as the treatment in Chalmers' book. The book is lavishly illustrated with excellent colour photographs by E. R. Rotherhan. These will be helpful to prospectors and amateur mineralogists, as they have been well chosen, and the mineral and rock specimens photographed are generally of top quality.

In summary, this is a well prepared book that can be recommended to amateur geologists and prospectors, but particularly to amateur mineralogists, for whom the extensive crystallographic and mineralogical sections will have greater appeal than for the prospector.—*R. H. Vernon, Senior Lecturer in Earth Sciences, Macquarie University, North Ryde, Sydney.*

TERRIGAL ITCH, A COASTAL WATERS DERMATITIS

By ELIZABETH C. POPE
Curator of Worms and Echinoderms, Australian Museum, Sydney

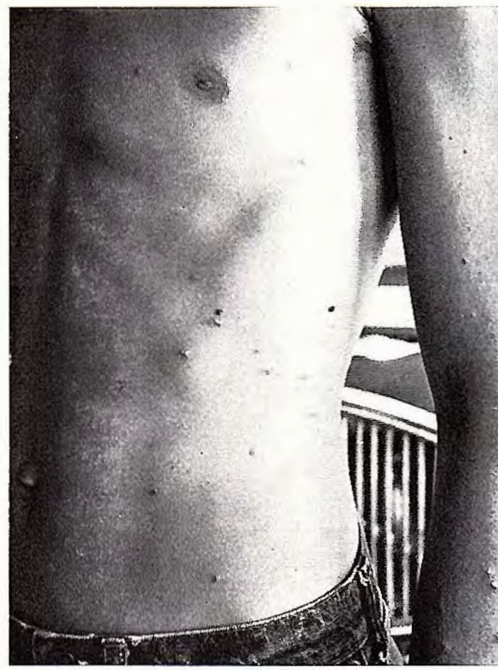
YOUNG Bill had been paddling about, lying face-downwards on his surf board in the shallows of Tambourine Bay, which opens into the Lane Cove River arm of Sydney Harbour. He moved slowly and his board was often awash. Although he was not aware of it at the time, his skin which was in contact with the water lapping over the top of his board had been penetrated by a number of microscopic larval flatworms, known as forked-tailed cercariae, belonging to a type of parasitic blood fluke called *Austrobilharzia terrigalensis*.

He may have felt a slight prickling on his skin as the cercariae penetrated, but it did not worry him at the time and probably felt like insect bites. It was not until two or three days later that he realized he had contracted what is variously known as bather's itch, Terrigal itch, Narrabeen itch, pelican itch, and, overseas, clam-digger's itch and, if the attack occurs to persons working in the rice paddies, paddy itch. These are by no means all the names it goes by, so it is easier to use the correct medical terms—either schistosome dermatitis or cercarial dermatitis.

The parts of Bill's body where the water had lapped his skin were the only areas affected, and had scattered raised red lumps which became acutely itchy when his clothes rubbed against them or when they were scratched.

His case was not an uncommon affliction, for attacks of dermatitis caused by cercarial larvae are well-known among fishermen and waders in the shallows of Australia's coastal lagoons and inlets. Reports are often received at the Australian Museum from doctors or members of the public wanting to know what has "bitten" the victims, who often believe they have been attacked by sea lice.

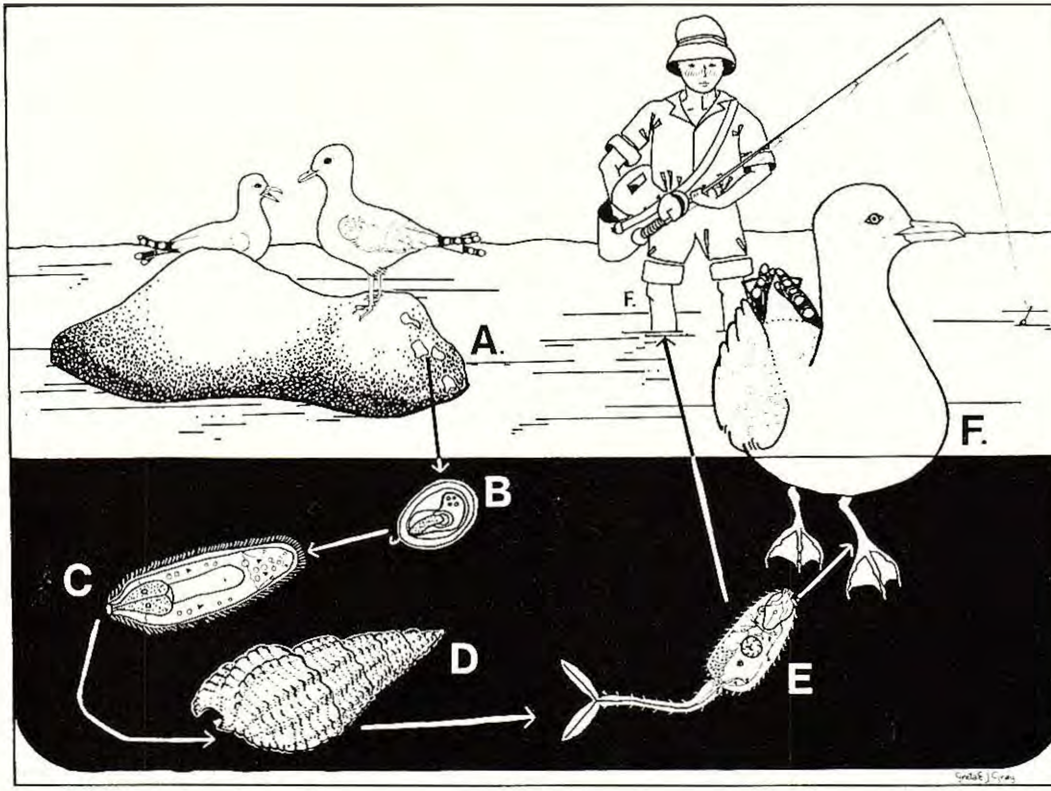
Such inquiries are most frequent in the hot summer months, but it is not clear whether



A mild case of cercarial dermatitis, caused by the flatworm *Austrobilharzia terrigalensis*, several days after the initial attack. [Photo: C. V. Turner.]

the cercarial larvae are only about at that season or whether it is just that the long school holidays coincide with the hottest part of the summer and more people go wading and bathing at that time and are therefore exposed to the possibility of attack. Probably both these factors combine to make us consider it a summer-time disease.

In Bill's case several hot days had preceded the day in early December when he paddled his surf board about, and this had been sufficient to cause the microscopic cercarial larvae to emerge from the tissues of their snail host and swarm at the surface of the water. He just chanced to paddle slowly



The life-cycle of the flatworm *Austrobilharzia terrigalensis* (shown in this drawing, which is not to scale) is complex, and involves two hosts—one a vertebrate, the seagull, and the other an invertebrate, the snail *Velacumantus australis.* Normally the adult worms live in the seagull (A), and their eggs (B) are passed out with the bird's faeces. If the eggs reach water they hatch and a swimming miracidium larva (C) emerges. Should the miracidium encounter *Velacumantus australis* (D) it bores into the soft tissues and settles down to grow; from it develops another larval stage called the sporocyst, which proceeds to grow and multiply asexually, giving rise to more sporocysts, which, in turn, give rise to a generation of fork-tailed, swimming larvae called cercariae (E). These emerge from the secondary host, *Velacumantus australis*, and actively swim about in search of their normal final host, the seagull (F). A human (also F) may accidentally become involved as host to the cercaria, which probably cannot distinguish between the two warm-blooded vertebrates, man and seagull, and penetrates the skin of the first one it encounters. However, if a human is infected the flatworm's life-cycle is broken, for, in the tissues of the host, the defence mechanisms of the body come into action, the foreign protein is rejected, the cercaria is immobilized under the skin, and the characteristic lesions of cercarial dermatitis erupt. [Drawing by Greta E. Jensen Gray.]

among them and thus became infected. The fact that the larvae were so far "inland" in Sydney Harbour is of some interest since it means that one may expect to contract cercarial dermatitis in almost all areas of this great waterway, provided that sea birds congregate there and the small whelk *Velacumantus* is also present on the zostera flats, near where the birds roost, for all these factors are necessary to allow the flatworms to complete their life-cycle.

Before discussing the disease these worms cause in human beings and what can be done to avoid or alleviate it, it is necessary to review the normal life-cycle of the worm that causes the trouble.

The adult worms

Austrobilharzia terrigalensis was first discovered living in the blood vessels of a seagull from Terrigal by the late Professor

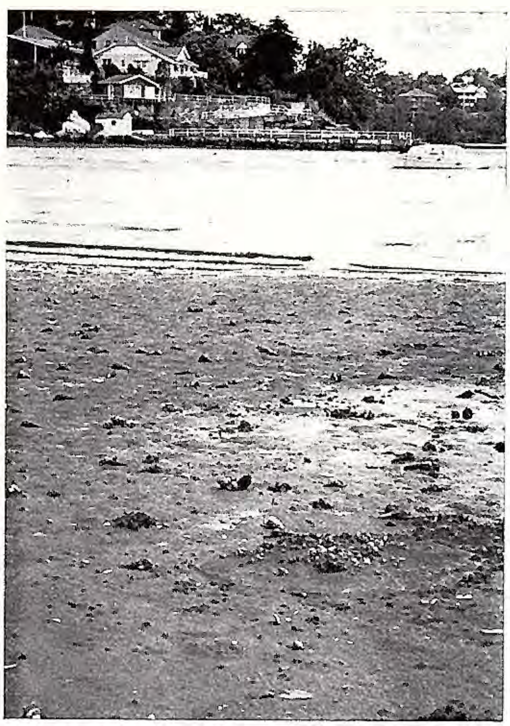
T. Harvey Johnston—hence the specific name *terrigalensis*. However, it is by no means confined to that geographic area, and probably ranges widely around the coast of Australia wherever the seagull, *Larus novaehollandiae*, and the intermediate host snail, *Velacumantus australis*, occur together on the shore. It belongs to an unusual group of blood flukes in which, unlike some of the well-known flukes such as the hermaphroditic liver fluke, the sexes are separate, i.e., there are both males and females. However, they generally occur in pairs with the longer and thinner female enclosed in a canal-like groove on the male's body; this groove extends from the posterior end of his body as far forward as his ventral sucker, in the front quarter of his body. The female projects from either end of the canal. The males measure about 3·4 or 3·5 millimetres (about one-seventh of an inch) long, and the females about 5 millimetres. Both worms have oral and ventral suckers by which they cling to the walls of the blood vessels of their hosts or move about, and these suckers are armed inside with fine spines for a better grip on the walls of the blood vessels.

Life-history

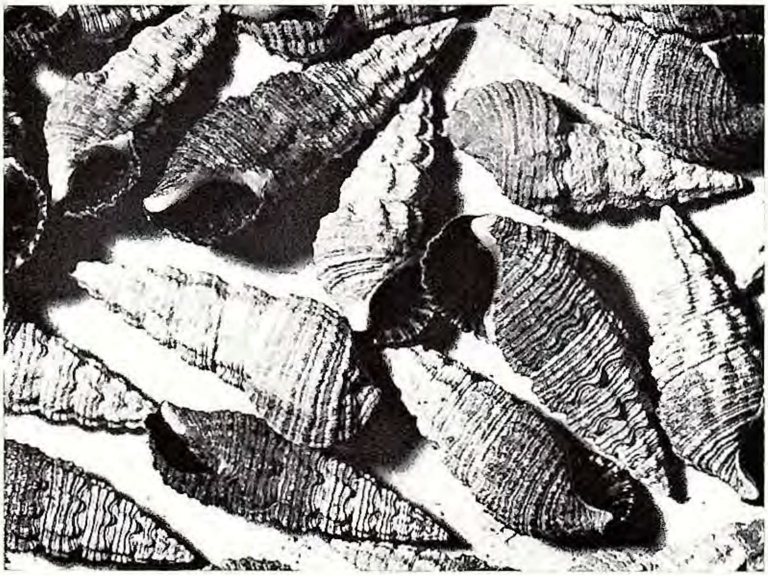
In an article in the March 1955 issue of *The Australian Museum Magazine* (as *Australian Natural History* used to be called), the author described the researches of Mr A. J. Bearup, of the School of Public Health and Tropical Medicine in Sydney, which were then in a preliminary stage but sufficiently advanced at the time to allow us to guess at the life-history of these flatworms with a fair degree of certainty. It is interesting to record that, after much patient research by Mr Bearup and others (notably W. Ewers), the full life-history is now established and much additional information has been found on the relations between the parasite and its hosts, and it has not been necessary to alter any of the assumptions made in that earlier story.

The life-history is set out in the diagram on page 218, but it should be noted that the mature adult worms (males and females) are not shown because they are in the final host, the seagull, and the larval stage, known as the sporocyst, is not shown, as it is hidden in the tissues of the secondary host, *Velacumantus australis*. Anyone requiring details of their appearance and structures can refer to A. J. Bearup's original paper, "Life Cycle of *Austrobilharzia terrigalensis* Johnston, 1917", in the scientific journal *Parasitology* (Vol. 46, 1956, 470–479).

The stages of life-history are described in the caption of the accompanying diagram, but one or two comments appear to be called for on certain facets of it. Firstly the chances that an egg will reach water, so that it can hatch and give the resulting miracidium larva a chance to seek out the right species of snail, are lower than might be expected. Similarly, after several generations of asexually produced sporocysts have appeared and each of these has metamorphosed into the next motile stage, the cercarial larva, they too have only a slim chance of encountering suitable final hosts, in spite of adaptations like



Shores in inlets, as shown above, are the type of habitat where attacks by cercarial larvae can be expected. At low tide molluscs lie about on the muddy sand; they include the secondary host *Velacumantus australis*, which, however, are too small to be identifiable in this photo. [Photo: C. V. Turner.]



The secondary host, the sea snail *Velacumantus australis*. [Photo: C. V. Turner.]

the powerful swimming organ, the tail, and the larva's ability to be attracted to warmth. In fact, it is this last ability, one which should help it seek out a warm-blooded bird, that may prove fatal to the cercaria by leading it to attach to and penetrate the skin of a human just because he is warm-blooded. This proves a dead-end for the *Austrobilharzia* cercaria because of the specialized system in the human being to resist the invasion of its tissues by a foreign protein. It is this rejection of the cercariae which causes the familiar, somewhat boil-like lesions that can become so irritable and annoying to the victim of cercarial attack, for it is rare merely to be attacked by only a few larvae at one time. They tend to congregate on the surface of the water, and victims generally get quite a number of spots at the same time.

Other interesting facets of the life-history include the egg's ability to dissolve its way through the seagull's tissues by means of enzymes, so that it enters the bowel and passes out in the excrement. And to do this the peculiar little J-shaped hook plays its part by anchoring the egg to the bowel wall, while the enzymes in the egg get to work on the host's tissues. Likewise, the process whereby the cercaria penetrates the vertebrates' tissues is a similar enzymatic action, of dissolving its way in, but this time the cercaria's sucker anchors it to the spot.

Human reaction to cercarial invasion

There are some species of blood flukes in which man is the final host—e.g., *Schistosoma haematobium* (Bilharzia)—and, in these, invasion of the host's tissues causes little or no reaction. It is only when the cercaria invades an unsuitable host that the dermatitis reaction occurs. Some people are lucky enough, even in this event, to suffer little or no inconvenience when bird schistosome flukes penetrate their skins. Others may suffer acutely, especially if their reactions have become sensitized by previous invasions of cercariae.

After the initial "pin-prick" feeling of entry, little happens for a day or so; then each point of entry appears as a pink spot which becomes larger and redder—about 3 millimetres (about one-eighth of an inch) in diameter—and only becomes itchy if scratched or rubbed by clothes. They become raised (people often report that "each bite is like a small boil") and gradually, over a series of days, they turn brown, like freckles. If not scratched and infected, the lesions normally recede and disappear after about two to three and a half weeks, leaving only the brown freckle-like pigment to mark the point of invasion. Even this fades in time.

Prevention and first aid

Measures against outbreaks of cercarial dermatitis can range from community measures to deal with the problem of areas known to be "bad", to personal efforts to prevent oneself being attacked while wading or fishing in shallow lagoons and inlets.

To break the life-cycle, such measures as the removal of the species of snails that harbour the intermediate stages of the life-history are possible on a community scale in areas favoured for wading and bathing, and bathing enclosures should not be juxtaposed to places where favoured roosting sites of gulls and pelicans are conveniently near to eel-grass tidal flats where the *Velacumantus* occur in hundreds. Students from the University of New South Wales did a survey in 1970 of the incidence of infestation by larval flatworms of mud-dwelling snails living in the vicinity of roosting sites of sea birds at Smith Lake, central coast, New South Wales, and they found that the shells nearer to the roosting sites were most heavily infested. The level of infestation tapered off rapidly, so the further any swimming or wading enclosure is from the favoured roosting sites of the birds the less likely it will be for people to become victims of cercarial attack, because the cercarial larva is not a long-distance swimmer.

The wearing of waders by fishermen standing in the shallows of coastal lagoons will prevent attacks, and even the wearing of good thick socks with jeans tucked into them reduces the chance of attack. Cream preparations, such as a 25 per cent dimethylphthalate in lanolin, are effective repellants for about 30 minutes, but this cream has a ruinous effect on plastics (e.g., car seats, pens, pencils, etc.). Probably as effective as anything is smearing the skin that will be submerged with petroleum-jelly. The cercariae can only attack at or below the water-line and can only penetrate the skin of a still or slow-moving person. They do not move very fast, and spend much of their time suspended near the surface waiting for contact with a victim.

First aid measures after an attack include the use of an antihistamine cream or a hydrocortisone preparation. Though most Australians are likely to have some experience of this pest sooner or later very few of them know what cercarial dermatitis is, and not all doctors recognize it. It is one of the troubles that can be encountered by the users of still, coastal waters—inlets and lagoons—along our coast. If treated properly it need not be more than a nuisance, so it is best to be informed about it and to know what to do should one encounter these microscopic invaders of the skin.

FURTHER READING

Buchsbaum, R.: *Animals Without Backbones*, Pelican Books, 2 vols.

Wells, M.: *Lower Animals* (paperback edition), World Univ. Library, McGraw-Hill Book Co., New York, Toronto. Chapter 11, "On Being a Parasite".

Insects Book in Colour

AUSTRALIAN INSECTS IN COLOUR, by Anthony Healy and Courtenay Smithers; A. H. and A. W. Reed, Sydney, 1971; price, $4.50.

The general public seems to have an insatiable appetite for books on insects in colour. This book is without doubt one of the better productions of this kind. Mr Healy's photography is superb, and he has added many new insects to the fast-growing repertoire of insects photographed in colour. I was particularly impressed by the photographs of a silverfish (page 11), backswimmer (page 47), phasmid eggs (page 25), and the myodactylid larva (page 51), to mention a few. There are also some magnificent shots of Homoptera, which are not often figured in this type of book.

The text by Dr Smithers has been clearly and concisely written, with a good blend of technical and non-technical material. The common and specific names for orders have been used, as well as family names, in the captions to pictures. This, I feel, is useful, since it does introduce readers to the correct terminology for insect orders and families and thus, perhaps, leads them on to further detailed reading.

The colour reproduction is first-class and each picture beautifully clear. I consider this book is well worth its price.—*F. J. D. McDonald, Senior Lecturer in Entomology, University of Sydney.*

A young Kangaroo Island (South Australia) echidna foraging for insects. This specimen is of a pale straw colour, which is not unusual on the island. [Photo: Ederic Slater.]

THE LIFE OF THE ECHIDNA

By M. E. GRIFFITHS
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ECHIDNAS (also known as Spiny Ant-eaters), along with their close relatives the platypuses, belong to a group of the class Mammalia called the Prototheria. These "primitive beasts" are oviparous, but they are classified as mammals mainly because they have mammary glands which secrete milk, comparable in every way with the milks of marsupials and eutherian mammals, for the sustenance of the young after hatching. Many other characteristics of their anatomy are mammalian, such as the three tiny bones or ossicles in the middle ear for conduction and amplification of sound waves, one bone only in the lower jaw, a false palate, a diaphragm separating chest from abdomen, and the covering of hair over the body. Some of the hairs on the back and flanks of echidnas are modified to form stout, sharp spines.

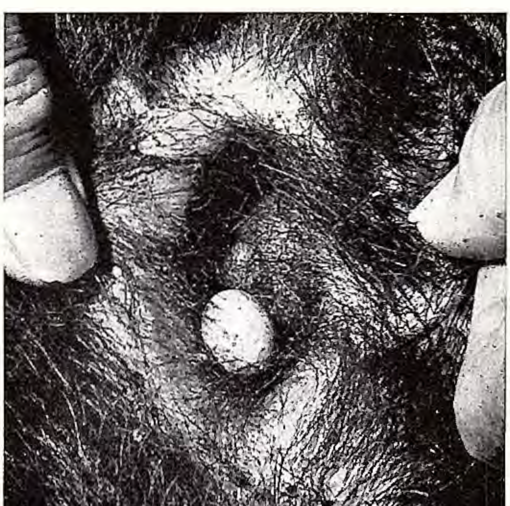
Echidnas are found all over Australia, including Tasmania and Kangaroo Island, in habitats ranging from alpine snow country to the hottest of deserts, and in New Guinea, where there are two kinds. The Australian echidnas and one of the New Guinea species belong to the genus *Tachyglossus*, but the other genus, *Zaglossus*, is found only in high mountainous country of New Guinea ranging from eastern Papua to the Vogelkop of West Irian. *Zaglossus* is a very large echidna, over a yard long, stands high on its legs, and has a very long, slightly curved snout.

Tachyglossus, on the other hand, has short stout legs, rarely attains a length of 18 inches, and has a relatively short snout.

Tongue is vital

This snout and the mouth cavity in both genera house a very long worm-like tongue, which is absolutely vital to the animal; without its use the echidna would starve, for this organ both catches and masticates the animal's food—ants and termites. In *Tachyglossus* the tongue can be thrust out for a distance of about 7 inches beyond the end of the snout, and, as it is covered with a sticky secretion of a set of salivary glands called the sub-lingual glands, any ants or termites coming into contact with it stick to it and are drawn back into the mouth cavity. All this happens with lightning-like rapidity, the tip of the tongue darting right, left, up, and down, even curving back on itself as it seeks out the scurrying ants.

Echidnas locate their prey largely by sense of smell, but there is evidence to suggest that the bones of the snout can conduct sound-waves to the cochlea of the ear, so it is quite possible that ants and termites may disclose their presence to the echidna by making noises detectable by the snout. Having located food, be it in an ants' nest deep in the ground, in a mound, or amongst leaf mould and forest litter, the echidna exposes it with its powerful forepaws, which are equipped with strong spatulate claws; if need be, the echidna will burrow 2 to 3 feet into a meat-ant mound to extract highly-prized items like virgin queen ants, which may contain up to 47 per cent fat. Fresh diggings in meat-ant mounds may be seen at any time between the end of July and the middle of October in the mountainous parts of eastern Australia.



An egg in the pouch at the eighth day of incubation. [Photo: Ederic Slater.]

Digestion

Echidnas have no teeth for chewing up their prey and they even lack the rough horny plates that serve for teeth in the platypus; nevertheless, they make a good job of grinding up the ants and termites the tongue transfers to the back end of the mouth cavity. They achieve this by the rubbing action of a set of horny spines on a knob at the base of the tongue against a series of transversely arranged spines in the roof of the mouth. The ants and termites are ground up by this process and are then passed back to the large crop-like stomach. Digestion occurs mainly in the intestines, since the echidna stomach completely lacks glands for the secretion of digestive enzymes. Only the soft parts of the insects are digested; the hard cuticular parts, which make up the exoskeletons of the termites and ants, pass to the exterior in the dung. Many of these undigested parts can be identified under the microscope down to genus level, and sometimes to species level, so one can find out what kinds and proportions of ants and termites have been eaten by the echidna by examination of scats picked up in the bush. With a little practice one can find these quite easily in places frequented by echidnas: inside hollow logs, in forest and scrub litter, in caves and niches in rocky country, or simply lying out in the open, especially in sandy spinifex country.

Whether an echidna is an ant-eater or a termite-eater depends on where it lives; in arid climates echidnas are largely termite-eaters, but in southeastern Australia, Tasmania, and Kangaroo Island some termites are eaten but ants by far form the major part of the diet. Why termites are preferred in arid areas is not known, but the reason for this may be related to water content of the insects—presumably termites living in the equable climates of mounds and galleries would have more water in their bodies than ants forced to forage outside their living quarters. The sole fact known in connection with this is that echidnas deprived of water can get along quite well and grow for at least two weeks on a diet of the termite *Nasutitermes exitiosus*, whose body is about 77 per cent water by weight.

Regulation of body temperature

The ability of the echidna to survive in habitats ranging from deserts to alpine snows is due to their warm-bloodedness and to their capacity for regulating body temperature, mainly by heat production. This makes them largely independent of changes in temperature in their environment, but, like many other mammals, if the weather becomes too cold they hibernate, the body temperature falling to a little above the temperature of the surroundings. On the other hand, if the weather gets too hot echidnas cannot regulate and the body temperature rises. This happens around 90° F ambient and the echidna must then avoid the heat by retreating to a burrow, cave, crevice, breakaway, and so on, or die of apoplexy if it cannot. By such behavioural means of temperature regulation the echidna can live through the hot summers of the arid inland. This necessity to avoid high temperatures has given rise to the notion that echidnas must be nocturnal, moving about and feeding at night. They probably are in hot weather, but in my experience they move and feed any time of the day if the weather is favourable.

Study of movements

From a study of the recapture rate of echidnas identified by means of a numbered band placed on the hind leg, it would appear that these movements are relatively limited in extent. Of sixty-seven echidnas banded between October 1963 and May 1966 and released at three different places in the Australian Capital Territory, twenty-three have been recaptured to date. The results for sixteen of the recaptures have been published elsewhere; these indicated that most echidnas could be recaptured within a mile or two of their release point up to two years and three months after, and indeed some echidnas were taken practically at the place of release one year afterwards. Nevertheless, two of the marked echidnas did move a long way in a short time: one went 3·4 miles in 7 days and the other 11 miles in 148 days—and these are only minimal distances, measured as straight lines between points of release and recapture. Since publication of that data, seven more marked echidnas have come to hand and the results are given, for the first time, in the table at the bottom of this page.

From this, apparently, some echidnas moved very little and others moved many miles from the point of release; all were in good health and all but one had increased in weight. The imprecise data in the last entry in the table is due to the fact that an observant bushwalker of Canberra found the animal at Mt Stromlo, recorded what was decipherable of the number, and then let it go again. The number observed was incomplete, but from the records it was found that it could have been released at Mt Tidbinbilla or at Gungahlin (Gungahlin is 9 miles from Mt Stromlo, Mt Tidbinbilla is 10) at times differing by only 38 days. I am inclined to think it came from Gungahlin, a habitat unfavourable to echidnas. Also, from these data it is apparent that an echidna can live for far more than five years in the bush.

MOVEMENTS AND BODY WEIGHTS OF ECHIDNAS BANDED AND RELEASED AT THREE DIFFERENT LOCALITIES IN THE A.C.T.

Place of release	Sex	Initial body weight (grammes)	Distance between point of release and point of recapture (miles)	Time taken for recapture (days)	Body weight at recapture (grammes)
Gungahlin	♂	1,910	4·5	1,388	4,600
Mt Tidbinbilla ..	♀	4,250	0·5	818	4,770
Mt Majura ..	♂	5,270	6·0	2,064	5,364
Mt Majura ..	♀	4,900	0·5	992	4,020
Mt Majura ..	♀	3,525	practically nil	1,055	3,600
Mt Majura ..	♂	1,950	0·2	271	2,522
Mt Tidbinbilla or Gungahlin.	..	..	9 or 10	1,402 or 1,440	..

Young emerging from an egg after about ten days six hours incubation. [Photo: Ederic Slater.]

Reproduction

By far the most interesting thing about an echidna's way of life is its mode of reproduction. The echidna breeds but once a year—in the spring—and at this time females can be found accompanied by three, four or even more male echidnas, presumably for mating. If she becomes pregnant a pouch begins to form on the ventral surface and during the last five or six days before the egg is laid the pouch and mammary glands develop at an astonishing rate. The gestation period is unknown but on two occasions eggs are known to have been laid seventeen and eighteen days respectively after the female had been separated from males. Recently I dissected a female echidna, which had been separated for thirty-four days from the four males it was originally associated with on a rocky outcrop near Alice Springs, and found a fertilized egg in her uterus. This period of 34 days could hardly be called gestation, but it may indicate that viable sperm can be stored in the uterus for many days after mating has occurred.

At the end of gestation the egg is placed into the pouch, probably directly from the extrusible cloaca, and incubated there for between ten and ten and a half days (see photo on page 223). Towards the end of incubation, movements under the shell can be detected, and a few hours after the onset of these movements the hatchling tears a hole in its shell, presumably with the special egg-tooth on the premaxilla bone of the upper jaw, and begins a prolonged struggle to escape from the egg (photo, this page). The newly-hatched has relatively enormous fore-limbs and practically no hind limbs (photo, this page). These strongly developed fore-limbs enable the newly-hatched to drag itself around the pouch to find, and attach itself to, one of the two milk patches on the dorsal surface of the pouch. The pouch young shown in the photo on this page is about

Young about four hours after hatching. The tissues attached to the abdomen are the remains of foetal membranes. Note the huge forelimbs and the milk in the stomach showing through the transparent abdomen. [Photo: Ederic Slater.]

A pouch young beginning to exhibit spines. [Photo: Ederic Slater.]

four hours old and it has already imbibed milk, which can be seen through the transparent wall of the abdomen. In another hatchling observed, milk was not detected in the stomach until 39 hours after hatching. Hind limbs are fairly well developed at three days after hatching. The time-span of pouch life depends on how long the mother will suffer the young one to remain once it begins to grow spines. The photo on this page shows a pouch young, about 300 grammes (about 10½ ounces) in weight, just getting spines, but this baby echidna was not cast out of the pouch until it was about 400 grammes in weight. Other pouch young observed have been dropped when only 200 grammes in weight. From data on rates of growth of young, it is surmised that on the average the pouch life is about fifty days.

Echidnas usually have only one young, but an echidna taken near Casino, New South Wales, had twin pouch young each about 60 grammes in weight. When the young is dropped for good it is hidden in a shallow burrow, to which the mother returns from time to time to suckle the baby. In the laboratory the mother voluntarily feeds her baby every one to two days, the young one taking in enough milk to last for the ensuing couple of days in a matter of twenty to thirty minutes. In this respect the echidna resembles the rabbit *Oryctolagus cuniculus* and the tree shrew (*Tupaia* species), both of which mammals exhibit long intervals between suckling and rapid, massive intake of milk on the part of the young.

Very small echidnas, 800 to 900 grammes in weight, have been found walking alone in the bush in the month of March. One instance has been recorded of a very large echidna accompanied by a very small one in the same month, and lactating echidnas have also been taken in February and late March. From these facts, it is concluded that weaning probably takes place in late February and March and that echidnas look after their young for at least three months after dropping them in a burrow.

FURTHER READING

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THE SHOVEL NOSED LOBSTERS OF AUSTRALIA

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and D. J. G. GRIFFIN,
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THE shovel-nosed lobsters belong to a family of marine decapod Crustacea known as the Scyllaridae. This common name derives from the extremely flattened antennal plates. Other common names for various species of the family are Slipper Lobster in Hawaii; Butterfly Lobster; Balmain Bug (*Ibacus peronii*) in New South Wales; Moreton Bay Bug and Bay Lobster (*Thenus orientalis*) in Queensland, and Prawn Killers in South Australia and New Zealand.

Shovel-nosed lobsters closely resemble the marine rock lobsters (family Palinuridae), but differ in the shape of the antennae or "main feelers", carapace or "head" shape, and method of eye protection. The shovel-nosed lobsters are divided into six main groups or genera. Although these differ quite widely in shape, they share a number of notable features. The head is obviously flattened in the horizontal plane; this contrasts with the rock lobsters, which generally have a high, cylindrical head. Furthermore, the eyestalks are protected by being located in definite sockets or orbits, whereas the rock lobsters have supraorbital horns or spines for eye protection. The main feelers are drastically modified, consisting of four moveable segments, the second and fourth of which are enlarged and flattened as shovels; there is no long whip-like feeler as is found in rock lobsters, which have cylindrical feelers.

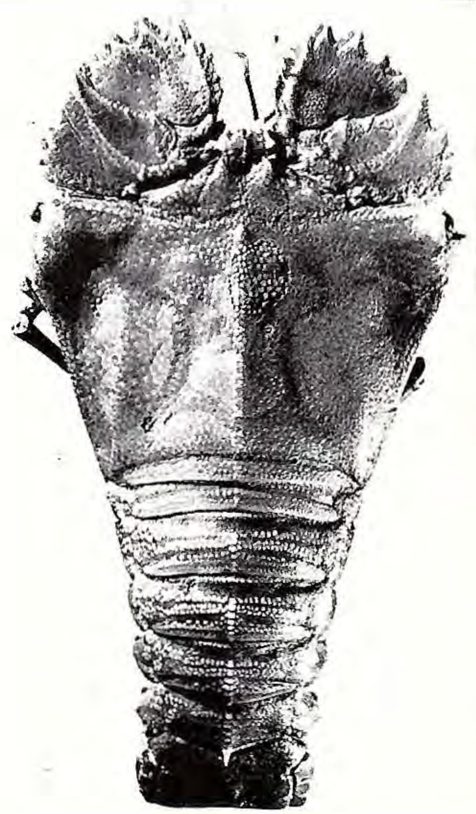
The last major account of the Indo-Pacific shovel-nosed lobsters was in 1946 by Dr L. B. Holthuis, of the Rijksmuseum, Leiden, in a report on the collections made in Indonesia by the Snellius Expedition of 1929–1930. At that time about fifty species were known, the largest number being in the genus *Scyllarus*. Since then a number of new species have been described by Holthuis, who is continuing work on a revision of all the species of this group. About sixteen species have so far been recorded from Australia, but it is highly likely that more remain to be discovered and named.

The Balmain Bug (*Ibacus peronii*). Note the strongly incised edges of the "head" and the eyes located near the midline. [Photo: C. V. Turner.]

The genera can be distinguished by use of the accompanying diagrams and photographs. Two major groups are readily apparent—the extremely flattened forms (*Thenus*, *Ibacus*, and *Parribacus*) and the not-so-flattened ones (*Scyllarides*, *Scyllarus*, and *Arctides*). The flattened forms can easily be distinguished from each other by the position of the eyes. In *Thenus* they are at the outer angles of the front of the head, while in *Ibacus* they are close together near the midline. In *Parribacus* the eyes are midway between the midline and the outer angles of the head. The genera of the other group are most easily distinguished by the front edge of the shovels. In *Scyllarides* the edge is almost smooth to the naked eye, in *Scyllarus* the edge is cut into a few prominent lobes, and in *Arctides* the edge has many small, rounded lobes.

Habitats and geographical distribution

Many shovel-nosed lobsters are found burrowing into relatively soft substrates, presumably using their shovels for this purpose. However, species of *Parribacus* occur on the outer edge of hard reefs, where shovels would obviously be of little value. *Thenus orientalis* is picked up in commercial prawn trawls on the muddy, sandy bottoms along the eastern Australian coast north from Moreton Bay in Queensland and around to



The Moreton Bay Bug or Bay Lobster (*Thenus orientalis*). The eyes are located at the outer extremities of the front. [Photo: C. V. Turner.]

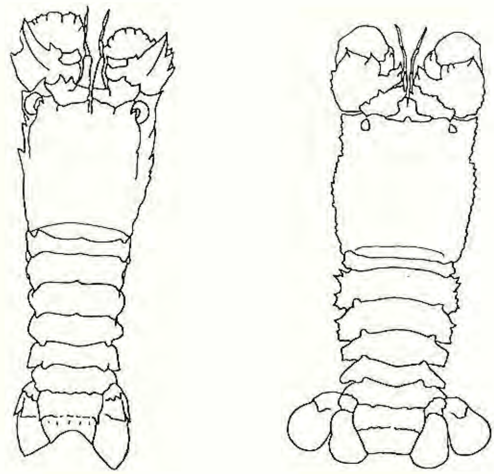
Exmouth Gulf in Western Australia. *Ibacus peronii* is trawled in cooler waters on a coarse, muddy, sand bottom in from 20 to 75 fathoms by fishermen and prawners along the southern coast of Australia between Geraldton, Western Australia, and Newcastle, New South Wales. Another species of *Ibacus*, *I. altricrenatus*, has been trawled only along the southern Australian coast between Newcastle and Bass Strait; it lives on soft substrates across the lower shelf and continental slope in depths between 45 and 300 fathoms. The rough, surf-washed, outer reef edge of the tropics is the habitat for species of the genus *Parribacus;* they live in the dark caverns and undercuts of the reef, moving out on to the reef flat on moonless nights. *Parribacus* species occur throughout the Indian and Pacific Oceans, and in Australia have been recorded only from the Queensland coast.

Less is known about the habitats of the species of the remaining three genera. *Arctides antipodarum* has been caught by divers and by fishermen in rock lobster pots along the New South Wales coast, where it probably lives at the rock-sand interface. *Scyllarides squammosus* is also taken by divers and in rock lobster pots, but it is apparently associated with coral reefs around Lord Howe Island, the Great Barrier Reef, and Western Australia in depths of from 10 to 20 fathoms.

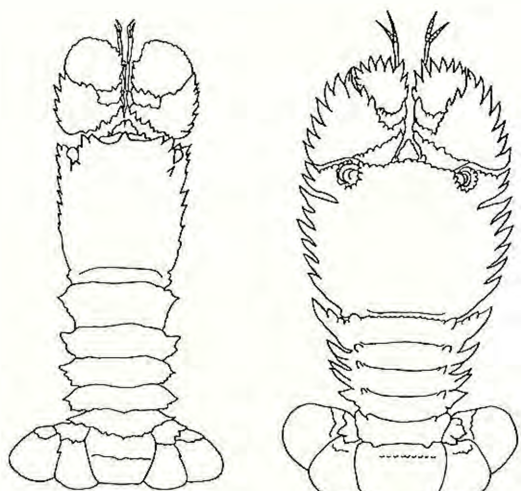
Species of *Scyllarus* are usually quite small (up to about 3 inches) and have been collected in a variety of habitats and by a variety of collecting methods. Some have been trawled or dredged on mud or sand in association with *Lithothamnion* and Bryozoa as deep as 150 fathoms by vessels such as the early exploratory ships *Thetis* and *Endeavour*; others are taken under stones and rocks between tide marks, and some in commercial rock lobster traps and from the stomachs of large and small reef fish.

Natural history of shovel-nosed lobsters

Like the rock lobsters, the shovel-nosed lobsters carry the eggs beneath the tail, where preliminary embryonic development takes place, and all these lobsters have a very characteristic flattened larval stage called the "phyllosoma" which ensures distribution from, and recruitment back to, the separate species populations. Mating usually follows



Diagrams of representative species of different genera of shovel-nosed lobsters, showing the variation in body shape. Above: *Scyllarus* (left) and *Scyllarides*. Below: *Arctides* (left) and *Parribacus*. [Diagrams by D. J. G. Griffin.]



the moulting of the mature females. Also, like the rock lobsters, the fertilization of the eggs is external, some species depositing a temporary sperm packet on the underside of the female which may remain intact for months, whereas the sperm mass of others rapidly breaks up and is immediately used. The large number of eggs (up to 750,000) which are produced by the orange-red ovaries come out of a small hole at the base of the third pair of legs of the females. An interesting difference between the rock and the shovel-nosed lobsters that have a temporary sperm packet is the position of placement. In *Parribacus* the black sperm packet is spread evenly as a narrow ridge across the underside of the first tail segment, whereas the rock lobster genus *Panulirus* has the sperm packet spread as a squarish mass on the underside of the chest.

After initial embryonic development the egg capsules burst, releasing the first of many flat, transparent, phyllosoma larval stages, which circulate in the plankton, rising and falling in the water column to maximize their chances of return to their area of release. Details of the behaviour and age of the separate larval stages are not known, but eventually some late-stage larvae do return to the coastal waters, moult into a "puerulus" stage (a stage resembling a young crayfish), and settle on the bottom. At this stage they grasp at any object, and fishermen often find them clinging to ropes and floats of their rock lobster pots or their suspended shark nets. Pelagic fish such as the tunas and salmon are among the major predators of the larval and puerulus stages. Off Cape Naturaliste, Western Australia, for example, one Tommy Ruff (*Arripis georgianus*) had its stomach stuffed full with thirty-five puerulus stages of a species of *Scyllarus*, indicating that these puerulus stages can occur in concentration and that their behaviour does not result from a haphazard movement at the mercy of the ocean currents. On the contrary, each stage would be expected to be strongly selected for, if the individual got into the right current at the right time, ensuring the best chance of being returned by the prevailing current systems. Losses of larvae through predation, by riding the wrong current, or by excessively abnormal seasonal variations in the current patterns, drastically reduce the larval numbers and account for good and bad seasons of recruitment.

Evolutionary trends

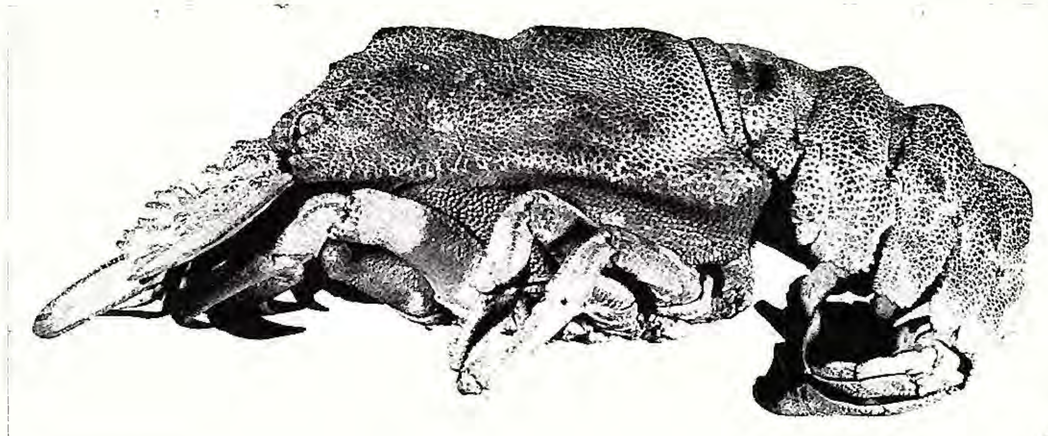
Not much research has been directed towards the assessment of evolutionary trends within the family Scyllaridae, and the continuing revision by Dr Holthuis should enable a much clearer indication in the future. Nevertheless, a trend in the general head-shape can be seen from a compact form which is not excessively flattened and has forward-directed shovels (*Scyllarus*) to one with a very flattened body and outwardly directed shovels (*Thenus*). The earliest fossil form, *Scyllarella*, is from the Paleocene; this has a moderately high head like *Scyllarus*.

New Australian lobsters

At the time Dr Holthuis' report on the Snellius expedition was published, two species of *Scyllarides* were considered to occur in the Australian region. By 1960, however, it had become evident that Australian records of "*Scyllarides guineensis*" and "*Scyllarus sculptus*" referred to an undescribed animal. Dr Holthuis described this as *Arctides antipodarum*, and it is now known from many localities along the New South Wales coast, as well as from Lord Howe Island and New Zealand. It also became evident that the specimens which Alan McCulloch had recorded from Lord Howe Island in 1906 as *Scyllarus sieboldi* were actually *Scyllarides haanii* (a species previously known from Japan) and not *S. squammosus* as had been thought.

In the last four years a number of interesting shovel-nosed lobsters have arrived at both the Australian and Western Australian Museums. These are not *Arctides*, however, but two different species of *Scyllarides*. At present it is clear that *S. haanii* occurs around Lord Howe Island and off the central west coast of Western Australia (Ledge Point), while *S. squammosus* occurs in eastern Australia (Queensland and N.S.W.) as well as in Western Australia (North West Cape and Geraldton areas).

Side view of the lobsters *Scyllarides squammosus* (above) and *S. haanii* (below). Note the much more humped appearance of the tail (the right end) in *S. haanii*. [Photo: C. V. Turner.]



The two species are very similar. The most important difference (see photographs) is that in *S. haanii* the midline of the upper surface of the third and fourth segments of the tail is distinctly humped, or bears a strongly elevated ridge, whereas in *S. squammosus* the back of the tail is almost flat. There is also generally a difference in colour. Both species are pale with red blotches. The upper surface of the first segment of the tail bears a small red blotch on each side of the midline in *S. haanii* but a broad, red, wing-shaped area in *S. squammosus; S. haanii* is generally paler than *S. squammosus.* There are further minor differences between the Australian specimens we have seen and Japanese specimens which suggest that the Australian animals may be a distinct species. Similarly, further work may show that the common shallow-offshore species of *Ibacus* in Australia is distinct from that found in South Africa.

At least some species of shovel-nosed lobsters are of commercial importance, and it is to be hoped that this fact will lead to further studies which will increase our understanding of these interesting animals.

BOOK ON FRESHWATER FISHES

FRESHWATER FISHES AND RIVERS OF AUSTRALIA, by John S. Lake; Thomas Nelson, Melbourne, 1970; 61 pages and 16 pages of plates; $4.95.

Although relatively few, Australia's freshwater fishes display a number of adaptations for reproduction in the driest continent. With this theme, John Lake has summarized knowledge of the reproductive biology of Australian freshwater fishes, much of it the result of his own research.

Four chapters on rivers and lakes, the freshwater fishes, modes of reproduction and distribution, and the future of Australian freshwater fishes, plus a glossary, list of references, conversion table from metric (which is used throughout) to British units, and indices of common and scientific names, make up the volume. The glossary is helpful with specialized terminology; however, a diagram of a typical fish with labelled parts would have been of value.

The first chapter briefly characterizes the fifteen drainage systems Lake uses to show fish distribution. The major portion of the book, thirty-five pages, is a systematic treatment of the fifty families which occur in our fresh waters. Of the 231 species listed, only some 150 are both native and entirely restricted to fresh water. For each family is given a generalized outline drawing (some of which, like that for the Pempheridae, seem poorly chosen for this work), a list of the freshwater species with drainage systems ennumerated, and details of their biology and distribution where known. Biological information on food, habitat, maximum size, and edible quality is often given; however, it is the reproductive aspects that are emphasized, with data on spawning behaviour, times, and temperatures, fecundity, and development presented for the studied species. One omission is that of the blind subterranean eel of northwest Australia, *Anommatophasma candidum.*

The treatment afforded various fishes is extremely varied; the species of gobioids receive less than half the space of the seven serranid species. This results from the amount of information available, and, unfortunately, most of our fishes fall into the goby category; Lake's book points out the many gaps in our knowledge.

The ninety-six photographs, most in colour, illustrate forty-eight different species and a number of different aquatic habitats. Many of the pictures are aquarium photos of living fishes, and most are well done. Some indication of the size of the specimens would have been helpful. All of the photos and most of the detailed text information are restricted to species occurring in New South Wales or Queensland, where the author has carried out his research.

A summary of reproductive strategies and distribution patterns makes up the brief third chapter; one would have hoped for a more extensive treatment. The book ends with a timely discussion of the future of Australian freshwater fishes. Man's effect on our inland waterways has resulted in a list of endangered or potentially endangered species totalling fifty-one, more than one-fifth of the fauna. Let us hope that Lake's call for urgent action is heeded.

Notwithstanding the statement on the flyleaf, this book will be of little help in the identification of specimens. It is not designed as a field guide; no keys and few taxonomic characters are included, and the size alone, 8½ inches by 11 inches, militates against field use. Most of the species are only listed under the family heading. Lake emphasizes the systematic problems present in a number of families, and also mentions that taxonomic studies are considered second-rate science by many. The two problems are correlated, and, until systematics is given some importance in Australian universities, definitive field guides will be few and far between.

Anglers, aquarists, students, and professionals will find in this book a summary of existing knowledge on the biology of our freshwater fishes and a guide to future problems. Reasonably priced, the book should find a place in the library of all interested in Australian freshwater fishes.—*John R. Paxton, Curator of Fishes, Australian Museum.*

Two "cleaning fish", *Labroides dimidiatus*, cleaning a batfish, *Platax pinnatus*, at Heron Island, Great Barrier Reef, Australia. [Photo: D. R. Robertson.]

BEHAVIOURAL ECOLOGY OF THE "CLEANING FISH"

By GEORGE S. LOSEY, Jnr
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LOUSE-EATER, parasite picker, the finned doctor, and barber fish are names given to the various brightly-coloured cleaner fishes found on tropical reefs. These cleaners have long fascinated the underwater naturalist as they pursue their habit of removing ectoparasites from other fishes. A typical scene on a tropical reef can be witnessed as a large parrot fish approaches a cleaner above the reef. The parrot fish stops abruptly and hangs, tail down, as if suspended by its beak in mid-water. The cleaner swims slowly to the seemingly narcotized parrot fish and begins a close inspection of its body and fin membranes. The cleaner picks at a few spots on its back and inside its gill covers until the parrot fish jerks suddenly as if awakening, swims away over the reef, and resumes feeding as the cleaner attends to its next customer. A single cleaner may service several hundred such fish per day as it removes and ingests copepods, isopods, flukes, and other ectoparasites.

Cleaning symbiosis has now been found on tropical and temperate reefs throughout the world, in mid-ocean water, and even in freshwater streams and lakes. Most cleaners centre their activities about certain locations on the reef, termed cleaning stations. A careful observer may find five to ten of the cleaner's customers, termed host fishes, on the station at one time.

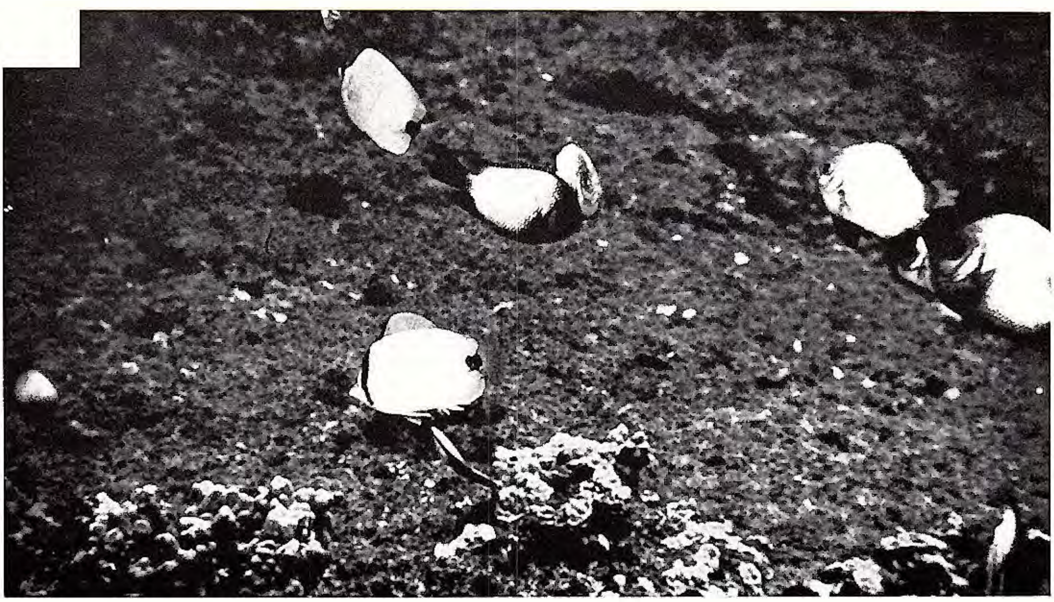
In an early experiment, Conrad Limbaugh removed the cleaners from a small reef in the British West Indies. After removal, his observations suggested that most of the host fishes left this reef, and those that remained became heavily parasitized. This experiment, coupled with the ectoparasites found in the gut contents of cleaners, and the large number of host fishes serviced per day, led observers to believe that the cleaners were necessary for the control of fish ectoparasites and the health of the reef fish community. Thus, cleaning was referred to as a mutualistic symbiosis. The cleaners benefit by having their food "delivered on a platter" while the hosts benefit through being rid of their ectoparasites.

At about the same time, other workers experimentally exposed large predators from one ocean to cleaners from another ocean. Instead of eating the unfamiliar cleaner, the predators entered into normal cleaning interactions. These, and more recent experiments with naive (or inexperienced) host fishes, suggested to some that the hosts showed an inherited recognition of cleaner fishes. Other observations showed that cleaners frequently entered the mouths and gill chambers of large predators and emerged unscathed. It seemed that the hosts not only recognized the cleaner, but also refused to prey on their symbiotic partner.

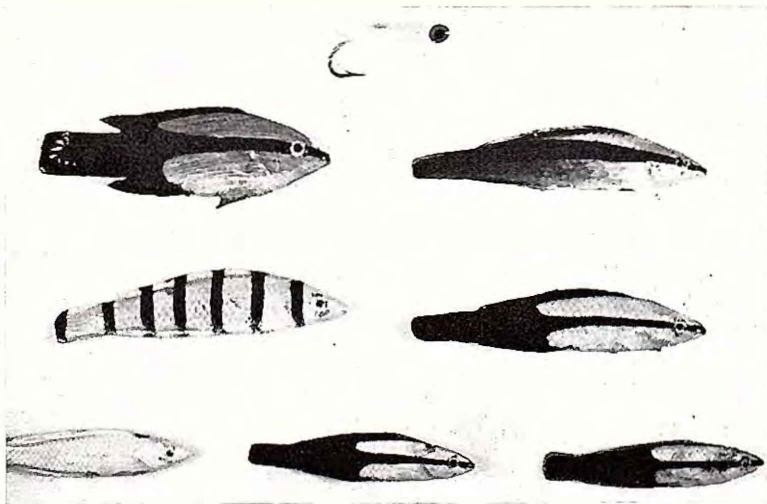
Hypotheses tested

Over the past several years, the existing hypotheses as to the function and operation of cleaning symbiosis have been tested, primarily in California by Dr Edmund S. Hobson, and in Hawaii and Eniwetok Atoll by Mr Marshall J. Youngbluth and the author. These experiments have shown that cleaning symbiosis does appear to be important in the behavioural ecology of reef fishes, but the mechanics of its operation are probably quite different to what was supposed.

Since cleaning is a symbiotic relationship, both parties, the cleaners and the hosts, should be studied at the same time. One convenient method is to consider aspects of cleaning symbiosis as a communication system. Communication in this sense refers to the transfer of information between individuals. This information may be in the form of identification signals which ensure that the host will recognize the cleaner, or a solicitation display whereby the host



The Hawaiian cleaning wrasse *Labroides phthirophagus* (bottom) cleaning chaetodontid fishes. [Photo by courtesy of William Harrigan.]



Assorted models that have proved to be effective stimuli for the release of posing behaviour in Hawaiian host fishes. The models range from realistic representations of *Labroides phthirophagus* and *L. dimidiatus* to unrealistic models and a fishing lure. The length of these model fish is from 2 to 3 inches. [Photo: Author.]

communicates to the cleaner that it can be cleaned, or, to hazard an anthropomorphism, that it "desires" cleaning.

Series of experiments with *Labroides* species of cleaners showed that there are a number of avenues of communication. It was suspected that certain aspects of the coloration and shape of the cleaner served as recognition signals. Models of the Hawaiian cleaning wrasse, *Labroides phthirophagus*, were moulded out of latex and painted realistic colorations. Host fishes usually posed when they saw these models exactly as they did for living cleaners, indicating that they recognized the models as cleaner fishes. The analysis of field observations demonstrated that there was also recognition and selection of host fishes by the cleaners. Certain fishes, such as large parrot fishes and wrasses or labrids, were strongly preferred to small parrot fishes and damsel fishes. Thus, two avenues of communication involve mutual recognition of symbiotic partners.

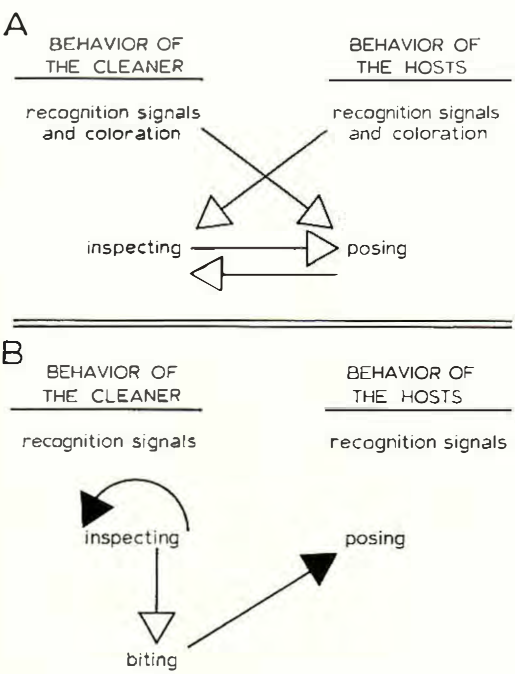
It had been long suspected that the host fishes communicated with the cleaner through a cleaning solicitation display termed posing. The tail-standing pose of the parrot fish was mentioned above, but other species show many different combinations of head-down, tail-down, and belly-up postures combined with colour changes, fin erection, and many other behaviours. The amount of posing performed by host fishes was increased by depriving them of cleaning for about one week, and then exposing them to cleaner fishes. The cleaners responded to the increased posing in the hosts by markedly increasing their approach and inspection of the soliciting hosts. But again two avenues of communication were found. Not only did the host-pose behaviour increase the amount of cleaning by the cleaner, but the inspecting behaviour of the cleaner also served as a solicitation display in that it further increased the posing done by the hosts.

Communication system

It is interesting to look at the communication system as uncovered at this point (fig. A in the accompanying diagram). Both recognition and solicitation signals can favour the performance of a cleaning interaction. But these very solicitation signals, posing and inspecting, are also the typical patterns involved in the actual cleaning. Thus, once cleaning has begun, they all provide positive feedback or form a mutually reinforcing network. If these were the only factors involved, once an interaction began, all of the behaviours would favour continued cleaning until the animals were physically fatigued. But these interactions do end, of course, so there must be some negative feedback through either a waning in responsiveness due to habituation, or through other stimuli which end the interaction.

Interestingly enough, there does not appear to be any obvious reduction in the host's response to a model of a cleaner fish, or recognition signals. This is particularly true when the model is moved back and forth by an electric motor on the end of a wire. Host fishes frequently pose ceaselessly for several hours next to a rubber model in an aquarium. But the cleaner fish does show a decrement in its response to a posing host. Thus, one method of ending the interaction is by having the cleaner cease to inspect the host (fig. B in the diagram).

Still another avenue of escape from the positive feedback system is provided by the bite of the cleaner fish as it removes ectoparasites, and even scales, from the host. This frequently precipitates the end of the interaction, presumably through painful stimulation of the host. Occasionally this will even happen with the moving model of the cleaner as it strikes the host's eye or when the suspension wire for the model catches on an erect fin ray. While this does not indicate that the cleaner teleologically "intends" to end the interaction, it does demonstrate another avenue of communication, probably through tactile rather than visual stimulation. While other behaviour doubtless enters into the communication system, the features of positive and negative stimulation pictured in the diagram appear to form the major core of the interaction.



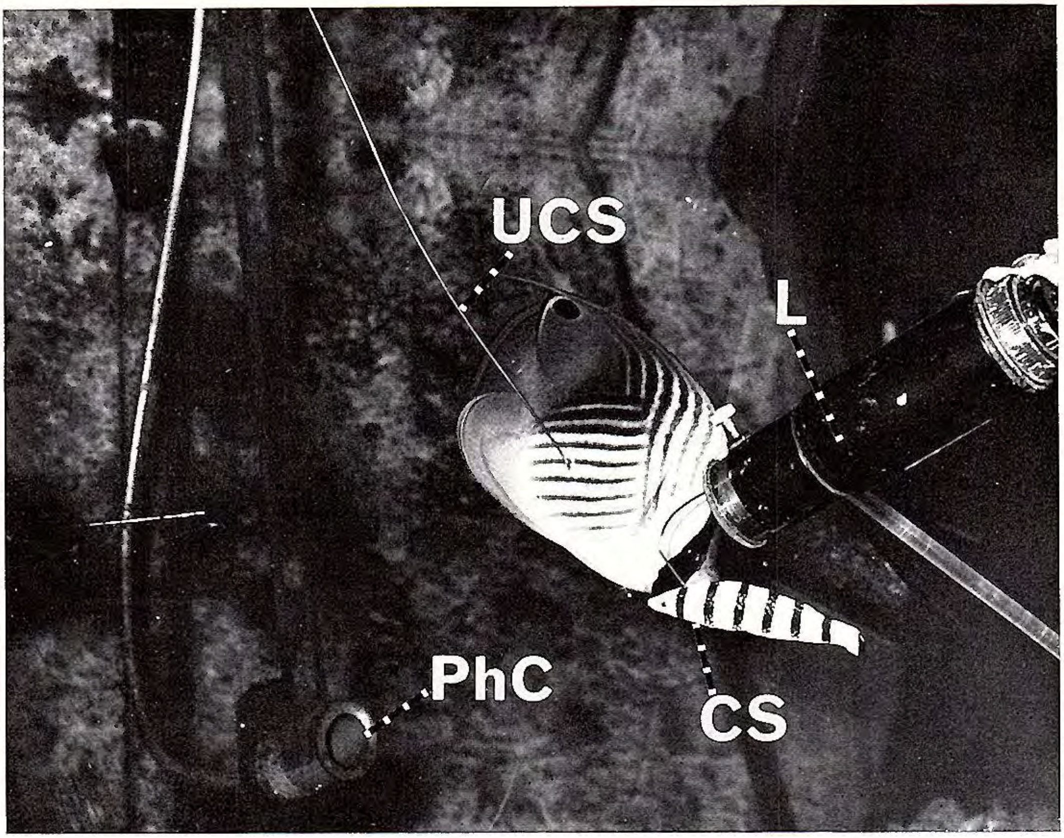
A: Facilitative interactions between cleaner and host fishes. The behaviour or signal at the foot of each arrow increases the probability of the occurrence of the behaviour at the head of the arrow. B: Decremental interactions that tend to terminate the interaction between cleaners and hosts. The arrows with shaded heads indicate a decrease in the probability that the behaviour will occur. See text. [Diagram by the author.]

The observation of interactions on the reef provides information as to how this communication system operates. Either the host or the cleaner may initiate the interaction. On many occasions the host solicits initially, as with the large parrot fish described in the opening paragraphs. But it is at least as common to find the cleaner initiating the interaction by approaching and beginning to inspect a passing host, which then may begin to pose. In fact, it is not uncommon to see a cleaner actively pursue and bite passing fishes until they either flee or turn and attack the cleaner. A 100-millimetre (about 4-inch) *Labroides phthirophagus* cleaner has been seen to chase a large jack or carangid about 1·5 metres (about 59 inches) in length and bite it repeatedly until it fled from the area!

Possible new view of interactions

Such observations have shown that there is considerable variation in the relative amounts of posing, inspecting, and chasing behaviour by the symbionts. At this stage of investigation, attention shifted toward the sources of this variability, or the motivational aspects of cleaning symbiosis. What causes cleaners and hosts to increase or decrease their interactions? This research is still in its early stages, but the results obtained to date clearly indicate that we will have to rewrite several of our chapters on cleaning symbiosis and may have to consider the interactions in an entirely new light.

The first step was to repeat and quantify the cleaner-removal experiment by Limbaugh outlined above. Mr Youngbluth removed cleaners from a patch reef in Hawaii, but he noted no subsequent changes in the number of cleaning interactions with the one remaining cleaner, nor were there any increases in the evident ectoparasitic infestations. But the many different types of interactions that have been found in



A host fish, *Chaetodon auriga*, responding in the conditioning experiments. The host is in its species specific pose position. UCS = unconditioned stimulus or "reward" in the form of a moving wire which gives tactile stimulation to the host. CS = conditioned stimulus, an unrealistic model which is presented outside the aquarium as a signal that the host must pose in front of this model in order that the UCS be presented. L = source of the light beam which the host must cross when it poses for the CS. PhC = photocell which senses that the fish has crossed the light beam and, if the CS is present, causes the UCS to be presented. [Photo: Author.]

different host species since this experiment, and the variability in the form of these interactions, suggested that much more detailed information was needed before we could accept the "null hypothesis" that cleaning had relatively little effect on the reef. We chose to make separate detailed records of the distributions of host fishes, and the sequential distribution and duration of behaviour for each host species on the reef, using underwater tape recorders and chart type event recorders operated by SCUBA divers.

With the help of Mr Peter Rosti, my efforts were rewarded when we found marked changes in the behaviour of the host fishes after the removal of all but two cleaner fishes. In general, the fishes showed much more solicitation behaviour, but nearly every species differed in the details of the changes. Surprisingly, some ceased to come to the remaining cleaners at all! It was even more perplexing when a detailed count of the numbers of ectoparasites per individual failed to show any increase, even nine months after the removal of all of the cleaners.

At the same time, a series of laboratory experiments were conducted to examine the relationship between the number of ectoparasites on a host fish and its response to a model of a cleaner fish. It was suspected that a large number of parasites would lead to increased posing response. But, when parasites were artificially removed, the fish showed no clear-cut change in response apart from a rather variable increase in posing over time, under all conditions. The mystery was further enhanced when it was found that fishes would respond similarly to a realistic model, or to altered colour patterns, and even to small fishing-lures or the bare suspension wire itself. The seemingly "neat" cleaner recognition signals seemed subject to doubt.

Posed under electric light

A few rather casual experiments on the learning capabilities of chaetodontid butterfly fishes quickly put the entire relationship under a different light and offered a possible solution to all of these problems. When the presentation of a moving model was paired with turning on an electric light, our subject, *Chaetodon auriga*, soon began to pose directly in front of a 40-watt electric light, even when the model was not presented. They appeared to show Pavlovian or classical conditioning to the light as a conditioned stimulus, with the moving model of a cleaner fish as the unconditioned stimulus or "reward". Subsequent repetition and refinement of techniques showed that they would also learn to swim in front of a light beam in order to cause the model to be presented as a "reward", much as a rat learns to press a lever for a food reward.

As a final blow to past recognition theories, at least for this host species, the model itself was not necessary for the learning to occur. Any moving object would suffice, such as the suspension wire, so long as it could rub against the host. But if this rubbing, or tactile stimulation, was removed, the fish extinguished their learned response or ceased to pose for the light or cross the light beam. In fact, if the tactile stimulation was removed, the fish soon ceased posing for the most realistic model. But, so long as the fish positioned themselves properly, and the wire moved so as to touch them gently, they continued to respond to the light and the wire.

Fish rewarded

These findings suggest that at least this species of host fish is rewarded by gentle tactile stimulation, and that it learns to pose for nearly any small visual stimulus that is paired with this tactile stimulus. Posing need not then depend on ectoparasite removal or an inherited recognition response. If a naive fish receives gentle tactile stimulation from a pursuing cleaner, it should learn to pose for the visual stimuli associated with the cleaner. But if too little tactile stimulation is received, or, presumably, if the painful biting stimulation is too frequent, the host should cease to respond to the cleaner.

At the moment, these studies must be extended to a variety of host species to see if they show a similar response to tactile stimulation. But it is not too premature to use these results to form a tentative hypothesis to explain the results of the cleaner removal experiments, and the possible causal basis of cleaning symbiosis.

Removal of most of the cleaners from the reef effectively reduced the number of cleaning stations, or places where fishes could receive tactile stimulation. Thus more fishes came to the remaining cleaner, and, as the competition for its services increased, the fishes entered into more numerous and lengthy solicitation displays. Several species were never cleaned at all, and it seems as if those which stopped coming to the cleaning station were those which received little or no attention. These might be expected to cease responding to the cleaner, like the experimental fish when tactile reinforcement was withheld.

This tactile reward system might operate quite independent of ectoparasitic infestation. In fact, it might be difficult to design a system whereby parasite removal was rewarding, as the actual removal appears to be a painful process. Fishes seem to be preadapted for this tactile reinforcement system in cleaning symbiosis since other forms of tactile stimulation, such as the frequent chafing behaviour in bottom fishes and jumping over floating objects in pelagic fishes, seems to be related to irritating stimuli such as ectoparasites. Cleaning symbiosis seems to have taken advantage of a reward system which is not directly related to parasite removal. If this hypothesis is correct, then even if parasite removal is the *raison d'etre* for cleaning, the symbiosis may continue for at least many generations when parasite removal is no longer an ecological necessity.

The cleaners may concentrate on feeding upon mucus and an occasional scale, but this would be of little harm to the host fish. At other times and in other places, the symbiosis might be as critical in the control of ectoparasites as was previously supposed. It would thus still be favoured by evolutionary processes.

Now as we watch cleaners on the reef, their interactions take on an entirely new light. The interactions are perhaps not unlike social grooming in monkeys or patting as a man rewards his pet dog. The mechanisms of cleaning may be taken as a lesson in the methods of evolution which at times may appear unapproachably complex, and at other times utterly elegant in simplicity. And certainly as research continues on the many species that enter into cleaning symbiosis, we can expect many modifications and reversals of our present hypotheses.

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Handbook on Australian Sea Birds

THE HANDBOOK OF AUSTRALIAN SEA-BIRDS, by D. L. Serventy, Vincent Serventy, and John Warham; A. H. and A. W. Reed, Sydney and Melbourne, 1971; ISBN, 0 589 07079 7; 256 pages, four colour plates, and many black and white photographs; price, $8.95.

This is the first modern book to deal in a comprehensive manner with all the Australian sea birds, and is a necessary part of the library of anyone interested in these birds.

The book does not just consist of a systematic account of sea birds. The front part consists of four sections:

(1) The geography of Australian sea birds, which includes information on the water masses and their temperature around Australia and also on the environment during and since the Pleistocene.

(2) The sea-bird fauna, with general information on breeding, drinking of sea-water, and other biological problems of sea birds.

(3) Research of Australian sea birds, in which is given a short account of the history of this research and the valuable part bird banding has played in finding out about the movements of sea birds. Much of this banding has been done by amateurs working under the Australian Bird Banding Scheme, operated by the CSIRO Division of Wildlife Research.

(4) Sea-bird conservation problems in Australia. The greatest threat to Australian sea-bird colonies has been, and is, by white fishermen.

The commercial mutton-bird industry is now strictly controlled and the populations of Short-tailed Shearwaters (*Puffinus tenuirostris*) are as large as ever.

The above sections enable a much better understanding of the movements and distribution of Australian sea birds, and this is the first time they have been published together with special reference to Australian birds.

The end-papers have useful maps of Australia, giving a list of all islands and places mentioned, but unfortunately Sharks Bay, which is frequently mentioned in the text, has not been marked.

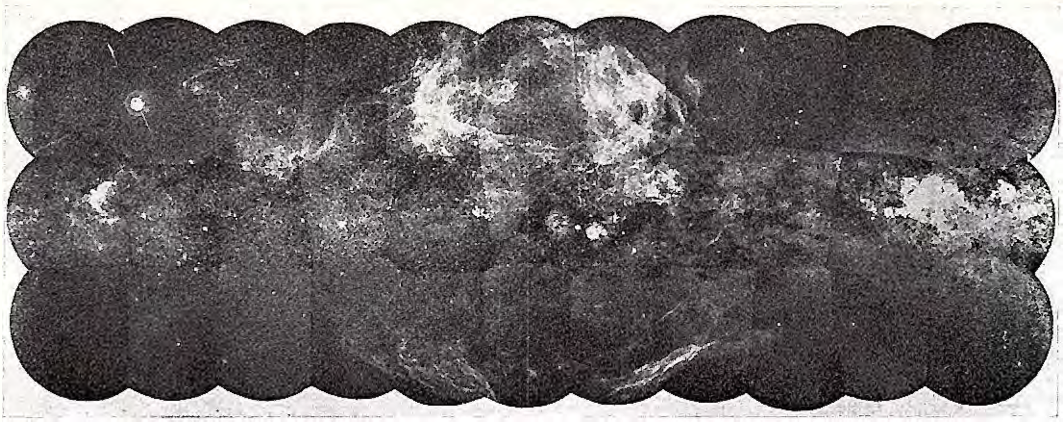
The systematic section covers 104 species recorded around the continental shelf, and, indirectly, also deals with the sea birds of Lord Howe Island and Norfolk Island.

Each species is described under the following headings: field characteristics and general habits; status in Australia; migration; voice; display; breeding; enemies and mortality; food; breeding distribution. Under these headings the present knowledge of the bird is given. However, it is a pity that these headings do not stand out more in the text, as it is difficult to quickly find any particular item. It would have been valuable, where a bird's food, etc., was not known, if this had been stated and room left for the information to be inserted in future editions.

The authors have relied on excellent black and white photographs for illustrations, and fifty-nine of the species have been so illustrated. These photographs, with sketches, have been chosen to illustrate typical postures and features.

In addition, there are fifteen coloured illustrations which show examples of the four orders and usefully illustrate some of the differences between closely-related forms or species.

It is felt that this book will greatly help to increase our knowledge of the sea birds, and that many of the gaps it makes apparent will thus be filled.—*H. J. de S. Disney, Curator of Birds, Australian Museum.*



A mosaic picture, made up of a number of individual pictures, of the southern Milky Way, showing the multitudes of stars and the gaseous material of interstellar space. The gaseous material shows as extensive diffuse areas of light. The stars are the tiny points of light. [Photo: Mount Stromlo and Siding Spring Observatories.]

THE GALAXIES

By HARLEY WOOD
New South Wales Government Astronomer

IN the clear country air on a moonless night the band of the Milky Way across the sky is a magnificent sight. The elucidation of the general character and size of this great star system in which we are situated and the realization that it is just one of the many millions in the space observable by mankind constitute one of the scientific achievements of this century. There has been a leap forward in our ideas of the universe comparable with the one arising from the ideas of Copernicus over 400 years ago.

Our situation within the Milky Way makes it difficult to decipher its structure. The size became evident from the study of distances of star clusters, and the lines of evidence have converged to give the picture of a great disc, about 100,000 light-years in diameter, sprinkled with about 100,000 million stars. Our own Sun is about 30,000 light-years from the centre. The system is in rotation. For stars in the Sun's vicinity the period of revolution about the centre is $2{\cdot}4 \times 10^8$ years.

Apart from the gaseous nebulae in the Milky Way there are in the sky many other objects which could not be resolved into stars with the telescopic powers available before this century. These also were given the class name nebulae. The names of these objects come from catalogues which, by 1910, listed over 13,000 of them. For example, the Great Galaxy in Andromeda is M31 or NGC 224 (that is, Messier or New General Catalogue).

There was for a long time speculation—and some evidence, too—that these "nebulae" might be star systems somewhat like the one in which we find ourselves. Then in the 1920's the Andromeda Galaxy was resolved into stars by the 100-inch telescope in California. Among the stars were types recognized as occurring in the Milky Way. These, serving as an index of distance, immediately settled the question and opened the way for an enormous enlargement of our notion of the universe.

Study of the nearer galaxies outside the Milky Way led to the realization that our system is one of a Local Group of about twenty galaxies forming a cluster about

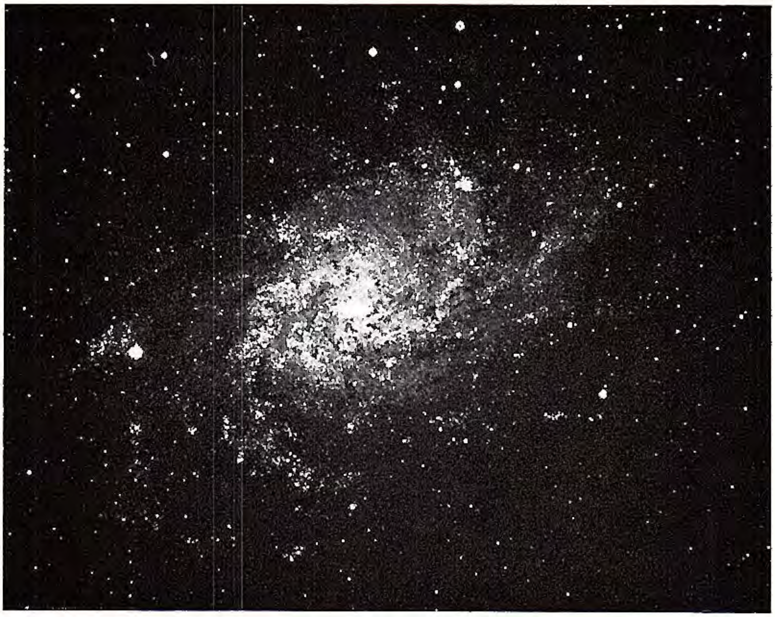
4,000,000 light-years in diameter and including, besides the Milky Way, the Andromeda Galaxy and the Magellanic Clouds which lie in the Southern Hemisphere. There is another large galaxy, M33 in the constellation Triangulum, and about fifteen smaller and fainter ones.

The contents of some of the nearer galaxies, in particular of the Magellanic Clouds and the Andromeda Galaxy (M31), run parallel to those of the Milky Way. There are great gaseous nebulae, dark dust clouds, loose star clusters of the kind which occur along the Milky Way, and globular clusters whose distribution is coextensive with each system. The opportunity to study these star systems as a whole from outside is of vital importance to the understanding of galaxies, for in this way is avoided the handicap of the interstellar obscuring clouds which, in the Milky Way, hinder so much of the examination of the system.

The Magellanic Clouds are easy to see in a dark sky during the summer. They have the appearance of detached portions of the Milky Way. The Large Cloud at the boundary of the constellations Dorado and Mensa is about 6° across, and the Small Cloud, in Tucana, about 3°. On photographs of long exposure, and especially when outlying globular clusters are included, the diameters are much larger. Examination of the clouds in the 21-cm radio emission of hydrogen shows the size to be larger still. The need for detailed observation of the Magellanic Clouds as examples of galaxies and as sources of objects of all kinds is one important reason for the establishment in the Southern Hemisphere of large telescopes like the Anglo-Australian telescope being built on Siding Spring Mountain, near Coonabarabran, New South Wales.

The distances, which depend fundamentally on identifying star types, are for both Clouds about 160,000 light-years. Their diameters are smaller than that of the Milky Way. The observed apparent brightness combined with the distance shows that the Small Cloud radiates about as much light as 100,000,000 Suns and the Large Cloud six times more.

A section of the Large Magellanic Cloud, showing gaseous nebulae, as in the Milky Way, and star clusters. The clusters are bright patches which consist of stars not easy to distinguish separately on a picture at this scale. [Photo: Mount Stromlo and Siding Spring Observatories.]



The spiral galaxy M33 in the constellation Triangulum. [Photo: Lick Observatory, California, U.S.A.]

The two great galaxies of the Local Group, apart from the Milky Way, are the Great Galaxy in Andromeda, M31, and M33 in the neighbouring constellation Triangulum. These have been extensively studied. They, too, serve as stepping stones to knowledge of the great assemblage of galaxies that inhabit the universe. Both show on photographs a beautiful spiral structure which must also be a characteristic of the Milky Way. On good photographs the extent of M31 is about 3° × 1°. Its distance is estimated at 2 million light-years and it is visible to the naked eye as a small hazy patch. It is awe-inspiring to think that we see this great star system by light which has travelled towards us for the period of the existence of mankind on the Earth. The apparent angular size and the distance combine to yield a diameter of more than 100,000 light-years for M31.

M33 lies at about the same distance as the Andromeda Galaxy. It has a diameter of about 60,000 light-years and ranks third in size in the Local Group. The spiral arms of M33 are much more loosely wound than those of M31.

Distances of galaxies

In the study of the nearer galaxies characteristics are sought to form the basis for determining the distances of galaxies in space beyond. It is only in galaxies of the Local Group that many stars can be recognized, and even the brightest stars can be made to yield distances of only a few galaxies beyond this group. Research in the nearer galaxies gives estimates of the luminosities of the brightest stars, of globular clusters, of star clouds or large patches of gaseous nebulae. The recognition of these in slightly more distant galaxies enables further distance estimates to be made.

The domain in which recognizable contents of galaxies can be used for determination of distance proves to be very small in the vast region in which they are observed; so it is necessary to use the diameter or the total brightness, which are the only characteristics measurable at very large distances.

Surveys of galaxies reveal a tendency towards clustering. The clusters may contain from just a few to several thousand galaxies. In the constellations Coma Berenices and Virgo, for example, there are clusters of galaxies with many hundreds of members. The brightest stars can be recognized in the nearest one to us, the Virgo cluster, which lies at a distance of 40,000,000 light-years. The brightest galaxies of the cluster are bright enough to be seen in a small telescope.

The examination of photographs taken with the 48-inch Schmidt camera on Mt Palomar has revealed more than 2,700 clusters of galaxies. The surveys show that there are more galaxies in the northern half of the sky than the southern.

The clusters of galaxies are important because each provides a sample of many galaxies at the same distance, so that averaging of properties may be used to eliminate the uncertainty which arises from the great variation in brightness and size that makes unreliable the estimate of the distance of a single galaxy. Thus the clusters of galaxies are the most distant objects for which reasonably trustworthy distances are obtainable by using as the criterion of distance the difference between the measured apparent brightness and the intrinsic brightness estimated from collected experience.

The mass of galaxies

The distribution of mass within galaxies, and the total mass, is found by measuring the characteristic velocities of the components at various distances from their centres. This may be done by measuring the Doppler shifts in either the optical spectrum or the 21-cm hydrogen radio line. As a simple case, the orbital speeds in the outer parts of a galaxy beyond the bulk of the mass become slower approximately in accord with Kepler's law. The motion of a star in such a position then enables the mass of the galaxy to be calculated in much the same way as the motion of a satellite yields the mass of a planet.

The velocities in M31 around its centre are approximately proportional to distance from the centre as far as 1°—equivalent to about 30,000 light-years. The density of stars falls off after this distance and the orbital velocities decrease. The mass indicated is about 2×10^{11} solar masses, perhaps somewhat more than that of the Milky Way. A rapidly rotating small volume near the centre of M31 indicates a core of higher density. The remaining members of the Local Group are lower in mass. One estimate for M33 gives $3{\cdot}4 \times 10^{10}$ solar masses, and several of the smaller systems may be only a few million solar masses.

Information on masses of galaxies may also be gained on the assumption that a cluster, or a pair, is stable and held together by its gravitational attraction. The fact that results found in different ways may not be in accord provides a puzzle still to be solved.

A group of galaxies. [Photo: Lick Observatory, California, U.S.A.]

Types of galaxies

The galaxies have been classified according to shape. The forms are spiral, barred spiral, elliptical, or irregular. The galaxies which show spiral arms are represented in the Local Group by the Great Galaxy in Andromeda, the Milky Way, and M33. The arms have a proportion of highly luminous stars and clouds of gas and dust in which the young stars are born. About a quarter of the spiral galaxies are of barred spiral type. This consists of a bar across the centre, from the ends of which spiral arms emerge more or less at right angles.

Then there is a large class of elliptical galaxies which are divided into classes from E0 to E7 in order of increasing ellipticity. They contain no trace of spiral arms. The change in outline is sometimes due to the orientation in which the galaxy happens to be placed and which could make even a much-flattened system appear circular as we view it; but there are too many almost circular ones to be accounted for in this way. There must be many whose true shape is almost spherical. The elliptical galaxies are typically lacking in highly luminous blue stars, dust, and conspicuous emission nebulae. Globular clusters may be present.

The irregular galaxies are represented by the Magellanic Clouds. The galaxies of this class do not have a nucleus nor the symmetry displayed in the other classes. It seems that the Large Magellanic Cloud is a large example of this type, some members of which give only a hundredth as much light.

The galaxies are distributed in space to the greatest distances at which they can be observed, several thousand million light-years. In other fields of astronomy, as instanced for measurement of masses of galaxies, shifts of the spectral lines of bodies clearly measure the speeds with which they are moving in the line of sight from the observer. When the galaxies are observed in this way, the spectrum lines are found to be shifted towards the red in a way which could indicate that the galaxies have velocities away from us in proportion to their distances.

The structure of the universe

Taken at face value, this result means that the universe is expanding at a rapid rate, but it does not mean that we occupy a privileged position from which the expansion is taking place. The nature of the expansion would appear the same to an observer wherever he were situated. The circumstance is similar to what occurs when a rubber balloon bearing spots is blown up. As it expands, every spot recedes from every other one—and so no spot may be taken to have a favoured position from which the others stretch.

Mankind has always pondered on what the universe as a whole must be like. Since the recognition of the nature of the galaxies, observation appears to be making real contribution to the problem. The expansion indicated by the red shifts appears as a property of the universe, and the galaxies can now be observed to distances where their recessional velocities are a large proportion of the velocity of light. If it is accepted that the velocity of light is the greatest velocity at which an influence can be propagated, this appears to indicate that we must be observing a significant portion of the universe or, at any rate, of the part of it which is observable from the Earth. We must try to infer the properties of the whole from the part we see. There have been developed several theories of the universe which can be judged by comparing their results with those obtainable from observation. Relevant data continue to be gathered, but agreement among cosmologists may not come easily.

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MEET OUR CONTRIBUTORS . . .

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DESMOND GRIFFIN is Curator of Crustaceans and Coelenterates at the Australian Museum. He obtained his Ph.D. from the University of Tasmania in 1967. He was a Visiting Research Associate at the Smithsonian Institution, Washington, in 1970. His interests are in the taxonomy, ecology, and social behaviour of crabs, shrimps, and lobsters.

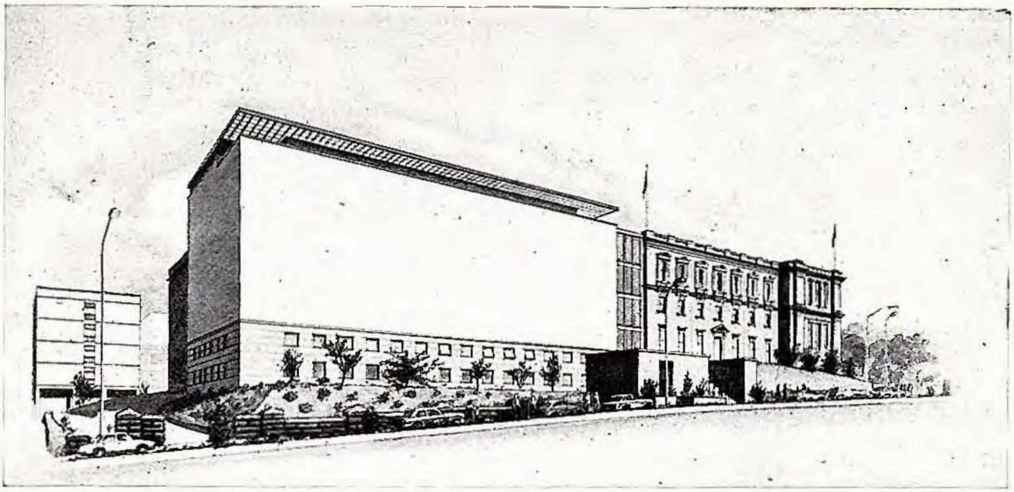
MERVYN GRIFFITHS is a Senior Principal Research Scientist in the CSIRO Division of Wildlife Research, Canberra. He graduated B.Sc. in 1937, and later M.Sc. and D.Sc., at the University of Sydney. He has carried out post-graduate research at McGill University, Canada, Harvard University Biological Laboratories, U.S.A., the National Institute for Medical Research, England, and at the University of Sydney as a scholar of the Royal Exhibition of 1851 and a Linnean Macleay Scholar of the Linnean Society of N.S.W. He is currently interested in the lactation processes of monotremes and marsupials.

GEORGE S. LOSEY was born in 1942 and raised in southern Florida, U.S.A., where he became an avid skin and SCUBA diver. He received his B.S. in zoology at the University of Miami, Florida, and his Ph.D. in marine biology at Scripps Institution of Oceanography in California. His research has concentrated on field and laboratory studies of ethology and behavioural ecology. Research in fields other than cleaning symbiosis has included the social behaviour of marine blennies, mimicry in fishes, the function of bioluminescence, and the alarm reaction in fishes.

BARBARA MULLINS is a journalist and author who has made a particular study of Australia's flora. Her deep interest in wildlife conservation and the Australian scene in general is reflected in her many published works, most of them in collaboration with photographer Douglass Baglin. These include a popular book on banksias, *Australian Banksias*, *Australian Wattles*, *Australian Eucalypts*, and *Australian Wildflowers in Colour*.

ELIZABETH C. POPE is the Australian Museum's Deputy Director and Curator of Worms and Echinoderms, and for over thirty years has taken an interest in marine invertebrates that are harmful to man. She is a co-author of the book *Australian Seashores* with the late Professor W. J. Dakin and Isobel Bennett. During her fieldwork near Darwin, Northern Territory, she was most interested to learn that one of the chief factors contributing to the failure of the rice-growing project at Humpty Doo was that the waters of the irrigation channels were invaded by the flatworm *Trichobilharzia ocellata*, which has a bird for its final host. Men working the rice farm soon contracted cercarial dermatitis and, once the cause of the sores was traced, they refused to work the paddies. Attempts were made to design farm machinery to do the planting, but without success.

HARLEY WOOD is Government Astronomer, New South Wales. He was educated at the University of Sydney, which, in 1965, conferred on him the degree of Doctor of Science. Under his direction Sydney Observatory has published extensive catalogues of southern stars. He has been president of the Royal Society of New South Wales and the New South Wales Branch of the British Astronomical Association. He was foundation president of the Astronomical Society of Australia, and is at present chairman of the Australian National Committee for Astronomy. He serves on the organizing committees of two commissions of the International Astronomical Union.



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