

AUSTRALIAN NATURAL HISTORY



PUBLISHED BY

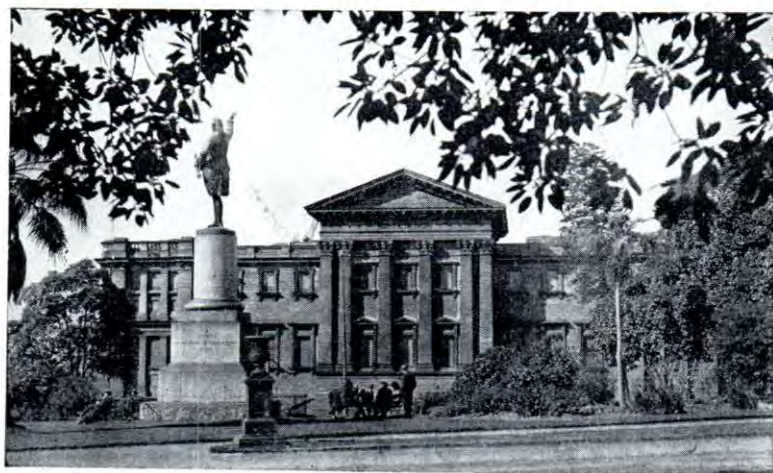
THE AUSTRALIAN MUSEUM
SYDNEY

Registered at the General Post Office, Sydney, for transmission by post as a periodical

SEPTEMBER 15, 1963

VOL. XIV, No. 7

PRICE, THREE SHILLINGS



CONTENTS

	<i>Page</i>
SEA ANEMONES— <i>Frank McNeill</i>	201
THE SWAIN REEFS EXPEDITION— <i>Donald F. McMichael</i>	210
BUTTERFLY MIGRATION	215
IS THERE A THREAT TO THE SURVIVAL OF THE KANGAROO?— <i>Allen A. Strom</i>	218
GLOW-WORMS— <i>Aola M. Richards</i>	222
EMUS— <i>S. J. J. F. Davies</i>	225
NOTES AND NEWS	229
THE MUSEUM COLLECTIONS, A BASIS FOR RESEARCH— <i>C. N. Smithers</i>	230

(Photography, unless otherwise stated, is by Howard Hughes.)

● **FRONT COVER:** The Brown Gannet (*Sula leucogaster*) on its nest on Gillett Cay, an islet in the Swain Reefs, Queensland. The photo was taken by Anthony Healy, a member of the Australian Museum's expedition to the reefs. An article on the expedition is on page 210.

GIFT SUBSCRIPTIONS

to

“Australian Natural History”

The order form below is to enable readers to send “AUSTRALIAN NATURAL HISTORY” to friends as a Christmas gift.

If the form is filled in, and this page torn out along the perforation and sent to the Government Printer, your friends will be informed by letter that the magazine is being sent to them as a Christmas gift, with your good wishes.

To: *The Government Printer, Harris Street, Ultimo, N.S.W.*

Please enrol as a subscriber to “AUSTRALIAN NATURAL HISTORY”
for one year (4 issues) @ 14/- posted
for.....issues @ 3/6d. per issue posted
(cross out line not required)

the person whose name appears below:

Name of person to whom copies are to be sent:

Mr.

Mrs.

Miss

Address of person to whom copies are to be sent:

Name and address of sender:

Additional names and addresses should be sent on a separate sheet of paper.

Please send the appropriate payment with the order form. Postal notes and cheques should be made payable to THE GOVERNMENT PRINTING OFFICE and exchange added to country and interstate cheques.

All Christmas Gift Subscriptions will start with the December, 1963, issue.



AUSTRALIAN NATURAL HISTORY



Published Quarterly by the Australian Museum

College Street, Sydney

Editor: J. W. Evans, Sc.D.

Annual Subscription, Posted, 14/-

VOL. XIV, No. 7

SEPTEMBER 15, 1963

Sea Anemones

By FRANK McNEILL

STRANGELY enough, it is not among the highly developed forms of animal life that the true qualities of endurance, tenacity and versatility are found. These attributes tend to belong instead to the more primitive and delicately constituted types that often possess abilities of adaption and longevity of quite an unsuspected order. Think, for instance, of the anemones whose graceful shapes so abundantly adorn the marine world—the Sea Flowers of the early naturalists. Among their ranks are some that enjoy life-spans estimated at hundreds of years, and this is not all. Numbers of them are known to have both the sexes combined in the one individual (hermaphroditism), while others again can reproduce their kind by more than one method (asexual) other than the normal sexual process. In their geographical distribution these same anemones occur almost from pole to pole, and there is barely any part of the oceans where they have not managed to survive, right from the very edge of the tide line down to great depths of 5,100 fathoms (30,600 feet) and perhaps more. It is in the warmer seas that they attain their most elaborate and colourful development. Many such forms grace the marine fauna of the Australian continent.

The familiar conception of an anemone is that of a sedentary animal, and this is gained from a casual observance of its kind in so many of the pools left by the tide along rocky coastal foreshores. While it is believed that the tougher deep-water forms probably rarely, if ever, move about once they have become adult and suitably settled, there are very few among all of them that cannot change their locations at will.

Among the adherent or best-known anemones are some that select a comfortable cranny or depression and stay there indefinitely. Others, however, are constantly on the move and will rarely settle in a given spot. Their regular means of locomotion is either a creeping movement by means of the base or by a complete loosening of the base so that the animal can be carried along by the water, assisted in some cases by an inflation of the body. Some lesser-known kinds of anemones are the so-called burrowers that anchor themselves in the sandy or silty floors of tidal flats. These, too, are no doubt capable of locomotion, for specimens removed from their anchorages have been observed promptly to insert themselves again by indulging in a jerky, rhythmic series of motions. At least two most unusual anemones of northern seas are



Cnidopus verater is a uniformly light to dark-green New South Wales species found occupying crevices in rock pools left by receding tides along the open coast. (Slightly enlarged.)
[Photo: Anthony Healy.]

capable of swimming in an active manner by vigorous lashing movements of their tentacles. There are also instances of an actual walking progress accomplished in an upside-down position and employing the tentacles as legs.

How are these extraordinarily versatile, though primitive, animals constituted? In their general body plan they are surprisingly simple and the characteristics present are those to which the term "polyp" has been applied. As well as in anemones, this same polyp structure is to be found in several other related groups, principal among which are the various kinds of coral growths.

General Structure

When viewed from above, a typical anemone is seen to bear a central mouth fringed with numerous hollow tentacles (disc). This is the sole opening to what, in principle, is a hollow cylinder (column), sealed at its lower end (base). Down inside the mouth-opening is a tubular throat (actinopharynx), and this opens at its lower end into the internal cavity of the main body cylinder (coelenteron). Radially arranged vertical partitions (mesenteries)

subdivide the body cavity into alcove-like compartments. These partitions are infoldings of the inner layer of the wall of the sac-like body, and reach for varying distances into the body cavity. The largest of them run out far enough for part of their upper edges to actually become united with the inner wall of the tubular throat.

The hollow cavities of an anemone's tentacles are continuations of the internal alcove-like compartments earlier described. In the expanded state the tentacles are normally smooth, simple, unbranched structures capable of great contraction. Usually both the tentacles and the disc from which they spring can be retracted and hidden from sight by the indrawing of some of the upper part of the main body or column. This practice is a common one indulged in by several of the conspicuous local seashore anemones when temporarily exposed by receding tidal waters. In some permanently immersed forms it is habitual for the animal to remain expanded even though it has the ability to retract, and may even do so on rare occasions. Still other quite contrary forms are incapable of retracting their tentacles and discs.

Notable exceptions to the conventional kind of tapered anemone tentacles are those of compound structure that become lobed or branched. These are seen in several of the better-known tropical anemones to be discussed at a later stage in this account. In some very unusual cases even blunt lobes in the form of thickenings of the skin are known to take over the function of tentacles. Whatever their shape or variety the tentacles of all anemones share one thing in common—a very wonderful apparatus of indispensable worth in the capture of small live prey. This consists of almost countless complex sting or nettle cells (nematocysts) and other so-called thread cells (spirocysts), all of microscopic size and lying embedded in the surface tissues. Within each of the cells is a spirally coiled or somewhat tangled fine thread, armed in the case of the sting cells with several sharp barbs. The threads are tubular and their walls are continuous with the walls of the capsule containers at one end. They are thus an integral part of the entire sting or thread cell mechanism, and are retained in their coiled position by curious, minute, highly sensitive trigger hairs (cnidocils). Any small form of life brushing

sufficiently firmly against a tentacle will result in great numbers of the trigger hairs causing instant contraction of their associated cells and their violent ejection from the ends of the capsules at which they are attached. They are not, however, allowed to escape by any tearing away from the capsule walls. What actually happens is a complete turning inside out or evagination of the threads which commences at their tips, much in the same manner as when the finger of a glove is pressed inwards from the top.

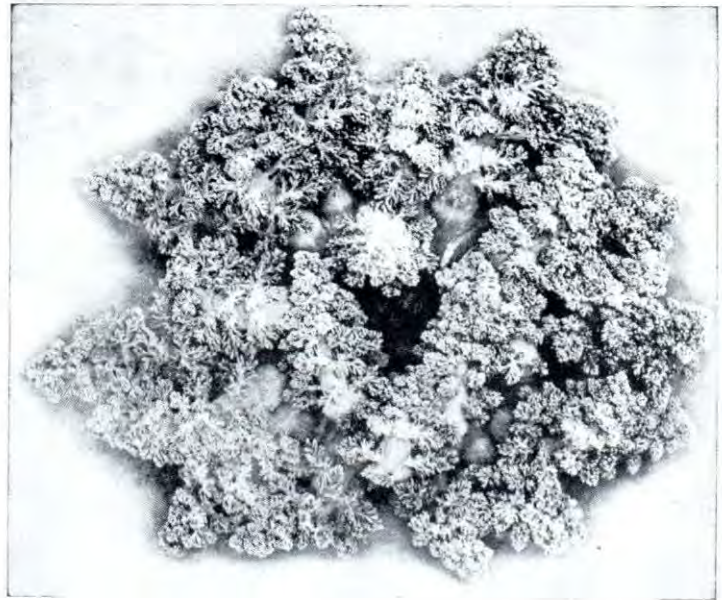
Feeding

The threads that are ejected from the capsules of the sting cells have the power to penetrate quite hard substances. They can, for instance, pierce the comparatively hard tissues of small fishes, and they carry with them a poison that can paralyse or kill. On the other hand, the barbless threads that are ejected do not penetrate prey; they are adhesive in nature and merely take hold. Having been thus seized, it becomes a simple matter for a victim to be transferred to the captor's centrally situated mouth. According to the particular kind of anemone involved



Another common anemone of the rocky coastal shoreline of temperate eastern Australia is *Oulactis mucosa*. It is easily recognized from its constant habit of gathering to itself fragments of shell-grit, pieces of gravel and coarse sand, which adhere in abundance to the body and tentacles. (Natural size.) [Photo: Anthony Healy.]

A tropical giant anemone, *Actinodendron*, to be found anchored in the sandy shallows of tidal flats along the north Queensland coast. It is characterized by having a disc produced into permanent arm-like lobes bearing short, branched tentacles. Its colours tend to merge with the background of its habitat. (One-third natural size.) [From a photo, after Saville-Kent.]



in this feeding process, aid is derived from muscular action on the part of the tentacles, the disc on which they rest, and also the throat. Often, too, a secretion of mucus is present, and in some cases assistance is given as well by directional motion of numerous short, hair-like processes (cilia) which clothe the tentacles and throat. Some of the smaller delicate anemones possibly derive the greatest assistance from cilia in the transference of food to the mouth opening. In these cases the cilia have been found to be plentiful on the outside body wall, as well as over the tentacles, disc and throat. Working together in their rhythmic directional beating, always in association with mucus, they are able to bear towards the mouth any tiny particles that fall upon and adhere to the body wall. This specialized method of food collection by mucus and cilia suggests that the food of the anemones concerned consists only of small objects. A complete contradiction of the above methods is seen in the occasional ingestion of chance lifeless food by the throat without the aid of the tentacles. As the throat is the only inlet to the body of an anemone, it must, of necessity, also function as the outlet for the undigested part of any food devoured.

The rapidity with which quite large food masses of the motionless kind are devoured by anemones is very striking. Such a meal could be any dead shrimp or fish lodging in the region of the mouth or a portion of fish flesh deliberately dropped on to the mouth of a specimen in the still water of an aquarium. On these occasions the mouth and throat prove to be extremely extensile and protusible. Together they are capable of a surprisingly wide gap for the reception of large objects, and the throat may even become everted to surround a food mass before this is swallowed. While anemones can survive for quite long periods without food, and show no apparent ill effects, they are normally voracious feeders. Generally speaking, nothing is rejected which can be caught and swallowed—crustaceans, molluscs, worms, fishes, etc. Very often, too, the objects consumed are of such a large size that the body of the anemone can barely accommodate them.

There is no doubt that anemones will occasionally consume one another, particularly if the attacker finds a victim sufficiently weak or otherwise too much out of condition to resist. It has even been observed that anemones of like kind are not immune from one another's stinging properties. One

will attack the other with its tentacles and cause wounds severe enough in some cases to result in death.

Offence And Defence

The sting cells of the tentacles of an anemone by no means constitute the animal's entire armament. These same cells occur also in the outer skin of the main body, over the disc among the tentacles, in the throat, and deeper down inside along the convoluted mesenteric cords or filaments forming thickened rims along most of the free edges of the largest of the radially arranged mesenteries. Some few kinds of anemones possess additional and usually large sting cells in certain thread-like structures (acontia) lying free internally except for attachment by one end to the edge of a vertical partition. These are shot forth at need by the animal, being usually propelled by water ejected during sudden contraction of the body. In some cases they reach the open only through the mouth. At other times they burst through either convenient soft spots or a system of tiny pores (cinclides) situated towards the base of the column. Their greater stinging powers make them highly efficient in both offence and defence.

Natural Enemies

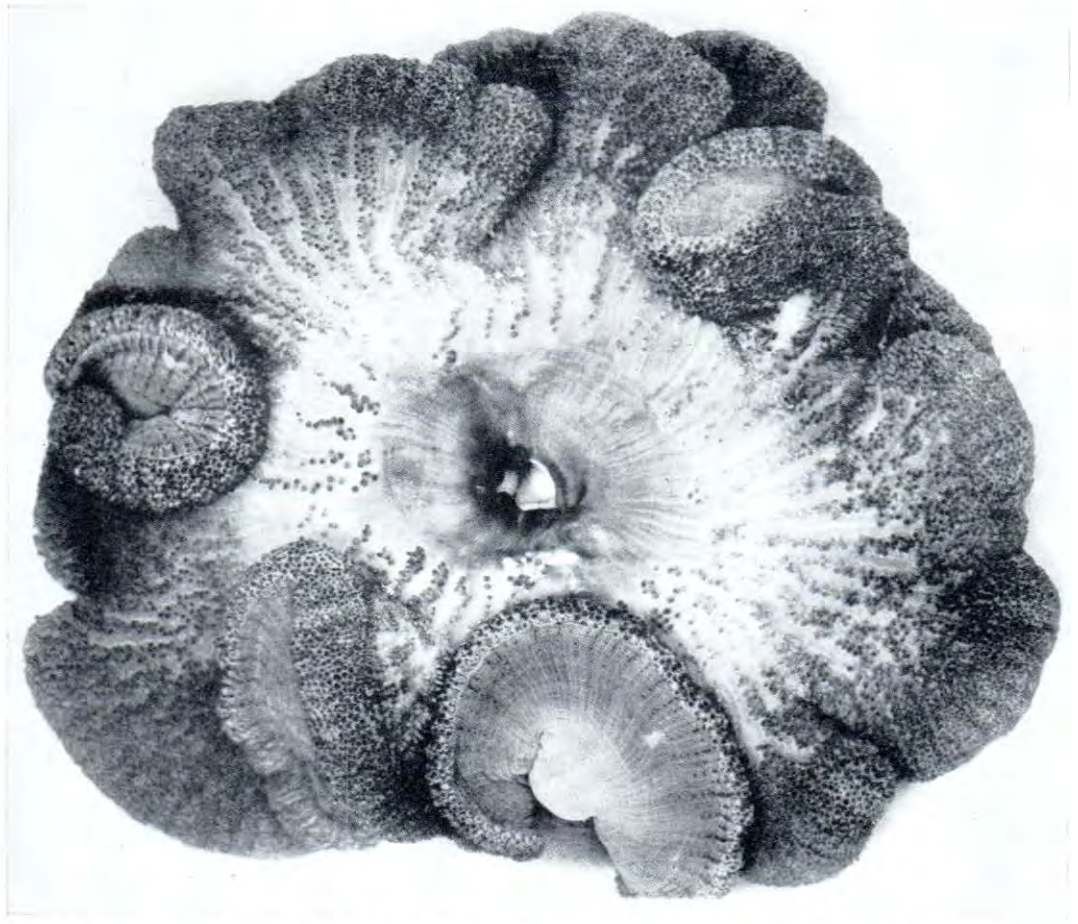
Some known natural enemies of anemones are various fishes, crabs and other higher crustaceans, sea-stars, large marine worms, sea spiders (Pycnogonida) and the slug-like, naked-gilled molluscs known as nudibranchs. The last-named are of especial interest as devourers of anemones. Certain of their kind are immune in varying degrees to the poisonous stings of their victims. Anemones' sting cells are not only swallowed by the predatory nudibranchs, but are not digested and in some curious way their mechanism and potency remain unimpaired. More extraordinary still is their migration from the intestine to positions in the outer skin layers of their devourers. Here they become re-employed for the useful purpose of protection against molestation. The considerable damage caused by sea spiders is interesting because they are commonly far smaller in size than the anemones they attack. They are often collected with anemones and have occasionally

been seen actually feeding on them. Their means of attack is a comparatively long proboscis which they manage to thrust deeply into the soft flesh of their victims.

Life-span

Longevity among anemones is well known, but in this regard the facts, of necessity, have had to be based on observation of specimens in the oldest established aquariums. One such record of unimpeachable source was published in 1927. It gives an age in captivity of at least seventy years for certain anemones which were healthy, as young as ever in appearance and still producing plentiful offspring. The author of these facts was the late Prof. T. A. Stephenson, who spent a lifetime on the study of anemones. His concluding statement on this subject of longevity was that there was no apparent reason why the anemones in question should ever die except by some accident. Furthermore, he made the claim that "it seems probable that, in the wild state, anemones live for hundreds of years under suitable conditions".

A number of instances are known of the close association of anemones with other animals (commensalism). Several kinds are always found attached to the shells occupied by certain hermit crabs. A local example is the partnership between a Great Barrier Reef hermit, *Dardanus deformis* and an anemone named *Calliactis miriam*. Another small anemone *Bucidium*, of the Atlantic coast of North America makes its permanent abode on the undersurface of a so-called hydroid medusa or jelly-fish, *Aequorea*. In both the cases cited, the "pick-a-back" anemones derive marked benefit from their means of transport. They enjoy a more rapid change of feeding grounds than they could independently manage, and are also able to help themselves to fragments of the food captured by their hosts. A partnership arrangement that completely reverses the foregoing is the use made of some small anemones by a crab, *Lybia tessellata*, of eastern tropical seas. This crab carries one or two anemones firmly gripped in each claw, and uses them as living food collectors as well as a means to ward off its enemies. Other messmates of large tropical anemones will be mentioned at a later stage.



Discosoma is the largest of the giant tropical Australian anemones, and lives with its main body deeply embedded in the yielding floors of tidal flats, particularly in northern Great Barrier Reef waters. Tentacles covering the folds of the rather flattened, expanded disc appear as small, perfectly spherular, bead-like protuberances. (One-third natural size.) [From a photo, after Saville-Kent.]

Breeding

While there are plentiful examples of normal breeding (sexual) among anemones, on the whole they exhibit marked versatility in their means of reproduction. As well as having the sexes separate in many cases, there are quite a number of hermaphrodite anemones. Some form of the latter condition is possibly more prevalent than is known. Leading authorities, however, claim that before this can be proved more knowledge is required concerning possibilities of sex-change, and of the history of the sex elements (gonads) throughout the life of individual anemones. As earlier commented

upon, the age of an anemone would seem to have little effect on the vigour of its reproduction. In the normal method of breeding (sexual) fertilization takes place in two ways—eggs and sperms are either shed and meet together in the surrounding water, or shed sperms enter an anemone's body and there unite with the eggs. In the former case the resultant larvae undergo their metamorphosis as free swimmers or floaters in the planktonic life of the sea. The alternative is for the eggs fertilized in a parent's body to undergo their development there before being released as tiny juveniles (viviparous young) complete with tentacles

and other adult characteristics. Both the methods described are known to occur in the same kind of anemone. Extraordinarily enough, it has been recorded that at least one versatile anemone is known to produce either eggs or sperms, sometimes both eggs and sperms at the same time, and at other times will shed its fully developed young alive (viviparous).

Internally developed larvae are a feature of the well-known and abundant Sea Waratah Anemone (*Actinia tenebrosa*) of the New South Wales coast. Quite tiny examples of its young are often to be seen resting in close proximity to an apparent parent. The same young can also be found in a well developed state within the body of a parent. Whether or not the Sea Waratah alternatively sheds eggs that undergo external fertilization or performs some other variation of this as above described, are questions that have not as yet been answered.

Other Methods Of Reproduction

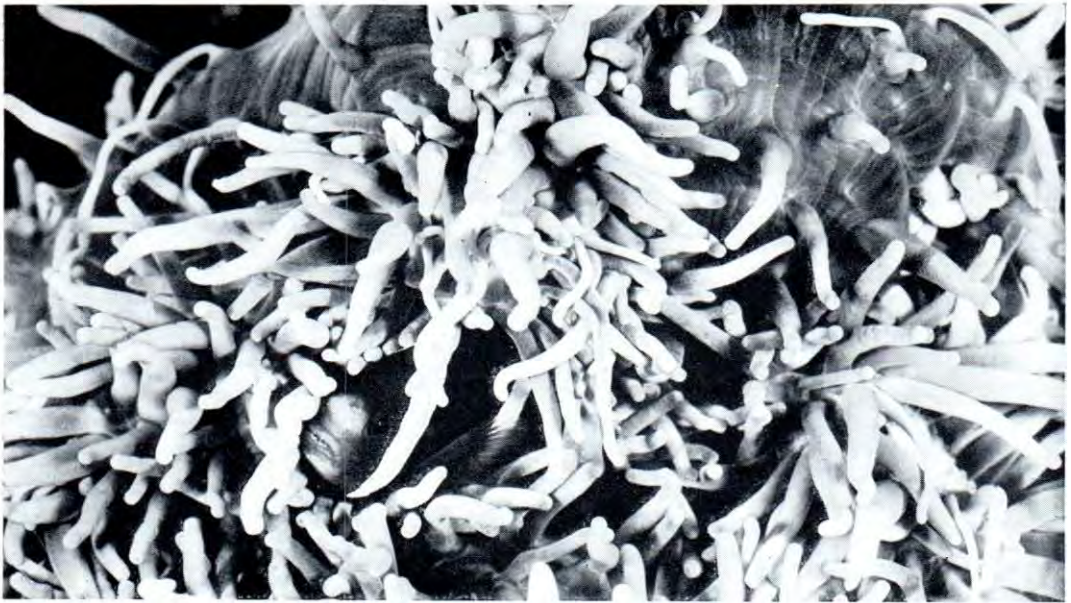
Reproduction among anemones by means totally devoid of sex are just as remarkable and varied as their orthodox (sexual) methods of breeding. For instance, longitudinal cleaving or fission of the body into two equal or subequal parts is a fairly common occurrence. The pair of individuals created by this method may gain the two halves of the throat and retain, as well, portions of the original set of tentacles. In this way there is no need to regenerate any

new parts. A variation of this characteristic process of fission is the ability some anemones have of dividing into two by a tearing operation that generally starts at the base of the body. Rupture of the flesh takes place when the two halves of the animal move away in opposite directions. At times more pieces than two result from a fission which does not necessarily involve tearing. The transverse type of fission is something new again, and one observed in several kinds of English anemones. In this particular process a second ring of tentacles grows out part way down the body wall (column), and at this point the animal will ultimately divide transversely into two individuals.

The reproductive process most astounding of all is known as laceration or fragmentation. In this case regeneration of missing parts is based on usually small pieces of flesh which have become separated from the edge of an anemone's base. During a lengthy period of regrowth of missing parts, shape is perfectly regulated until the ultimate state is a fully formed anemone. Two very different methods of this fragmentation process have been recorded. One of them has been called fragmentation by constriction, in which numbers of young may arise from a parent anemone's base. During their production the parent may be either quite stationary or on the move, and the young become separated from the base by constrictions. They very soon become rounded off and, complete with their new sets of

The Sea Waratah Anemone (*Actinia tenebrosa*) is readily recognized by its wine-red colouring. It is the most conspicuous of the New South Wales species, and congregates in numbers fully exposed on the rocky coastal platforms. (Slightly enlarged.) [Photo: G. C. Clutton.]





When fully expanded, the elongated tentacles of *Physobranchia* normally feature conspicuous lobes at their tips. This abundant anemone of Great Barrier Reef waters is almost invariably found lodged among living coral growths with its main body hidden from sight. Like other giant anemones in tropical seas, its tentacles provide a haven for certain small fishes which are immune to their stinging properties. In Australian seas these messmates include six fish species linked with the technical name *Amphiprion*, and a seventh species named *Actinocola percula*. (Natural size.) [Photo: K. Gillett.]

tentacles, move away of their own volition to an independent life. The second method of fragmentation is accomplished by a tearing process which apparently does not occur so long as the subject anemone remains stationary. During periods of roving about on its base it is prone to leave small or large pieces of this behind. These become ripped from the parent body while they adhere strongly to the substratum, and are abandoned. The progeny having their beginning in this way soon develop to a likeness of the parent and lead independent lives.

Double anemones are by no means uncommon. Occasional examples with two distinct mouths and discs are found, and others with two separate bodies which are united with a single basic main body or column. Others again may possess two distinct bases for two corresponding bodies which unite higher up and terminate in only one disc. Still other modifications of the same general kind may occur which exhibit in varying extent the duplication of parts.

Eminent authorities have considered that the double anemones may originate in very different ways. Some of them are thought to result from a process of partial fission which, terminating before its completion, has left behind a permanent double monster. On the other hand, it is also thought that the malformations have their origin in some disturbance linked with early development.

Tropical Giants

Some reference was made earlier in this account to tropical anemones which bore lobed or branched tentacles. Forms with these characteristics are not uncommon in Great Barrier Reef waters, and two of them can be considered as the giants of their class. The largest, *Discosoma*, reaches a diameter of 18 in. to 2 ft., and lives with its main body deeply embedded in the sand of tidal flats. Its colour is a light grass-green, usually flecked with brown. When the rather flattened disc is fully extended over the surface above the animal's burrow, it has the appearance of being covered with

what has been described as "perfectly spherular, bead-like papillae" (the tentacles) distributed thickly around the margins, with gradually shortening linear series of the same towards the central mouth. The other tropical giant, *Actinodendron*, is nearly as large as the foregoing. It, too, anchors itself in the sandy places, and has a disc which is produced into permanent arm-like lobes bearing short, branched tentacles. The colour is in varying shades of light brown and white, tending to merge with the background of the animal's habitat. Both of these large tropical anemones have a reputation for causing severe irritation to human skin when carelessly handled.

By far the most frequently observed large anemone of the Australian tropics is

one, *Physobranchia*, featuring elongated tentacles carrying lobes at their tips when fully expanded. It nearly always lodges itself amongst living coral growths with the tentacles extruded and the main body hidden from sight. Colours are brownish-red, tending to a greyish-white shade towards the lobed tips of the tentacles. This anemone and the others of large size from tropical seas all provide safe havens for a number of messmates. These take the form of colourful fishes, shrimps and, in one case, actually a small, unusual crab. All of them live in permanent association with their hosts, sharing in the food that is captured, and are in no way affected by the powerful stinging tentacles with which they are constantly in contact.

NEW BUILDING FOR MUSEUM



The Australian Museum, showing the new seven-storey wing (at left), which was officially opened on September 9. Two floors of the new wing are already occupied by Museum staff. A restaurant, on the top of the building, will be for the use of the visiting public. The other floors will be used partly for displays and partly for storage. Plans for equipping these floors are well in hand, but it will be some years before it becomes possible to open them for public exhibition.



The motor yacht *Coongoola*, which took the Australian Museum expedition to Swain Reefs, at anchor at Gillet Cay in the reefs.

The Swain Reefs Expedition

By DONALD F. McMICHAEL

ABOUT a century ago, the exploring and surveying ship H.M.S. *Fly*, while engaged in an extensive survey of the coasts of Australia under Admiralty orders, visited the outer portion of a large area of coral reefs off the Queensland coast just a little north of the Tropic of Capricorn. These were known as the Swain Reefs, having first been encountered by Captain Swain of the *Eliza* in 1798. The reefs were mentioned by Flinders though he did not visit them and, later, the ship *Stirling Castle* appears to have been wrecked on them in 1836. H.M.S. *Fly* found that the reefs consisted of a veritable maze of coral, with deep channels scarcely a mile across twisting and winding around reefs of all sizes. The *Fly's* tender *Bramble* was dispatched to survey the western portion of the reefs,

while the *Fly* sailed up the eastern side. The Swain Reefs were found to cover an area of some 2,500 square miles, and they were so dangerous that no subsequent survey vessel has attempted to penetrate their interior. To this day, the Swains appear on the Admiralty Charts as a large blank area, with only a few sketchy details around the outer reefs.

Though avoided by shipping, the reefs did not deter the hardy fishermen of Queensland who found in the Swains a vast untapped reservoir of commercial trochus shell, bêche-de-mer, and edible fishes, and so during the last hundred years many small boats have pushed deep into the area to reap some of the harvest awaiting exploitation. Like all people who work close to nature,

fishermen are often attracted by the curious living creatures which they come across in their daily work and so occasional specimens from this area filtered back to the scientific world. The material thus obtained was of considerable interest and included a number of quite remarkable species of shells, fishes and other creatures.

For some years, scientists at the Australian Museum had been interested in the possibility of getting into the Swain Reefs to collect the marine life which they knew must be there in profusion. Another person with a similar idea was Mr. Robert Poulson, of Heron Island, Queensland, the nearest settlement to the Swain Reefs. Bob Poulson was intrigued with the possibility of the Swains as a tourist attraction for fishing parties and marine cruises, so in 1960 he led a small survey party (which included an Honorary Associate of the Museum, Mr. Len Thomas) on a visit to the area. Only a few days were available, but the group found a number of uncharted coral islets, or cays, and Mr. Thomas brought back a number of marine specimens of particular interest. [For an account of this brief survey visit, and a map showing the position of the several cays found, see K. Gillett and F. McNeill, *The Great Barrier Reef and Adjacent Isles*, revised edition (1962) pp. 183-192 (Coral Press, Sydney).]

From this sprang the idea of a major Australian Museum expedition to the area, which was planned during the ensuing two years. Initial support was obtained from the Sydney retail store of David Jones Ltd., who generously agreed to sponsor the expedition. With additional financial help from the Trustees of the Museum, this enabled a party of nine scientists and naturalists to charter a 73-foot ketch-rigged motor yacht, the *Coongoola*, under the command of her owner, Mr. Norman Thomas, to sail direct from Sydney to the Swain Reefs, via Heron Island. At the latter port of call, Bob Poulson joined the expedition and under his experienced guidance the navigation in this dangerous area was successfully accomplished.

11 Days On Reefs

The personnel included a doctor, a photographer, several scientists, a skin-diver who was also a marine engineer, and the volun-

teer cook was also a well-known naturalist. A total of 11 days was spent in the Swain Reefs which roughly corresponded to a period of spring tides when the coral exposure at low tide was at a maximum. On reaching the area, *Coongoola* moved directly to Gillett Cay, named by the previous survey party, who had located a good anchorage and had found the reef-flat to be extensive and rich in corals. A camp was set up on the western end of the small islet of coral sand and rubble which had developed on the western end of a reef about three miles long, running approximately east-west, and about a mile wide, for the most part with its crest or outer edge just clear of the water at low tide. Between the crest and islet was a shallow lagoon which reached depths of up to 20 feet in places, but near the camp was only a few feet deep, thus enabling the party to wade out to the crest at low tide and collect in the shallow water by hand. In the deeper portions of the lagoon, the ship's lifeboat was used for dredging in the long sand patches between massive coral growths.

The cay was only a small island of accumulated coral debris, which had built up during centuries of storm and wave action on the coral reef. The steps in coral cay development are well illustrated by the variety of cays to be found in the Swain Reefs. In the earliest stages, the cays are merely banks of coral sand, together with some larger coral fragments broken off the reef edge and tossed ashore by storm waves. Material gradually accumulates until a stage is reached where a substantial mass of debris perhaps 100 yards long, 20 or 30 yards wide and up to 10 feet in height above the general level of the reef, is stable for many years. Gradually, as sea-bird guano accumulates and the seeds of grasses and shrubs are distributed, a low cover of vegetation develops on the islet which is then a fully stable, permanent coral cay. This was the stage of development reached by Gillett Cay at the time of our visit. Its subsequent history can be predicted from our knowledge of more mature cays, such as Heron Island in the nearby Capricorn Group. The gradual enlargement and consolidation of the island would take many centuries. As the grasses and shrubs died and decomposed, a sandy soil with some



The Masked Gannet (*Sula dactylatra*), with a large moulting chick.

humus material would develop, allowing the establishment of even larger plants, such as the casuarinas, pandanus palms and the large, fragile-limbed trees known as pisonia (but properly called *Heimerliodendron brunonianum*).

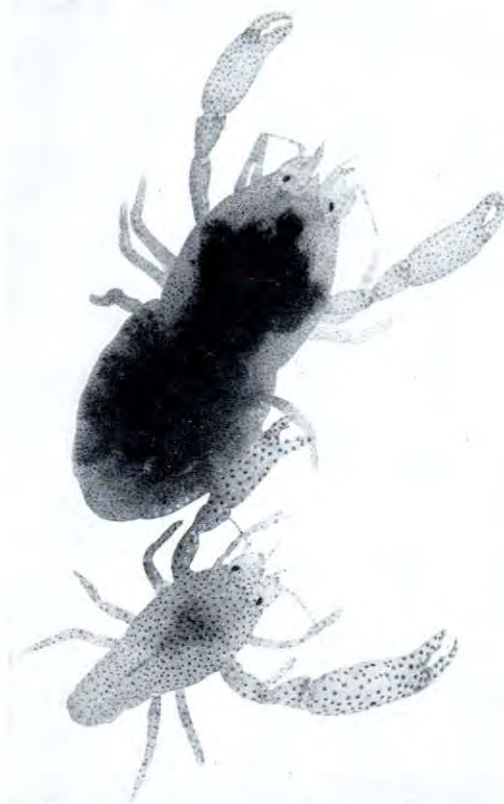
Sea-birds On Islets

The stable islets such as Gillett Cay are the home for thousands of sea-birds during the breeding season. As the time of our visit coincided with the latter part of the breeding cycle, most of the birds which nest on the island were still there with almost mature young. Notable among them were the Lesser Frigate Birds which had been noted as breeding in the Swains by a keen naturalist, Mr. A. J. Meagher, a few years previously. This represents the most southern breeding locality for the species. Also prominent among the birds were two species of gannets or boobies. The Brown Gannet is dark all over the neck, back, wings and head, with white underparts, while the Masked Gannet has a white head, neck and body, black wings and a black face

sharply delineated from the white of the head. Gannet chicks were everywhere, mostly large, rather immobile balls of fluff, but some were in the process of shedding their down and acquiring their juvenile plumage, after which they would be able to fly. A much smaller bird, the Bridled Tern, completed the list of species breeding on the island, but many others which were not breeding on the island at the time of our visit were seen flying about or resting on shore.

Commensal Shrimps

Among the more interesting activities of the expedition were the dredging operations and the investigations into commensal shrimps, found living inside bivalved molluscs. The latter occupied the writer



A pair of commensal shrimps, *Conchodytes tridacnae*, from the Black-lip Pearl Shell. Note the dark egg-mass showing through the semi-transparent body of the larger female.



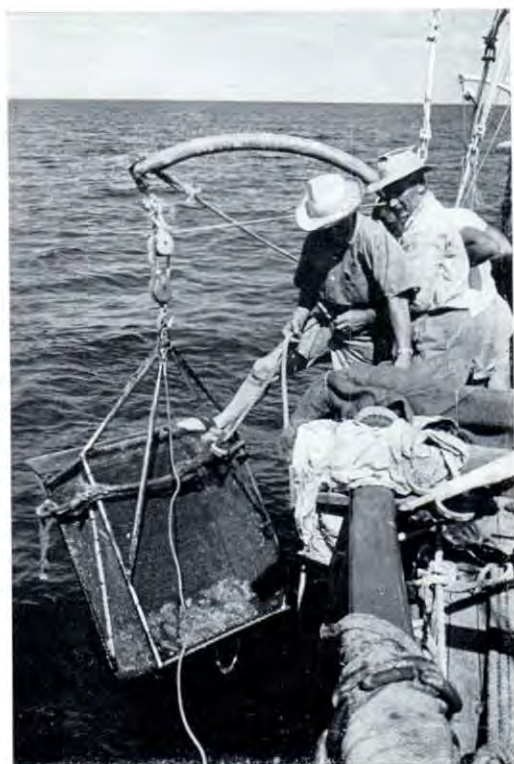
Expedition members dissecting clams in a search for commensal shrimps.

and Dr. John Yaldwyn, Curator of Crustacea and Coelenterates at the Museum, who has long been interested in the colour-change mechanisms of these small crustaceans, which spend their lives living in close association with other animals, though they are not parasitic on them. The word *commensal* means "together eating" and this gives a clear indication of the relationship which exists between a commensal and its host—usually the commensal species finds shelter and food in the vicinity of its host but does it no harm, leading a more-or-less independent existence. Two species of "giant" clam were living on Gillett Cay, neither of them particularly giant. One was the small Burrowing Clam (*Tridacna fossor*) which is found commonly on the Great Barrier Reef and elsewhere. The other was a larger species reaching about 18 inches in length, which seems to be confined to the general area of the Coral Sea. The name of this clam is still uncertain, but it is probably *Tridacna whitleyi*, first named from Middleton Reef, north of Lord Howe Island, where the freighter *Runic* went aground not long ago. The latter species

was found to house commensals of the genus *Archistus* and a large series of clams were brought ashore, placed one by one in an enamel dish and searched for the shrimps which were sometimes, but not always, to be found in the folds of the mantle-cavity. Similar commensal shrimps of another genus (*Conchodytes*) were found in the Black-lip Pearl Shells (*Pinctada margaritifera*) which were common on the reef-flat. A pair of shrimps from the latter species is illustrated in the photograph on the previous page. The female shrimp can be recognized by her swollen abdomen and greater size and some females were found to be carrying eggs.

Dredging Operations

The dredging operations were carried out a short distance off Gillett Cay where the water depth was about 40 fathoms and the echo-sounder showed the bottom to be fairly level. Several dredges and trawls were used at various times, pulled along the bottom by strong wire rope with a breaking strain of several tons. The material obtained from



The dredge comes aboard *Coongoola*, containing dredgings from 40 fathoms.

these depths at first sight seems to be a mass of useless rubble. However, sorting on board soon revealed a host of interesting and unusual animals, including numerous bryozoans and small corals, crabs and shrimps, sea-lilies and brittle stars, while small molluscs were abundant. Some unusual fishes were brought up, too, among which was a splendid new species of seahorse, striped like a zebra. After the living animals had been picked out and preserved, the remaining sand and rubble was packed away for return to the Museum, where it was washed and dried, then boxed for storage. After preliminary sorting, by several enthusiastic students of the smaller shells, approximately 300 species of mollusca have been isolated to date—a remarkable total from a few boxes of seemingly useless debris.

The results of the expedition cannot be assessed very easily. It will take many years of research by numerous scientists,

both here and overseas, before the material collected is identified and properly studied. However, from a knowledge of the range of material collected and based on estimates from colleagues familiar with various groups of marine animals, we can say that the collections made were comprehensive and will yield a mass of valuable information on the fauna of the region. Many new records of species previously unknown from Australian waters, and undoubtedly some new species, have been found, while the specimens of previously known species which were collected will add to our knowledge of distribution and variation, knowledge which may well prove essential to the world's ever-increasing population in the not too distant future.

[Photographs in this article are by Anthony Healy].

Appendix: List of Collecting Stations of the Australian Museum 1962 Swain Reefs Expedition.

- Station 1. Whole of reef and sand flats adjacent to north-west end of Gillett Cay ($21^{\circ} 43' S.$, by $152^{\circ} 25' E.$). Station 1A refers to the foreshore beach-rock in the general area of Station 1.
- Station 2. Reef crest at Price Cay, approximately three miles south-east of Gillett Cay.
- Station 3. Dredgings from coral sand, depth approximately 15 feet, lagoon of Gillett Cay, about one mile east of Cay.
- Station 4. Dredgings from approximately 20 fathoms, off Gillett Cay, adjacent to Station 3.
- Station 5. Dredgings from 15 to 20 fathoms, off Gillett Cay, in vicinity of anchorage at the western extremity of the reef.
- Station 6. Dredgings from about 35 to 40 fathoms, off Gillett Cay, approximately two miles north-east of anchorage.
- Station 7. Beach at Thomas Cay, approximately eight miles north-west of Gillett Cay.
- Station 8. Beach and adjacent reef at Capre Cay ($22^{\circ} 09' S.$, by $152^{\circ} 46' E.$).

The expedition also collected at Ballina, north New South Wales; at Heron Island, Capricorn Group, Queensland, and off Morna Head, south of Port Stephens, New South Wales, but station numbers were not allotted for these localities.

BUTTERFLY MIGRATION

SO far we know of about 20 species of butterflies which migrate in Australia; no doubt there are more which have this fascinating habit.

The Wanderer (*Danaus plexippus*) was first seen in Australia in about 1870 but its home is North America, on which continent it undertakes spectacular migrations each year. In the autumn the butterflies begin to fly south from Canada, forming groups as they go, the groups increasing in size and spending the nights on trees and shrubs. Eventually they reach their hibernating quarters in the southern parts of the U.S.A., where they spend the winter in enormous clusters, using as their roosting places the same trees year after year. The clusters have now become famous as tourist attractions. In the spring the butterflies set off individually towards the north, laying eggs as they go, their progeny continuing the northward movement as far as Canada. The following autumn the cycle starts again. What the movements of this species are in Australia is not yet known.

To find out the details of the migrations we need to have information on the flight directions of many individuals through the seasons and to know when they make their appearance and for how long they remain in various parts of the country.

Another way of obtaining information on movement is to mark individuals and release them in the hope that they will be recaptured elsewhere; this is the method which has added so much to our knowledge of bird migration. It is necessary, of course, to mark thousands of butterflies in order to get a small return as the chances of a marked butterfly being recaptured are very small.

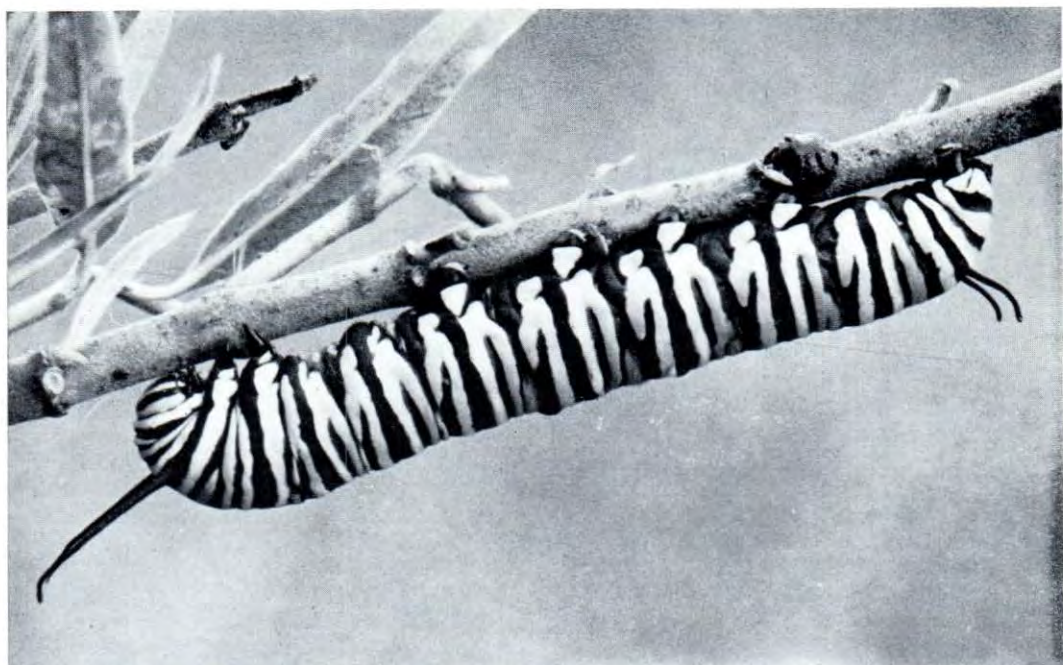
Butterflies for marking are either caught in the field or reared to adulthood from the caterpillar stage. The latter method has

the advantage that we know the age of the specimens released.

The pictures on this and the following pages show how the marking of butterflies for use in migration studies is being carried out by the Australian Museum with the co-operation of entomologists in several places in New South Wales and other States. Specimens are being marked at many localities and anyone finding a marked butterfly is asked to return it to the Australian Museum with details of when, where and by whom it was found.—C. N. Smithers.



Butterflies are caught with a net and slipped into a darkened box, where they remain until marked and released, or . . . (see next page)



..... they are reared from the caterpillar stage to

..... the adult butterfly.

A label with the return address and an identification number is glued to the underside of the hind wing and a note made of the date and place of release. The butterfly is then set free to go on its way.



"Return Museum Sydney"

Is There a Threat to the Survival of the Kangaroo?

By ALLEN A. STROM
Chief Guardian of Fauna, New South Wales

TRIGGERED-OFF by a front-page illustration in a Sydney newspaper and by a statement from naturalist David Fleay that some 10,000 animals were being destroyed weekly, there has been an abundance of publicity on the "slaughter" of kangaroos.

As if by accident, the urban population has suddenly discovered that significant numbers of these marsupials are being destroyed. It does seem rather amazing that a large section of the community could be so unfamiliar with events in country districts as not to be aware of the pressures being exerted against the kangaroo. Farmers and graziers have been building up the propaganda for years; from time to time newspapers have publicized the "conviction" that the kangaroo is a serious threat to rural industry. One fact arising from the recent publicity has shown that the man-on-the-land has had a great deal of unverified and, perhaps, unintentioned sympathy from city dwellers, and one is forced to assume that the emotional aspect of presumed cruelty has done more to arouse concern for the survival of a unique species of animal life than all the well-founded criteria of wildlife conservation. In fact, it has taken an outburst of emotion to bring some reputable scientists out of hiding and to encourage them to make statements in support of a balanced approach to kangaroo control. Unfortunately, New South Wales has been the centre of the conflict, since obviously this State is at a crucial position in development where expansion of population and industry could quite easily take the living quarters away from the kangaroo while we argue about the need to destroy the individual animal. Any publicity, it seems, is worthwhile if it encourages the community to think.

There have been almost continuous open seasons in the Western Division of New South Wales since 1952. These open sea-



Cartons of boneless kangaroo meat, trimmed and packed at Broken Hill, New South Wales. The cartons are deep-frozen to ensure insulation on the trip south to Victoria [Photo: Fauna Protection Panel, N.S.W.]

sons have been gazetted on advice which gave consideration to little or no scientific information and with very rough and rugged methods of estimating populations. Usually, action was taken after seeking guidance from sources which were obviously already interested in securing the destruction of animals. The administrator groped in the dark and made decisions which he knew would save him the most embarrassment. This does not mean, however, that kangaroos were not abundant in some places. As a frequent traveller in the Western Division

since 1952, it is my belief that populations have been high, provided one can accept casual sightings of animals as a sound method of estimation. In the Central and Eastern Divisions of the State, however, the population position has followed no comprehensive pattern. Open seasons have been gazetted in these Divisions for short periods, which, together with the occasional issue of licences, have covered such controls as were necessary. Unfortunately, the presence of high numbers of kangaroos in the Western Division has frequently developed a kind of mass hysteria amongst farmers and graziers, who have then sought open seasons in those places where the animal was not in numbers likely to have a significant effect on the economy of agriculture.

Added to this hysteria is the complicating factor that the term "kangaroo" is frequently applied to a variety of species of macropods from the Red (or Plains) Kangaroo to various types of wallabies. Anything that hops like a kangaroo is regarded as being a menace to the man-on-the-land.

The Damage Done By 'Roos

In order to secure a true picture of the kangaroo problem it does seem necessary to understand what damage the kangaroo

can do. Farmers and graziers have a long list of complaints but these damages appear to be well substantiated:—

- As large grazing animals they compete directly with sheep.
- They remove management from the control of the landholders by moving in large numbers and grazing in paddocks that are being rotationally spelled.
- They damage fences.
- Some species, particularly Grey Kangaroos, damage crops in some districts.

It is important to see these damages in the correct perspective and to attempt to estimate the order of such damages. Is it a significant amount or could it be disregarded? Obviously the order of damage will vary from place to place and besides being related to population size will be proportional to seasonal conditions, location of property, kind of crop and numerous other variable factors. There may be similarities between problems over wide areas, but in other situations each problem presents a new and novel circumstance.

It is essential for administration to know more about the animal and it is interesting to note that the Division of Wildlife Research, C.S.I.R.O., is now engaged in a long-term and thorough biological and ecological



The Red Kangaroo. [Photo: H. C. Barry.]

A mobile kangaroo-meat freezer and preparation room. These freezers originally stored rabbits—and still do when they can be obtained—but turned to kangaroos when myxomatosis was first introduced. [Photo: "Wildlife Service".]



study of the kangaroos and wallabies. Already this work is bearing fruit. Farmers and graziers have been telling us for years that the kangaroo eats as much as several sheep (anywhere from three to ten), travels great distances to secure the "best pick" and reproduces at a phenomenal rate that puts the sheep to shame. Now the C.S.I.R.O. has shown that a kangaroo eats about as much as a sheep, does not cover great distances and reproduces at a rate somewhat equal to that of the sheep.

Populations Fall After Meat Trade Takes Over

Kangaroos are protected animals in N.S.W. and may only be taken during an open season or under licence issued by the Chief Secretary's Department. There appears to be every reason to believe that populations of the marsupial have increased since the leases were taken up in the Western Division, but it is interesting and important to note that the sheep-carrying capacities of these leases were determined with the presence of kangaroos on the leases carefully considered. A long run of good seasons in the west appears to be the most important factor contributing to the maintenance of high populations in that area. Prior to the coming of the white man population losses amongst kangaroos were influenced by availability of water, and undoubtedly settlement has provided the animals with permanent supplies. Now, however, scientific investigation is leading competent people to believe that some ecological factor is beginning to influence populations of Red Kangaroos and this may well bring a "crash

period" in the populations of these marsupials. In the early and middle parts of the '50s the taking of kangaroos was restricted to shooting for skins and the casual shoots of landholders and amateurs, partly for recreation and partly to reduce numbers. Since the development of the kangaroo-meat trade, a very significant increase has occurred in the number of animals taken. Shooting for skins was simply a culling procedure which probably improved the quality of the remaining stocks and their breeding capacity. The kangaroo-meat trade is an exceedingly efficient method of reducing populations since it provides a ready market for a product more easily taken than skins. Animals are shot at night and usually dealt with on the spot, only the butts being retained. These butts are then stored in a mobile freezer which, when full, will take the meat back to a centre where it is deboned and packaged. It would appear that an efficient shooter could, under normal circumstances, take up to 60 animals a night, but whether this is done seven days a week is debatable.

Need For Control

It seems reasonable to assume that if the animals are in high numbers and if the populations have to be reduced in the interests of the rural industry then some attempt should be made to utilize any product. The real problem is to so control the shooting as to ensure that it takes place in those areas where it is most needed. The effects of the kangaroo-meat trade are now observable, particularly around large centres of population such as Broken Hill. This

does not mean that there are not still high populations of kangaroos in some places. What we need most urgently is a scientific method of estimating populations and the effect which shooting has on these populations. When such a method has been devised it will still be necessary to have sufficient staff to carry out the work entailed in applying it and in policing the operation of permits.

Is Extinction At Hand?

It has been estimated that almost half of the known species of marsupials in N.S.W. are either extremely rare or have become extinct. Naturally, members of the "kangaroo" family have suffered and a number of the smaller species have been threatened, including the Rat Kangaroo and the Rock Wallaby. But despite the tremendous onslaught which the larger macropods have had to withstand over a long period, not only from direct destruction but also from loss of habitat, there does not seem to be, on the short-range basis, an immediate threat of extinction. Admittedly, kangaroos and wallabies have disappeared from many areas where they were once abundant, and undoubtedly this has resulted from the destruction of habitat, which will continue to cause many populations to decrease or disappear.

It is on the long-term basis, however, that the greatest concern may be felt. The rapidity with which environments are being destroyed and land is being given over to purposes alien to the maintenance of wildlife stocks, certainly assures that in three or four decades the position could be drastically different to what it is today. Already scientific advice to the Fauna Panel indicates that there has been some change in the population dynamics of the Red Kangaroo, and caution is advised in providing control measures for this species. I have no doubt that the future holds great changes for the environments which are at the present time preserving the Red and Grey Kangaroos on the western plains, and the wallaroos and wallabies of the mountainous country. Only in the establishment of suitable reserves is the survival of the larger macropods assured.

The total area of land devoted to nature reserves in New South Wales amounts to

New Subscription Arrangements

Payments by post for subscriptions to "Australian Natural History" should in future be addressed to the Government Printer, Harris Street, Ultimo, Sydney, who prints this magazine, instead of to the Australian Museum.

This new arrangement is to facilitate handling of subscriptions, and will not, of course, result in any change to the magazine.

Visitors to the Museum will still be able to take out subscriptions there, and single copies of the magazine, both current and "back" numbers, will continue to be sold there.

about 1 per cent of the State or approximately two million acres, of which one and a half million are enclosed within the Kosciusko State Park. These national parks and faunal reserves have provided very little on the western plains of the State where reserves are imperative to the conservation of the Red and Grey Kangaroos. Reserves on the western plains will conserve the natural environments which are characteristic of this area. Despite the fact that the whole of the Western Division is under long-term leases, mostly of a very secure tenure, it is imperative for the needs of wildlife conservation generally, and for the conservation of the kangaroo in particular, to secure at this time a series of, say, three reserves amounting to about 100,000 acres in each case. In this way, it would be possible to secure representative selections of the biotic environments of the western country which carry a richly variable and extremely interesting flora and fauna, in addition to the kangaroos. It does appear to me that the State is wasting a considerable amount of money in pursuing the present wildlife conservation programme if it does not provide security for the wildlife which it is attempting to conserve.



Very long "fishing lines" of glow-worm larvae in the Demonstration Chamber, Waitomo Cave, New Zealand. [Photo: N.Z. National Publicity Studios.]

GLOW-WORMS

By AOLA M. RICHARDS

School of Biological Sciences, University of New South Wales

WAITOMO CAVE, one of the main tourist attractions in the North Island of New Zealand, has become world-famous for its Glow-worm Grotto. In this underground limestone cavern live thousands of glow-worm larvae, each emitting a bluish-green light from its tail end. Because bright light and noise disturb the glow-worms, the Grotto portion of the cave has been left in its natural state since it was discovered, and it is only quite recently that the habits of these interesting little insects have been studied.

In New Zealand, glow-worms are the larval stage of a luminous species of fungus gnat, *Arachnocampa luminosa* (Skuse) (Diptera, Mycetophilidae), which inhabit

damp, shady crevices, stream banks, tunnels and caves throughout the country, often forming quite impressive displays with their myriad twinkling lights. At Waitomo they occur in large numbers because of the ideal environmental conditions and the plentiful food supply.

Glow-worms also occur in Australia. They have been recorded from Queensland, New South Wales, Victoria and Tasmania. They are closely related to the New Zealand species, belonging to the same genus. The Tasmanian species, *A. tasmaniensis* Ferguson, occurs in large numbers in the limestone caves at Ida Bay and also in the Maracoopa Caves. On the Australian mainland the species is so far undescribed. Its habitat

is similar to that in New Zealand, but it is not very common in the bush, and seldom frequents caves or tunnels. So far its life history has proved very difficult to study. The general pattern of behaviour, however, is similar to the New Zealand species.

Remarkable Feeding Habits

One of the most peculiar features of the glow-worm is the feeding habits of the larva. The larva is narrow, elongated, segmented, semi-transparent, with a horny head which bears a pair of biting jaws. Behind the jaws are a pair of mucous glands. The larva builds itself a hollow, tubular nest of mucus and silk in which it suspends itself from the shelf or ceiling above by a number of fine silk threads. From the nest it lets down up to 70 strings of sticky droplets. These fishing-lines are formed in a peculiar manner. Each consists of a long thread of silk, which bears at regular intervals a series of mucus droplets giving the appearance of a string of beads. The fishing-lines vary in length, but can extend to 20 inches, and are used by the larva to catch prey.

Glow-worms feed chiefly on midges which breed in the water beneath, but are also cannibalistic, both on other larvae and on the adult flies. In the darkness, midges are attracted by the light emitted from the last abdominal segment of the larva, and fly upwards to become ensnared in the fishing-lines. The larva then moves along its nest to the appropriate fishing-line and, leaning out of its nest, hauls up the thread to which the midge is attached till it reaches its prey, which it immediately eats, discarding the remains. The hungrier a glow-worm is, the more brightly it will glow.

Life History

The life history is passed in four stages—egg, larva, pupa and adult fly. The eggs are laid in large numbers directly on to the walls of the cave. After about a three-week period they hatch into tiny larvae, which immediately emit quite a bright light; indeed, were it not for their light, they would be very difficult to find. They spread out over the ceiling of the cave and immediately commence building nests and letting down fishing-lines. These larvae grow over a period of several months till they reach a length of about one and a half inches.

When about to pupate, the larva shrinks in size and becomes translucent. Then it sheds its larval skin and develops into a pupa three-quarters of an inch in length, which is suspended vertically by a long thread from its point of attachment on the ceiling to the region behind its head. The pupal stage lasts for about 12 days. During this period there is a complete breaking down and building up of the tissues inside the pupa to form the adult fly.



A close-up view of a glow-worm larva's tubular nest (the long white object) and "fishing lines" on the wall of the Grotto, Waitomo Cave. [Photo: *Transactions of the Royal Society of New Zealand.*]

In the pupal stage sexual differences become apparent. The female pupa is larger and stouter than the male and possesses two prominent papillae (protuberances) at the rear end of the abdomen. In the male these papillae are much smaller. Both male and female pupae glow throughout all stages of their development. As in the larva, the luminous organ is situated in the last abdominal segment. The light is just as



Male (right) and female *Arachnocampa luminosa* flies mating. They are clinging to the empty female pupal case in the centre. [Photo: *Transactions of the Royal Society of New Zealand.*]

bright as that emitted by the larva, but is intermittent. In the female pupa the light appears to be connected with the attraction of male flies to the pupa. When gently touched, the female pupa lights up brilliantly for a few minutes. On several occasions two or three male flies have been observed attached to a female pupa which is glowing brightly.

When the female fly emerges she is still glowing, and usually is fertilized immediately by one of the waiting males. If mating does not take place, the female flashes her light on and off till she succeeds in attracting a male fly to her. Only one mating takes place. After mating the female still continues to glow intermittently, while she flies about seeking a suitable place to lay her eggs. Once egg-laying commences female flies seldom luminesce. The length of life of the female fly is governed by the

speed with which she lays her eggs, and can range from less than 24 hours up to 76 hours.

Male flies glow throughout the whole of their life, although not as brightly as the female. They tend to live longer, and are capable of fertilizing more than one female. They can survive up to four days.

The female fly of *Arachnocampa luminosa* is about three-quarters of an inch in length, with a wing span of four-fifths of an inch. It has a dark brown and white striped body and transparent veined wings. The male fly is slightly smaller. They are sluggish fliers and make a buzzing noise, but are seldom seen. The Australian species is slightly smaller in size, though similar in colour. In the caves at Waitomo the life cycle is continuous throughout the year.

The glow-worms' main predators are long-legged, small-bodied harvestmen, allied to spiders. The moist conditions inside caves are ideally suited to encourage fungal growth, and several species of fungi attack the larval and pupal stages of the glow-worm.

Organ Of Light

The most interesting structure in the glow-worm is its light organ. This is formed from the dilated tips of the four excretory tubules, which are extensions of the gut. These lie within a layer of respiratory tissue that acts as a reflector. The exact nature of the light still remains to be investigated, but the insect appears to be able to control it at will. Animal luminescence, or bioluminescence, has been recorded on many occasions, but no better example of this phenomenon can be given than that in the glow-worm.

This surely is one of the most fascinating members of our insect fauna, and the beauty of its twinkling light is unrivalled by any other insect.

MUSEUM CURATOR VISITS U.S.A.

Miss Elizabeth Pope, Curator of Worms and Echinoderms at the Australian Museum, is visiting the U.S.A. to attend the 16th International Congress of Zoology in Washington. She hopes also to work on collections in the Allan Hancock Foundation in Los Angeles, the U.S. National Museum in Washington and the Museum of Comparative Zoology, Harvard.



Migrating emus pause to drink at any claypan they happen to pass on their journey. [Photo: E. Slater, Division of Wildlife Research, C.S.I.R.O.]

Emus

By S. J. J. F. DAVIES

C.S.I.R.O., Division of Wildlife Research, Nedlands, Western Australia

“THE bloke who’s long and skinny like an emu” is a vivid bush description of a tall stranger. The emu (*Dromaius novaehollandiae*), although slightly smaller than the ostrich (*Struthio*), may sometimes exceed six feet from crown to foot. It is a member of the Ratites, a group of flightless, running birds including the cassowaries, kiwis, ostriches and rheas. Its wings are greatly reduced, scarcely eight inches long in adult birds, but it has long powerful legs which enable it to maintain 30 m.p.h. for a mile or more if necessary. The feathers are unusual. Two shafts grow from each feather base and these double feathers hang limply over the bird’s body, giving it a shaggy appearance. The plumage colour of individual birds varies from almost black to light brown, and pure white emus are occa-

sionally found. Birds from wet habitats are darker than those from dry ones, but, superimposed upon this difference, the feathers are darkest when freshly moulted, and fade slowly during the year. Emus have only three toes, probably as an adaptation to running, since a similar condition is found in other running birds, e.g., bustards and quail, and the ostrich goes even further and has only two toes. A parallel reduction in digit number occurs in running mammals.

Emus are found all over mainland Australia, from the heights of the Snowy Mountains to the tropical north, and closely related species once inhabited Tasmania, King Island and Kangaroo Island, but these insular forms were exterminated soon after white settlement.

The World Of The Emu

The particular emu with which this article is concerned live in an extremely arid environment in the interior of Western Australia. Although the average rainfall at Meekatharra is eight inches a year, in some years over twenty inches may fall and in others less than three. The district is regarded as one of irregular rainfall, but rainfall records of the last 50 years show more regularity than is often admitted. In almost every year there is at least one month in summer and also one month in winter when the rainfall exceeds one inch. So long as one's standards are low enough, therefore, the rainfall is a regular two inches a year, and any excess over that can be considered a "bonus". It is important not to overlook this regularity because some of the plants and animals are adapted to an incredibly low rainfall. For instance, certain individually marked trees and shrubs have been observed to flower in the same calendar week of two successive years, in one of which the annual rainfall was 297 points and in the other 970 points. Similarly, certain animals and birds, amongst them the emu, breed at the same time each year whatever the rainfall. Of course, the "bonus" rainfall is not without effect, for plants fruit more abundantly and animals breed more successfully in wet years than in dry ones, but it is useful to realize that the emu's world is basically regular, even though extreme.

Although the range is very great, the seasonal variation in temperature is much more predictable than that of rainfall. Daily maxima in summer are commonly about 110°F. while the temperature at dawn in winter may be below 30°F.

The vegetation is predominantly mulga steppe, although it is broken by areas of spinnifex sands and saltbush flats. In the strip extending 400 miles inland from the west coast of Western Australia rocky areas predominate, and the creeks drain relatively rapidly into large rivers, the Murchison, the Gascoyne and the Ashburton. Numerous pools remain in these creeks long after the rivers themselves have ceased to flow, and some persist for over 12 months once they have filled. Farther inland, on the other hand, sandy areas are more common, and the water drains into extensive salt lakes, such as Barlee and Carnegie. Artificial watering points, which the emu use freely, are less common because the sheep and cattle stations are larger and fewer. On the other hand, certain food plants of the emu, e.g. the quagdong (*Santalum acuminatum*), appear to be more abundant than nearer the coast.

The station people do not hunt emus in any systematic way. They shoot them occasionally and take the eggs when they find them, but emus are common over the whole area, with a breeding pair in every five to ten square miles. Fluctuation in their numbers seems to depend more on seasonal conditions than human interference.

The Life Of Emus

In the Murchison district of Western Australia emus pair in December and January. Hens, which are slightly larger than cocks, weigh about 100 pounds in January compared to about 90 pounds for their mates. The pair remain together for the next five months, walking long distances each day but keeping to the same general area. To what



A cock emu and four half-grown chicks drinking at a small water-hole during the heat of the day. [Photo: Author.]

The cock emu rolls its eggs towards it as it settles on to its nest in mulga scrub. [Photo: E. Lindgren.]



extent this area is defended is not clear, but sometimes they will drive away other emus which they encounter. At the end of May and in early June the hen lays her clutch of five to twenty large greenish eggs, each weighing one and a half to two pounds. They have a fine bloom when first laid but this rapidly rubs off against the breast of the sitting bird. The nest is not elaborate, a cleared patch of soil or a pile of dry leaves, but the sitting bird generally has a commanding view of its surroundings, even though the eggs are often laid in the shelter of a bush. The first few eggs are covered with debris when the pair is absent. The cock, which has built up large fat reserves in the autumn, begins to incubate before the hen has finished laying and sits continuously for the eight weeks of incubation. He rises only occasionally and takes little food, so that when the chicks hatch he is very thin and has lost 10 to 20 pounds in weight.

As soon as the eggs are laid the hen apparently leaves the immediate nest area and her reproductive organs regress. Together with young non-breeding birds she may migrate away from the breeding area altogether, if seasonal conditions are very bad. In any case she has nothing further to do with either eggs or chicks.

The baby emus have striped, downy plumage, with alternate brown and yellow marks running along their backs and sides. They follow the cock, running ahead of him and behind him, and succeed in getting thoroughly mixed up in his legs as he strides slowly along. At night they gradually become less and less ready to follow him, until

he finally sits down and they all gather beneath his plumage. In inland Western Australia the cock leads the chicks for 18 months, but it is possible that the period of parental care is shorter in more favoured regions. In the second December after the chicks hatch the cock is again free to start a new breeding cycle. It is not known how old the young chicks are before they are able to breed, but it is certainly more than two years.

Food

There is much truth in the traditional idea that emus will eat anything, but there are times when they are very selective feeders. The available food is of six kinds: the leaves of trees and shrubs; dry grass and herbage; fresh green herbage; fruits; flowers; insects. The first two are the mainstay of the pastoral industry for much of the year but emus eat relatively insignificant quantities of them. Of the other four classes, emus have definite preferences, and these are demonstrated in their annual food cycle. In summer they pick the seeds of shrubs, such as mulga (*Acacia aneura*) from the ground, but when the summer rains come they turn at once to grasses and other green herbage. If the rains are good the caterpillars hatch in large numbers and the emus forsake vegetable food for the insects, pecking individual grubs off the bushes. Throughout the winter they feed on the leaves of various herbs, eating the fruits and flowers of shrubs whenever these are available. The green pods of *Cassia* in July are particularly important. There are often droves of grasshoppers in spring and,

if these appear, emus' gizzards are crammed with them. The quagdongos and other fruits are favourite foods in September, just before the emus have, once again, to fall back upon the seeds of shrubs.

Baby emus hatch in June and July, as the winter rains germinate the herbs. They are especially ready to take the young succulent leaves of portulacca-like plants, but will eat any green herbage, and soon take much the same food as the adults.

Migration

C.S.I.R.O. and Western Australian Department of Agriculture jointly undertook a study of emus in response to the complaints of the farmers whose crops have long suffered emu damage at harvest time. The "Emu War" of 1934, in which the Army was called out to deal with the birds at Campion, highlighted the farmers' direct attempts to prevent this damage. Spectacular numbers of emus appear in the wheatbelt at irregular intervals and it has long been suspected that they breed in the interior and move south to the farming areas when drought conditions prevail inland. There is no doubt that movements of this type do occur, and the steady progress of bands of emus on the move is an impressive sight. Once I sat on a hill and watched more than 50 pass below me in two days, all heading south-west.

It is important to map this movement carefully with individually marked birds,

but normal trapping methods cannot subdue a wild adult emu. However, a method has been devised by which an anaesthetic drug, Flexadil, can be injected into an emu, so that banding can be carried out with relatively little danger either to the bird or the operator! It is injected by a syringe, fired from a gas gun, and puts the emu to sleep within 10 minutes. The injection of another drug, Neostigmine, as soon as the bird collapses, brings about a dramatic and apparently complete recovery in a further 10 minutes, allowing ample time for the bird to be banded and examined. The syringe is generally fired at emus as they approach water points where it is quite easy to get within 20 yards of them. Emus appear to need a good deal of water each day and, so long as the bird has not drunk, it does not wander more than 100 yards from the water, even after the shot. Often it conveniently stands in the shade of a nearby tree, examining the situation intently to try and discover the cause of the disturbance. Once the drug has begun to act, it does so very quickly, and the bird sits down quietly and falls asleep.

Emus As Desert Animals

In Western Australia the emu lives and breeds successfully in an extreme environment. It lays each year at the same time, and the eggs hatch when the food of the chicks, young green growth, is most likely to be available. If the season is dry the non-breeding birds leave and move south,



An emu, anaesthetized with the drug Flexadil, has just been banded.
[Photo: Author.]

and, although many perish, there is evidence of a much smaller return movement later in the year. The population control is catastrophic. In a bad year many birds die. In a good year the few which survive raise large numbers of chicks. So long as a few breeding birds can survive around permanent water, feeding on the seeds of shrubs, the population as a whole is in no danger. Unlike many inland birds, emus are not nomadic, but come to terms with their environment by adaptation to its regularity and exploitation of its "bonus" years.

NOTES AND NEWS

VISITOR FROM HONG KONG

Mr. A. T. Marshall, a lecturer on zoology at the University of Hong Kong, who is in Australia under a Commonwealth Scholarship and Fellowship Plan, visited the Australian Museum in July and discussed entomological matters with the Director, Dr. J. W. Evans.

AUSTRALITES AND METEORITES FOUND

Mr. R. O. Chalmers, Curator of Minerals, was in northern New South Wales, northern South Australia and central Australia from May to July as a member of the Australian-American Meteorite Expedition. The party acquired australites near Tibooburra, N.S.W., and personally collected 180 australites in the sandhills towards Lake Torrens, west of Leigh Creek, S.A. At the Henbury and Box Hole meteorite craters in the Alice Springs district, using a metal detector, they collected 680 metallic meteorite fragments, mostly in areas surrounding the craters.

AUCKLAND ISLANDS EXPEDITION

The Australian Museum's Curator of Crustacea and Coelenterates, Dr. J. C. Yaldwyn, was a member of the Auckland Islands Expedition 1962-63, and was on the islands, in the subantarctic zone to the south of New Zealand, for most of December, 1962, and January, 1963. He was interested mainly in the decapod Crustacea and other invertebrates of the shallow waters, and spent much of his time in dredging and trawling with Mr. J. Moreland, ichthyologist at the Dominion Museum, New Zealand. The expedition also made valuable observations on the flora of this island group, and on the breeding of Hooker's Sea Lion and the Enderby Island race of the Royal Albatross.

NORTHERN TERRITORY INVESTIGATION

Dr. Dick Tedford, Museum of Palaeontology, University of California, has lately been in the Northern Territory with a party of geologists from the Bureau of Mineral Resources, Canberra, investigating the possibility of Tertiary sediments in the country surrounding Lake Amadeus.

Australian Museum Publications

The following Australian Museum publications are available at the Museum:—

AUSTRALIAN MUSEUM HANDBOOK: A comprehensive natural history handbook, as well as a guide to the Museum; 140 pages; 4/-. **posted 4/6.**

THE NATURAL HISTORY OF SYDNEY: An account of much of the land and marine fauna, topography, geology, fossils, native plants, and Aboriginal relics of the Sydney area; contains articles already published in this magazine, with two others added; sixty-four pages; 5/-. **posted 5/6.**

EXPLORING BETWEEN TIDEMARKS: An introduction to seashore ecology; forty-five pages; 4/-. **posted 4/6.**

THE FROGS OF N.S.W.: Thirty-eight pages; 3/6, **posted 4/-.**

AUSTRALIAN ABORIGINAL DECORATIVE ART: Sixty pages; 6/-. **posted 6/6.**

AUSTRALIAN ABORIGINAL ROCK ART: Describes engravings and paintings on rock faces and in caves; seventy-two pages; 6/6, **posted 7/-.**

N.S.W. ABORIGINAL PLACE NAMES AND EUPHONIOUS WORDS, with their meanings; thirty-two pages; 1/6, **posted 2/-.**

AUSTRALIAN ABORIGINES: A booklet of special interest to school children; 6d., **posted 1/-.**

THESE ARE INVERTEBRATES: A folder, illustrated in colour, explaining how to use the Museum's unique exhibit "These Are Invertebrates"; 1/6, **posted 2/-.**

LIFE THROUGH THE AGES: A coloured, illustrated chart (34in. deep and 24in. wide), showing the progress of life from the primitive invertebrates of more than 800 million years ago to the present. The durations of the geological periods are shown and examples of the forms of life that existed in each are illustrated. Designed for hanging in schools; 6/-. **posted 6/9.**

LEAFLETS on natural-history and Aboriginal topics: Free of charge.

Also on sale: **AUSTRALIAN ABORIGINAL CULTURE,** published by the Australian National Advisory Committee for UNESCO. A handbook of the life, arts and crafts of the Aborigines; 2/6, **posted 3/-.**



A section of the new cabinet storage system for dried insects. The specimens are arranged systematically, and the drawers are interchangeable throughout the cabinets to allow easy expansion of the collections.

The Museum Collections—A Basis For Research

By C. N. SMITHERS

MUCH of the activities in the Museum centre around its collections, whether they be collections of animals, minerals or man-made objects; much time and energy have been spent in the past in accumulating vast numbers of specimens and the process is going on at an even greater rate to-day. The collections form the basis for some of the research which is undertaken by Museum staff; without collections to refer to we would be handicapped in our attempts to identify specimens and in our efforts to make known facts concerning the species which they represent. A drawer full of butterflies is much more than a display of

beautifully coloured objects; the specimens represent a living entity in nature, and the information on the labels attached to them tells us where and when we can expect to be able to find the species active. The specimens were once part of the population of insects in the field and by having them on hand in the collections they can be studied whenever necessary. One of the functions of the collections is to make available specimens of as many species of animals as possible. If collections are accumulated from many parts of the country we have a permanent record of the distribution of the species, an important point in

these days of rapid alteration of the country by man, with its consequent effects on animal life. Specimens of some species in our collections were captured in places where they can no longer be found owing to the spread of cities or the removal of vegetation; the collections can help us keep track of the recent history of such species. Museum specimens form the basis for studies in such subjects as anatomy, distribution, variation, relationships and evolution of animals, and their collection and care are therefore of vital importance to zoology.

The collections have been housed at the present Museum site since the middle of the last century and they have been growing continuously ever since. The rate of acquisition of specimens has, of course, varied over the years but has been increasing in all departments; for example, thousands of shells are added each year and, in the case of the insect collections, the addition of 12,000 specimens is considered a moderate annual addition. With extended accommodation now available, the expansion of the collections is easier and more rapid.

Waterhouse Butterfly Collection

The collections have been built up from various sources. Many of the specimens from more distant parts of Australia have been collected on special, sometimes arduous, expeditions made by Museum staff; much of the material is collected on shorter, less spectacular, but equally important field trips and by casual collecting. Some of the most important collections have been privately accumulated ones which the collector has bequeathed to the Museum. Amongst our privately accumulated collections is the famous Waterhouse Butterfly Collection; this is a collection of Australian butterflies containing nearly all of the type specimens of species described by Waterhouse and containing most of the specimens on which the illustrations in the standard work on Australian butterflies are based. The collections also contain specimens figured by A. W. Scott in his magnificent *Australian Lepidoptera*.

Collections of animals invariably need special treatment and care to ensure that the specimens do not deteriorate or are not destroyed by pests, and the treatment re-

quired differs according to the type of animal concerned. For example, mammal collections take four forms: Collections of skins and skulls, of skeletons, alcohol- or formalin-preserved specimens and mounted specimens. Insects may be pinned out, dried and mounted to show salient features of the anatomy; they may be preserved in alcohol or other liquid preservative or they may be specially treated and immersed in resin-like media on a small glass slide for examination through a microscope. Some of the techniques used to ensure safe keeping of the specimens are time consuming and all require skill and practice in their use.

Storage Methods

Each specimen must be labelled with information relating to its place and time of capture, its collector and its identity, together with any other interesting information which may be available. This label data is extremely important and unlabelled specimens are, in most cases, virtually useless for scientific work. The prepared and labelled specimens must be stored, and collection storage space is a perennial problem in Museums. Here again, the methods of storage vary in accordance with the type of animal and the size of the specimen; poor storage can mean the loss of specimens and valuable information. Smaller specimens in liquid preservatives are kept in jars and bottles and housed on shelves; larger specimens are kept in large tanks of preservative, as is the case with some of the fishes and large snakes. The smaller insects and spiders are kept in glass vials, the vials closed with cotton wool or plastic stoppers and immersed in preservative in a larger bottle. Skins and skulls are dried and kept in large cabinets. Pinned insects are kept in glass-topped drawers lined with cork into which the pin on which the insect is mounted is inserted; these drawers are arranged in cabinets. No matter what form of dry storage is used, the cabinets must be designed to prevent mould and insect pests from attacking the specimens.

Despite the enormous proportions which the collections have now reached, it is essential that each specimen can be immediately located for examination. This means that specimens must be registered and in-

A small part of the Museum's collection of spirit-preserved specimens. These bottled specimens are arranged in a systematic order and are indexed to permit immediate location of specimens.



dexed in some way. The result is that card indexes and bulky registration books form conspicuous adjuncts to the collections themselves, and these indexes often contain information about specimens over and above that to be found on the specimen labels. They are, therefore, of considerable value in themselves.

Collections Of World Importance

The acquisition, preparation and care of the collections are one of the tasks of a Museum curator. In this age of specialization a curator will carry out research on only a part of the collections in his care, and in caring for those parts in which he does not have immediate personal interest he is performing a service for his fellow scientists. Few scientists can collect all the material they need to study themselves and it is to the established Museum collections that specialists turn for help when they need specimens of a particular species or something from a particular area for their research work. The collections are therefore consulted by scientists from all parts of the world; also, the peculiarities of Australia's fauna make our collections here particularly interesting and important to people outside this continent. It is an essential part of a curator's work to make sure that specimens are named, properly arranged, accessible and in suitable condition for study by competent scientists.

The value of Museum collections lies not in their monetary or market value (although these are, in some cases, quite great) but in their value as research and reference collections. The various forms of animal life, minerals, and the symbols of man's culture are there for reference and study—the raw material of scientific research. The collections are part of the national heritage and a contribution to world science. In this lies their true value.

ABORIGINAL ROCK ENGRAVINGS

Mr. F. D. McCarthy, Curator of Anthropology at the Australian Museum, and Mr. H. Hughes, Museum Photographer, spent May in far-western New South Wales making detailed records of several extensive sites of rock engravings and obtaining material for a film on this subject. This work completes a long-term programme of recording rock art in this region.

GIFTS TO MUSEUM

A collection of 144 specimens of mats, bags, pottery, weapons, ornaments and other objects from the New Hebrides and Solomon Islands was recently presented to the Australian Museum by the Rev. G. J. Stewart. It includes a fine series of six boomerangs from the New Hebrides. The Museum had only one example of this boomerang previously. Another collection, presented by Brother Colman, of Marist Brothers School, Lunga, British Solomon Islands, per favour of Captain Sadler, consists of 25 specimens illustrating the manufacture of native shell-money on the east coast of Malaita. It includes a stone-pointed drill, which has now been replaced by metal points.

THE AUSTRALIAN MUSEUM

HYDE PARK, SYDNEY

BOARD OF TRUSTEES

PRESIDENT:

EMERITUS PROFESSOR A. P. ELKIN, M.A., Ph.D.

CROWN TRUSTEE:

F. B. SPENCER.

OFFICIAL TRUSTEES:

THE HON. THE CHIEF JUSTICE.

THE HON. THE PRESIDENT OF THE LEGISLATIVE COUNCIL.

THE HON. THE CHIEF SECRETARY.

THE HON. THE ATTORNEY-GENERAL.

THE HON. THE TREASURER.

THE HON. THE MINISTER FOR PUBLIC WORKS.

THE HON. THE MINISTER FOR EDUCATION.

THE AUDITOR-GENERAL.

THE PRESIDENT OF THE NEW SOUTH WALES MEDICAL BOARD.

THE SURVEYOR-GENERAL AND CHIEF SURVEYOR.

THE CROWN SOLICITOR.

ELECTIVE TRUSTEES:

O. G. VICKERY, B.E., M.I.E. (Aust.).

EMERITUS PROFESSOR A. P. ELKIN, M.A.,
Ph.D.

F. McDOWELL.

R. J. NOBLE, C.B.E., B.Sc.Agr., M.Sc., Ph.D.

E. J. KENNY, M.Aust.I.M.M.

F. L. S. BELL, M.A., F.R.A.I.

FRANK W. HILL.

G. A. JOHNSON.

PROFESSOR J. R. A. McMILLAN, M.S.,
D.Sc.Agr.

S. HAVILAND, C.B.E.

G. H. SLADE, B.Sc.

PROFESSOR L. C. BIRCH, D.Sc.

DIRECTOR:

J. W. EVANS, Sc.D.

DEPUTY DIRECTOR:

H. O. FLETCHER, M.Sc.

SCIENTIFIC STAFF:

Birds: H. J. de S. DISNEY, M.A., Curator.

Reptiles and Amphibians: H. G. COGGER, M.Sc., Curator.

Mammals: B. J. MARLOW, B.Sc., Curator.

Fishes: G. P. WHITLEY, F.R.Z.S., Curator.

Insects and Arachnids: C. N. SMITHERS, M.Sc., Curator; D. K. McALPINE, M.Sc., Assistant Curator.

Molluscs: D. F. McMICHAEL, M.A., Ph.D., Curator.

Crustacea and Coelenterates: J. C. YALDWYN, M.Sc., Ph.D., Curator.

Worms and Echinoderms: ELIZABETH C. POPE, M.Sc., Curator.

Minerals and Rocks: R. O. CHALMERS, A.S.T.C., Curator.

Fossils: H. O. FLETCHER, M.Sc., Curator.

Anthropology: F. D. McCARTHY, Dip.Anthrop., Curator; D. J. MILES, B.A., Assistant Curator.

EDITORIAL ASSISTANT AND PUBLIC RELATIONS OFFICER

PETER COLLIS.

EDUCATION OFFICER:

PATRICIA M. McDONALD, B.Sc., Dip.Ed.

EXHIBITION DEPARTMENT, ART AND DESIGN SECTION:

F. J. BEEMAN.

LIBRARIAN:

MARY DAVIES, B.Sc., L.A.A.

PHOTOGRAPHER AND VISUAL AIDS OFFICER:

H. HUGHES, A.R.P.S.

HONORARY SCIENTIFIC STAFF:

Zoologists.

E. A. BRIGGS, D.Sc.

H. LEIGHTON KESTIVEN, D.Sc., M.D.

MELBOURNE WARD, F.R.Z.S., F.Z.S.

TOM IREDALE.

A. J. MARSHALL, D.Sc., D.Phil.

JOYCE ALLAN, F.R.Z.S.

S. J. COPLAND, M.Sc.

ELLIS TROUGHTON, C.M.Z.S.

A. A. RACEK, Dr.rer.nat. (Brno).

F. A. McNEILL, F.R.Z.S.

Ornithologist.

K. A. HINDWOOD, C.F.A.O.U., F.R.Z.S.

Philatelist.

FRANK W. HILL.

The Australian Museum

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

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

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

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

College St., Hyde Park, Sydney