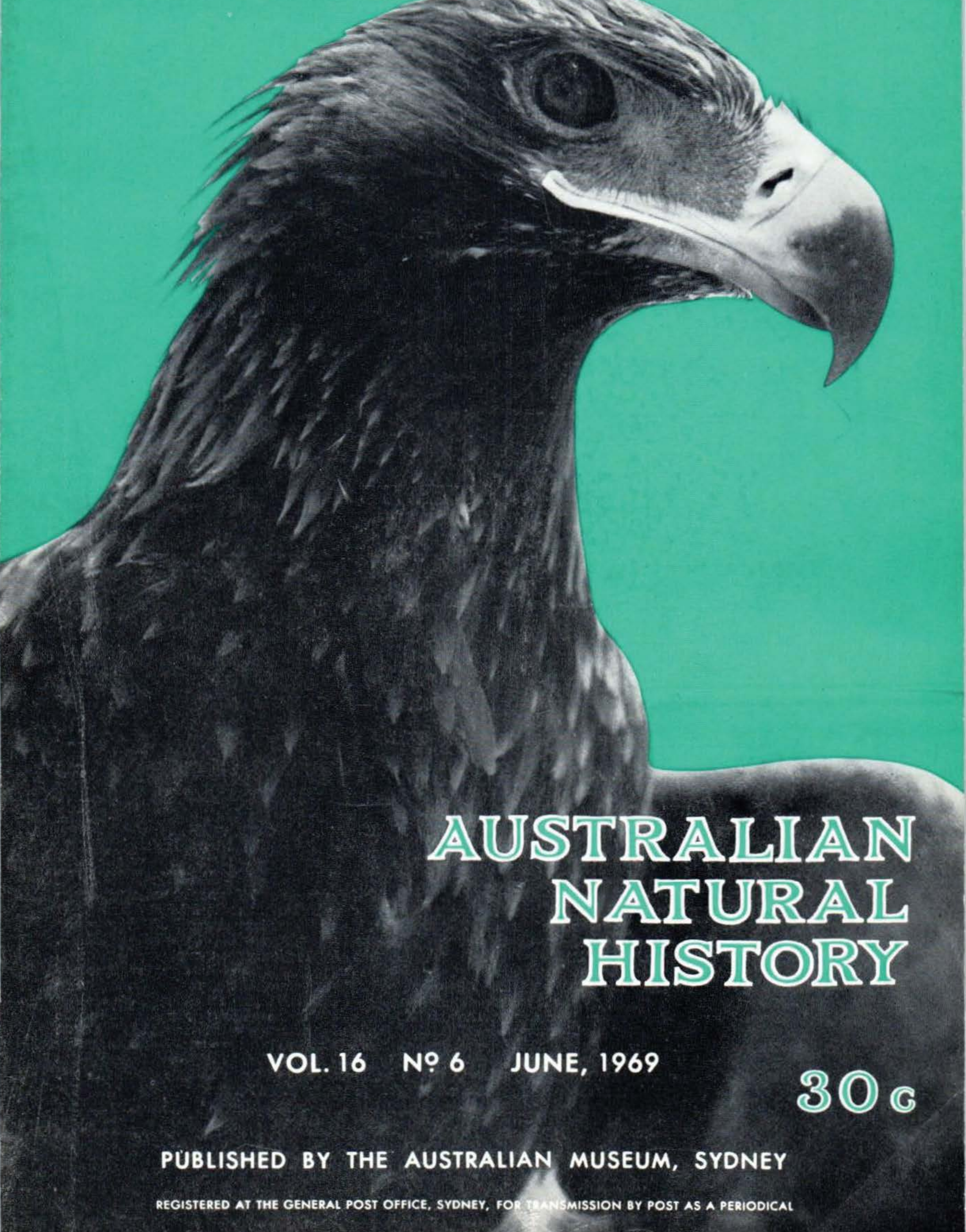

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CONTENTS

● FRONT COVER: The Wedge-tailed Eagle (*Aquila audax*), of Australia and Tasmania, has a wing-span of from 6 feet 3 inches to 7 feet 3 inches, with a Tasmanian specimen having a record of 9 feet 4 inches. It weighs about 8½ pounds. Like its relatives the Golden Eagles, it has always been accused of taking young lambs. This problem is now being investigated by members of the Wildlife Research Division of the CSIRO. They have found that the bird's diet is very varied and may consist of young kangaroos, rats, possums, crows, frogmouths, and large lizards. A few lambs have been found among its prey, but it is impossible to say whether they were healthy or sick when taken. BACK COVER: The origin of this interesting bark painting in the Australian Museum collections is uncertain. At the time of the Melanesian art exhibition in the Art Gallery of New South Wales in 1966 this painting and several others in the same style were found to be unnumbered and undocumented. However, this distinctive painting style occurs only in the area of the Keram River, a southern tributary of the Sepik River, northwestern New Guinea, and this group of barks can safely be attributed to that locality. They were probably collected in the 1930's by E. J. Wauchope, who conducted several expeditions up the Sepik and bought many superb artefacts for the Museum. The colours in this painting are red, white, yellow, and black. [Photos: C. V. Turner.]

HOW DANGEROUS IS THE MORAY EEL?

By JOHN E. RANDALL
Marine Biologist, Hawaii Institute of Marine Biology, University of Hawaii, and Ichthyologist, Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A.

THE moray eel has the unenviable reputation of being grouped with the shark and barracuda as an extremely dangerous fish which makes unprovoked attacks on man. It is popularly believed to be reluctant to release its grip once it has bitten a diver, thus possessing the potentiality of holding a victim beneath the surface long enough to cause him to drown. Furthermore, its bite is sometimes regarded as venomous.

No one can doubt that the moray's appearance alone warrants such notoriety. With its large powerful jaws, long needle-sharp teeth, and muscular snake-like body, it has all the attributes to elicit a fright response. The mere sight of a large moray by a novice diver usually results in a rapid removal of his presence from the eel's vicinity, if not from the sea altogether.

More experienced divers gradually discover that they are not in mortal danger when they encounter a moray—at least when the moray's view of them is total and not just a close-up glimpse of part of an arm or leg that might be mistaken for a fish or octopus. The collective experience of many divers has shown that the moray's sinister reputation as a man-killer is undeserved (and, it might be added, that the threat of the barracuda is also exaggerated). Also, the notion that there is a venom associated with the teeth of morays is fallacious.

Morays, if they are seen at all, are nearly always observed with just their heads projecting from a hole in coral or rock, or while making a brief excursion from one hole to another. When confronted by an underwater swimmer, they generally remain in essentially the same position; they may emerge slightly, as if curious, or they may withdraw completely. If tapped on the head with a spear tip, they retreat. If speared through the head, they make a herculean effort to pull back into their hole which may result in considerable bending of the spear. A few adventurous divers have fed morays by hand, a practice which should be discouraged, for one would not expect a hungry moray to display the best table manners; a finger might easily be included with the proffered food.

The author pulling a moray eel, *Gymnothorax javanicus*, on two spears to the surface at Johnston Island. Only the head end of the big eel is visible. The pointed end of one of the spears can be seen projecting from the lower jaw. [Photo: Alan Banner.]

In an attempt to dispel the much-maligned moray's evil reputation, I do not want to be guilty of creating an impression that this

The head of a 4½-foot specimen of the moray eel *Enchelynassa canina*, from Marcus Island (24° N., 154° E.). This eel has slender and somewhat hooked jaws with exceptionally long teeth. It is believed to be among the more aggressive of morays. [Photo: Author.]

group of fishes is docile and harmless. On the contrary, the moray is voracious, and, when adequately stimulated, very aggressive. Many divers have been injured by morays; I have been bitten four times. Nearly all of these incidents fall into two categories. The first is the placing of an extremity, usually a hand, in the proximity of an eel's head in such a manner that only the hand or foot or portion thereof is seen. In biting, the eel presumably mistakes the human extremity for a fish or octopus (an outstretched hand could easily look like an octopus, a favourite food of many morays). The presence of a speared fish, struggling lobster, or detached shellfish will certainly increase the chances of being bitten. Bardach, Winn, and Menzel (*Copeia*, 1959, no. 2) have shown that the sense of smell is the principal sense used by morays for locating food. The second category into which moray attacks fall is the result of provocation, such as spearing, or being brought into a boat on hook and line. Once pulled free of its hole on a spear, the moray's behaviour is apt to change. It will often bite the spear if able to do so. If it frees itself from the spear, it may direct its vengeance at its tormentor, the spear-fisherman.

In general, a moray that has bitten a man soon releases its grip. An analysis of the dentition of morays will reveal that these fish are not equipped to cut pieces from large-sized prey in the way that many sharks do. When a finger is discovered attached to a hand, or a hand to a substantial arm, the eel seems to realize that it has not encountered a meal. Like a snake, whose evolution of an elongate body, loss of limbs, etc., remarkably parallels that of the eel, the moray usually swallows its food entire. Its long pointed teeth are adapted for seizing and holding slippery prey, and the larger canines are depressible inwards so that the prey, once firmly captured, can move only toward the eel's stomach.

Three of my bites were probably the result of morays striking at what they believed were items of food. The first occurred in shallow water at Kauai, Hawaiian Islands. I gripped the reef-flat to maintain my position as a wave approached, thrusting some of my fingers into small holes. One finger was nipped; the pattern of close-spaced rows of tiny punctures left little doubt that my diminutive assailant was a moray.

The second occasion was when I imprudently placed my hand over the front of a cannon at the wreck of an old ship off Aguadilla, Puerto Rico. I had not noticed that the barrel was occupied by a Purple-mouth Moray (*Gymnothorax vicinus*) 2½ feet in length, which promptly seized an index finger. At this moment I realized more fully the hapless position of a small fish similarly grasped by a moray. The bite felt as if it were inflicted by a pair of pliers studded with stout needles. I had long admonished myself to try to refrain from a reflex pulling back of a limb if bitten by a moray, to avoid severing blood vessels and tendons in the slashing wounds that would result. So, for perhaps a second, I left my finger in place. It was with relief that I felt the jaws relax and the teeth being disengaged. Unfortunately, before the teeth were fully free, the eel pulled back into the barrel, and the slashes I so assiduously sought to avoid were nonetheless inflicted. I reacted in small-boy manner by spearing the eel, dragging it ashore, and smashing its head.

The third incident occurred while I was walking barefoot in only 4 inches of water on the outer reef-flat of Eniwetok Atoll, Marshall Islands, in an area where many holes led to surge channels below. A very rapid bite was inflicted by an unseen moray on the inner surface of my heel; only the upper jaw came in contact with my foot. A hemispherical pattern of seven puncture wounds resulted which, when compared with the jaws of morays in the collection of the Bishop Museum, indicated an eel size of about 3 feet.

The fourth wound falls into the provocation category. I impaled a small moray in a Tuamotuan lagoon on a Hawaiian sling spear. Then, spotting a grouper, I decided to spear it, too, while still retaining the eel on the spear. As I drew back the spear to shoot the grouper, I brought the eel within range of my left hand. It promptly sank its teeth into one of my flexed knuckles—an event which saved the life of the grouper. (The grouper is known in Australia as groper.)

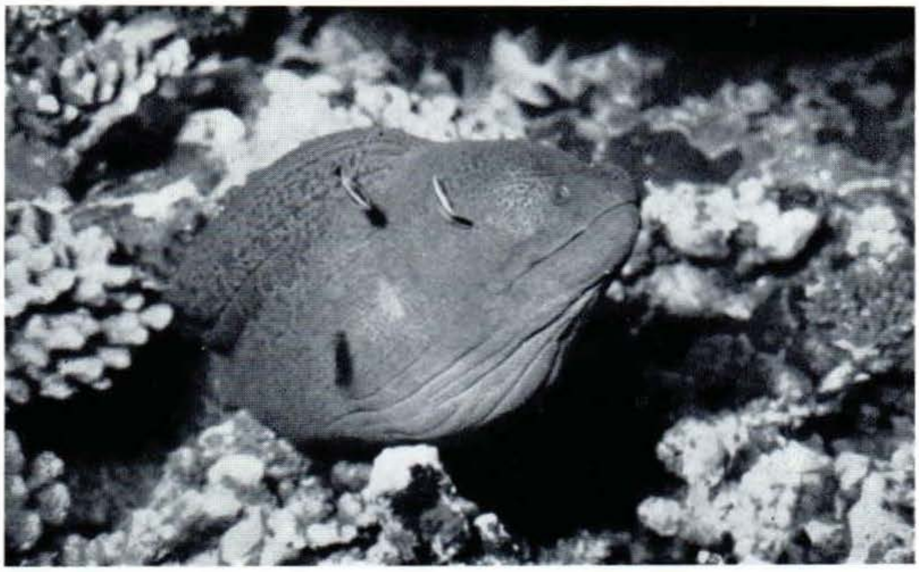
Attack by a giant moray

These minor incidents fortunately involved only small eels. When larger eels are provoked by spearing and are in a position to attack, they can produce terrible wounds which could easily be fatal. In 1948 Vernon E. Brock, now Director of the Hawaii Institute of Marine Biology of the University of Hawaii, sighted an enormous, brown, dark-spotted moray eel in 20 feet of water at Johnston Island (about 700 miles WSW. of Oahu) after spreading the fish poison rotenone in the area. The eel appeared dead from the effect of the rotenone. Brock speared it instead of taking it by hand and swam up with it to the surface. The eel, however, was not dead, and moved up the spear toward Brock, who let the spear go and swam quickly away. He was overtaken by the eel, which seemed intent on attacking his head. Brock lifted his arm to protect his face and was savagely bitten on the elbow. The eel soon released the arm, and Brock swam to the boat, where a tourniquet was applied to stop the profuse bleeding. A Navy doctor spent 2½ hours sewing up the wounds. Brock was then flown to Tripler Hospital in Honolulu, where he convalesced for a month. It was 3 months before he had any reasonable use of the arm.

Dr Leonard P. Schultz, formerly Curator of Fishes at the United States National Museum, described Brock's encounter with an eel in greater detail in *Natural History* (January, 1949). He thought the species of eel may have been *Enchelynassa canina* or a close relative, and gave the length as about 10 feet. A recent interview with Brock has led to the more probable identification of the eel as *Gymnothorax javanicus* and estimation of its length as 7 to 8 feet. *G. javanicus* is the only large moray that has been taken in the many collections made at this island. *Enchelynassa canina* has yet to be found there (although it would not be surprising if it were).

The longest moray recorded from Johnston Island was 7 feet 10 inches (by Stephens, 1963, *Sea Frontiers*, vol. 9, no. 3). The

The head of a large moray eel, *Gymnothorax javanicus*, protrudes ominously from a coral reef in Bora Bora, French Polynesia. The two small fish close to the moray's head are Cleaner Wrasses (*Labroides rubrolabiatus*), which feed on the crustacean ectoparasites of other fish. [Photo: Erwin Christian.]



largest of 639 adult *G. javanicus* collected by personnel of the Hawaii Institute of Marine Biology at Johnston during the period 1963 to October, 1968, weighed 48 pounds, with a length of about 7 feet. The second largest weighed 43 pounds and was 5 feet 7 inches in length (eels of the same length may vary greatly in weight). Several divers have seen an individual eel at the island which they estimate must weigh about 80 pounds; these men have collected *G. javanicus* up to 30 or 40 pounds and their judgment is to be respected. And so should such an eel!

Many morays in Hawaii

Gymnothorax javanicus is wide-ranging in the tropical Indo-Pacific region, but it does not occur in the Hawaiian Islands. Hawaii is not lacking for morays, however, as 31 species are recorded from the archipelago, including *Enchelynassa canina* to lengths of at least 5 feet, and *Gymnothorax flavimarginatus* and *G. undulatus* to about 4 feet; some species are unusually abundant. Nor is Hawaii lacking in moray-inflicted injuries to man. Guy S. Haywood, M.D., a surgeon from Maui, informed me that he has averaged two cases of moray bites per year in his 21 years of practice in the islands; most of the injuries have been to the hands. A patient of one of his colleagues was bitten repeatedly on the inner thighs by a small eel without any apparent provocation.

Gymnothorax javanicus was responsible for a second attack—this time on a spear-fisherman who was stationed at Johnston Island in 1965. The man was spearing large morays for the Marine Toxins Program of the Hawaii Institute of Marine Biology. He followed a policy of spearing an eel and then returning to the boat for about 15 minutes. During this waiting period, the eel was expected to die or be sufficiently weakened to be easily pulled free of its hole and safely transported to the boat. One good-sized eel was apparently little affected, for it extricated itself from the spear and bit the man in the shoulder. The wound was not serious, and he was soon on duty again.

I very nearly became the third victim of *Gymnothorax javanicus* attack at Johnston Island. Last August three of us were collecting large morays by setting baited traps. Often we encountered eels which had been attracted to the vicinity by the bait but had not entered the traps. These we endeavoured to spear. One such eel, of about 25 pounds, was speared in the head. While being towed on the surface to a nearby skiff, it looped its tail over the forward part of its body to form a knot and wrenched itself free of the spear. Instead of swimming back to the bottom, it swam directly at me with awesome jaws agape. I accelerated my swimming to the maximum, kicking the sea into a froth with my swim-fins. The moray easily overtook me, and I felt its powerful body slither across mine. Miraculously, its jaws failed to engage in any part of my anatomy, and it retired to the bottom without making another attack. After that incident, eels were all taken with two or more spears, and the larger ones were often subdued with a 12-gauge shotgun power head.

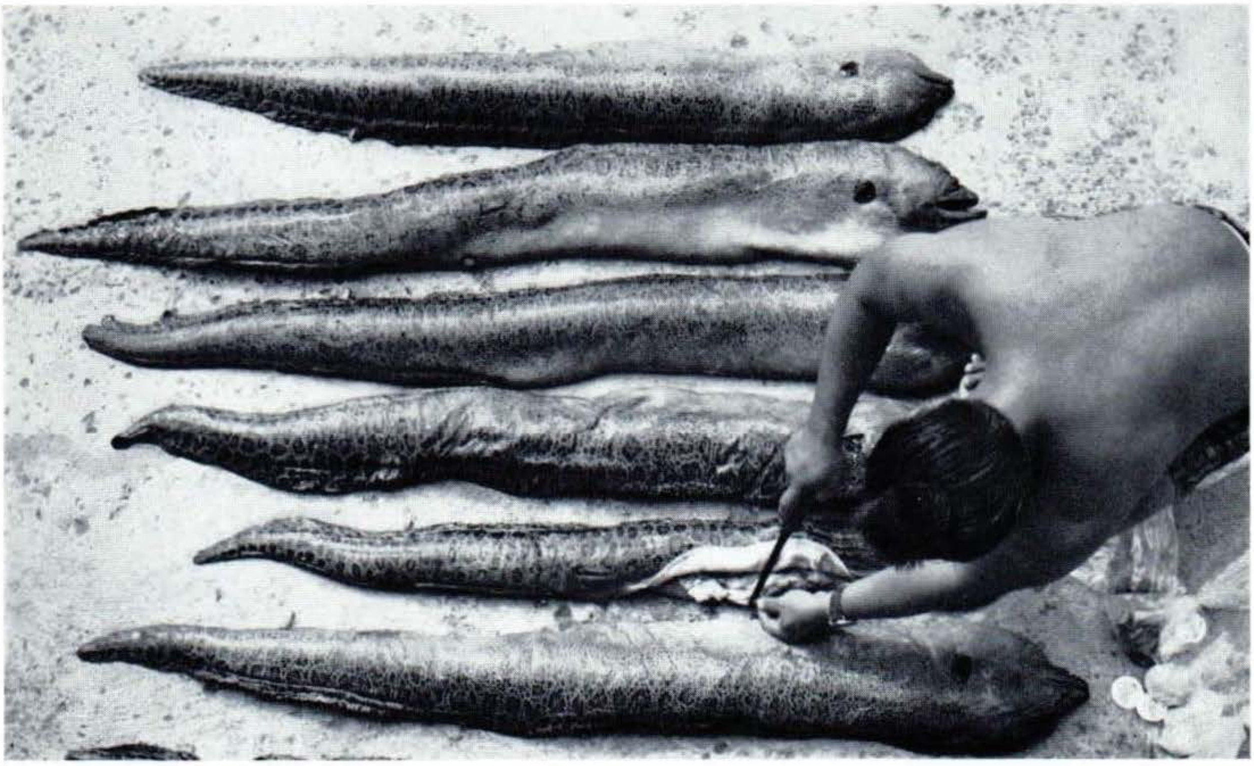
Another more recent incident involving the same species is worthy of mention. At Palmyra Island, Line Islands, in November, a large eel swam into a small crevice in live coral beneath my feet. Shortly after, I felt a tug on one of my black rubber swim-fins, which was partially wedged in the coral. It was pulled free without much effort. Some fresh scratch marks indicated where the eel's teeth had scraped the fin.

Green Moray also large and dangerous

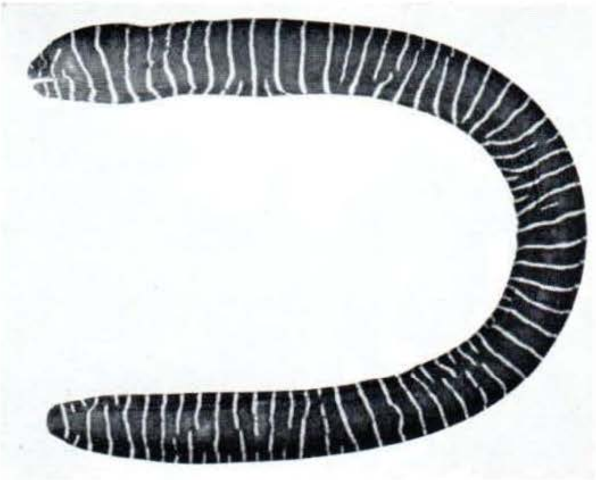
Gymnothorax javanicus is not the only large eel which has attacked man. Stephens reported, in *Sea Frontiers*, a serious wound to the right wrist of Lt R. Enders, USN, near Key West, Florida, by the Green Moray (*Gymnothorax funebris*) in 1961. Enders spent several weeks in hospital. A few months later, when he was diving at the same place, a large moray, which he believed to be the same eel, swam completely out of its hole towards him. A companion speared it in the head, but it pulled off the spear and escaped. It was estimated to be at least 7 feet long. Louis S. Mowbray, the Curator of the Government Aquarium at Bermuda, has written (personal communication, October, 1968) that he has maintained a Green Moray as large as 8 feet in the aquarium, although the largest actually measured by him was 7 feet 7 inches and weighed 64 pounds.

The moray eel family (Muraenidae) is primarily a tropical group, but a few species penetrate cooler seas, such as *Gymnothorax kidako* in Japan and *G. mordax* of California waters. A number of divers have been bitten by the latter species, particularly those reaching in cracks or crevices in search of abalones.

Not all morays have long needle-like teeth. *Gymnothorax pictus*, a white eel peppered with black specks, which is a common inhabitant of only inches of water or less on reef flats of tropical Indo-Pacific islands, has short, but still sharp, teeth. It feeds primarily on crabs and has been observed to actually come at least partly out of the water in quest of grapsids. Other



William Hashimoto, of the Hawaii Institute of Marine Biology, taking a gonad sample from one of the day's catch of *Gymnothorax javanicus* at Johnston Island. A high percentage of eels of this size have poisonous flesh at Johnston Island. [Photo: Author.]



A specimen of *Echidna zebra*, slightly more than 2 feet in length, from the Hawaiian Islands. Like other members of the genus *Echidna*, this moray has blunt, nodular teeth. [Photo: Author.]

morays of the genus *Echidna* have only blunt nodular teeth. Examples are the brown and white barred *E. zebra* and the white *E. nebulosa*, with black stellate blotches containing one or more bright yellow centres. Limited data indicate that species of *Echidna* feed mainly on crustaceans, especially crabs.

Ciguatera

In tropical waters, particularly among coral reefs of oceanic islands, some large morays, when eaten, have caused a serious illness known as ciguatera. It can also be produced by ingesting many other fishes besides moray eels, but few species have consistently produced such severe symptoms as large morays.

One of the most spectacular series of cases was reported by Khlentzos (1950, *American Journal of Tropical Medicine*, vol. 30, pp. 785–793). On 8th May, 1949, fifty-seven Filipinos at Saipan in the Mariana Islands sat down to a meal of a huge moray eel, said to have been about 1 foot thick. The moray was fresh and had been cooked for 30 minutes. As the fish was eaten, a scratchy sensation in the mouth and throat was noted. About 20 minutes later the men experienced tingling and numb sensations about the lips and tongue. Approximately 30 minutes after the ingestion of the moray, some were unable to talk. The entire group became alarmed and was taken to a dispensary, where each was given a gastric lavage. In spite of this, the condition of the men worsened. Most vomited, and by the next day all experienced tingling of their hands and feet. The respiratory chest muscles showed progressive inability to function. Many of the men had convulsions. Eleven became comatose, and two died.

The cause of ciguatera still remains one of the sea's mysteries. It is believed that some benthic organism, perhaps an alga, produces the toxin (or its precursor substance) and this is passed on through food chains to the larger fishes that man eats. The worst offenders are the larger carnivorous fishes, especially those, such as morays, that feed heavily on reef fishes. The toxin accumulates in the tissues of these fishes; thus the older they are, the more apt they are to be poisonous. The liver and viscera of ciguateric fishes contain a much higher percentage of toxin than the flesh.

Personnel of the Hawaii Institute of Marine Biology have been studying ciguatera for over 10 years under the direction of Dr A. H. Banner. The principal source of toxin for biochemical and pharmacological research has in recent years become *Gymnothorax javanicus* of Johnston Island. The Institute pays 40 cents per pound for all morays of this species 10 pounds or more in weight (smaller ones are usually nontoxic or only weakly toxic).

Recently a study of the biology of *G. javanicus* has been initiated at Johnston Island. It is hoped that knowledge of the food habits and aspects of the life-history of this eel will clarify some of the complexities of ciguatera.

THE AUSTRALIAN BIRD-BANDING SCHEME

By D. PURCHASE
Secretary, Australian Bird-Banding Scheme, CSIRO, Division of Wildlife Research, Canberra, A.C.T.

ON 18th September, 1887, an albatross of undetermined species was found near Triggs Island, Western Australia, with a tin collar around its neck which carried the following message, "13 naufrages sont refugies sur les iles Crozet 4 Aout 1887" (thirteen shipwrecked sailors have taken refuge on the Crozet Islands, August 4, 1887). This message was telegraphed to the French authorities, who despatched the warship *La Meurthe* from Madagascar to the Crozets, which are in the south Indian Ocean, and it was established that the message had been attached to the albatross by the crew of the French sailing ship *Tamaris*, which was wrecked in the Crozets on 9th March, 1887. The unfortunate seamen, however, did not live to see the successful result of their experiment in bird-banding, as they apparently perished in an ill-fated attempt to reach nearby Possession Island, two months before the arrival, on 2nd December, 1887, of *La Meurthe*.

Although this episode is far removed from the bird-banding methods in use today, it is the earliest and most remarkable case of a banded bird arriving in Australia from overseas; the bird had covered a distance of 3,027 miles in no more than 46 days.

Bird-banding today is usually confined to the systematic marking of wild birds with numbered metal bands. As each band has its own unique number, birds can subsequently be recognized as individuals and data on a variety of aspects may be collected about them. This technique has become essential in studies of the ecology, behaviour, migration, and population dynamics of birds.

The foundations of modern scientific bird-banding were laid in Denmark in 1899 when Christian Mortensen placed aluminium bands, stamped with numbers, on the legs of 162 young starlings. This technique was rapidly adopted elsewhere and many countries now have national schemes devoted to bird-banding.

The Wandering Albatross (*Diomedea exulans*) is a familiar sight to sea voyagers in the Southern Hemisphere. The large-scale banding of this species in New South Wales coastal waters has resulted in some spectacular recoveries from their breeding sites.

Bands were first used in Australia in 1912 and were placed on Short-tailed Shearwaters (*Puffinus tenuirostris*) and White-faced Storm-petrels (*Pelagodroma marina*) by members of the Bird Observers' Club, Melbourne, and the Royal Australasian Ornithologists' Union. After that the growth of bird-banding was relatively slow until 1947, when a joint scheme by the CSIRO and the Tasmanian Fauna Board was initiated for banding Short-tailed Shearwaters. Shortly afterwards several States started independent schemes for the banding of waterfowl. Then in 1953 the Australian Bird-Banding Scheme was launched by the CSIRO, Division of Wildlife Research.

At present there are six banding schemes operating within Australia. The Australian Bird-Banding Scheme, in collaboration with the State fauna authorities, operates throughout Australia and its territories; five schemes are operated by State Government instrumentalities concerned with waterfowl management: Department of Primary Industries, Queensland; Department of Fisheries and Fauna Conservation, South Australia; Tasmanian Fauna Board, Tasmania; Fisheries and Wildlife Department, Victoria; and Department of Fisheries and Fauna, Western Australia.

Unlike the State schemes, which are undertaking specific projects connected with the management of their waterfowl resources, the Australian Bird-Banding Scheme does not confine its activities to any particular group of species, and bands are made available to approved ornithologists, both amateur and professional, for use in projects on a wide variety of species. Bands supplied by the Australian Bird-Banding Scheme have been used throughout Australia, as well as in Papua, New Guinea, New Britain, Bougainville, Lord Howe Island, Norfolk Island, Christmas Island, Cocos-Keeling Islands, on cays and reefs in the Coral Sea, and in Antarctica. Bands have also been supplied to a British ornithologist in Sabah by arrangement with the British Trust for Ornithology.

The Australian Bird-Banding Scheme, as well as providing a technical service of great importance to the bird investigations being carried out by the Division of Wildlife Research, is enabling non-professional ornithologists to conduct studies of a high scientific calibre. It has also brought Australia into line with other developed countries in the world, many of which possess officially sponsored schemes.

To many ornithologists, bird-banding is something of a modern sport, and it draws its adherents from all walks of life and ages. When the interest and enthusiasm thus generated are directed into worthwhile channels by the careful planning of projects, bird-banding becomes not only an enjoyable weekend occupation, but it also enables amateur workers to make a valuable contribution to Australian ornithology.

The type of banding being undertaken varies from the detailed study of the behaviour of a few birds in a suburban garden to the large-scale banding of one species in order to obtain records of migration. Another type of banding is in the regular operation of permanent banding

A young Superb Lyrebird (*Menura novaehollandiae*) being banded alongside its nest. Much of the work carried out on the life-history of this species by the Victorian Ornithological Research Group, at Sherbrooke Forest, Victoria, and the CSIRO Division of Wildlife Research, at Tidbinbilla, A.C.T., relies on the observation of marked individuals. The knowledge so obtained is essential for the effective conservation of this bird, which, though in no danger of extinction, is unique to Australia and worthy of conservation.

stations, from which data can be obtained concerning the seasonal fluctuations and movements of bird populations, especially passerines.

Over the years, the research programmes of the CSIRO Division of Wildlife Research have benefited greatly from the wider banding coverage made possible by the participation of amateur banders. Examples include the work being carried out on the Short-tailed Shearwater and on waterfowl, ravens, cormorants, pigeons, and doves.

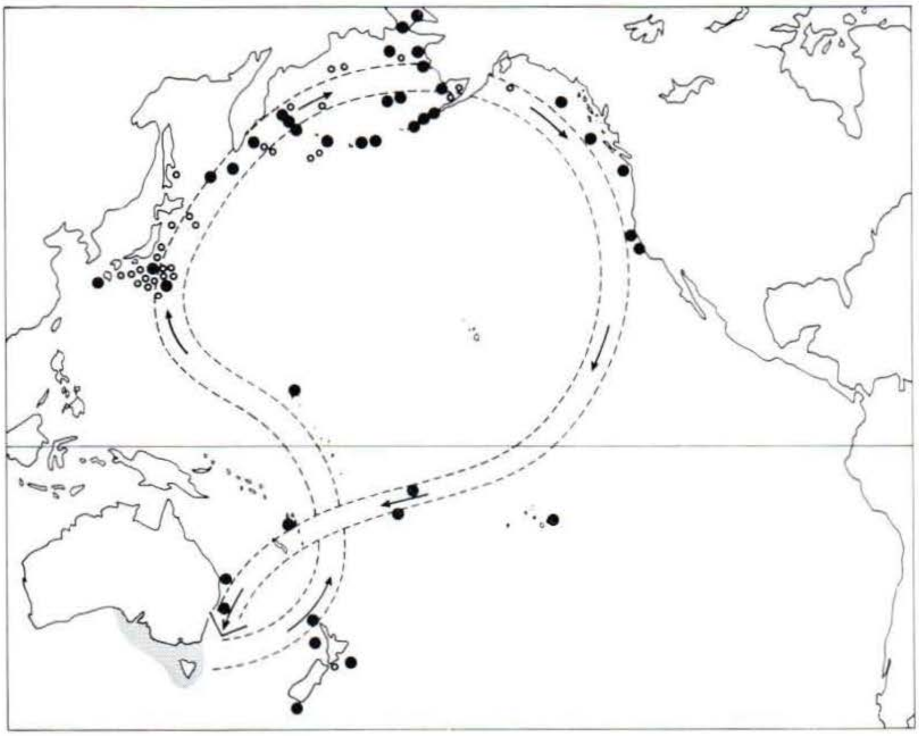
The bands in use are made from aluminium, aluminium alloy, or monel, and are manufactured in a variety of sizes. Each species of bird is allocated a size which has been found by experience to be the most suitable for it. In some cases bands have been specially designed to fit particular species, such as the burrowing shearwaters, penguins, and pelicans. When correctly applied, the fastening of one of these light metal bands around the leg of a bird causes little, if any, inconvenience to the bird.

The techniques used for obtaining the birds which are to be banded depend on the species involved and the type of study being undertaken. The methods include various types of nets, and a wide variety of wire-netting cages fitted with either drop doors or funnel entrances. Other birds are simply banded as nestlings, but the bander must be able to reach the nest or nesting colony. This can often be a major challenge, requiring a variety of skills and equipment, depending on whether the nest is situated on a cliff, in a tree, on an island, or in the middle of a swamp.

When a bird is banded a record is taken of the following: the band number; the species on which the band has been used; the date and place of banding; and other details, such as age and sex. This information is then forwarded to the central office in Canberra, where it is processed so that it may be referred to again if the bird is recovered, or if the information is required for analysis.

Since the scheme began in 1953 a total of 780,000 birds of 657 species have been banded, of which 70,500 (9·1 per cent) have been subsequently recovered. Many of the birds are recovered on more than one occasion, the record being held by an Eastern Silvereye (*Zosterops lateralis*), banded in Sydney, that has been retrapped a total of 287 times in 482 days.

More individuals of the Eastern Silvereye have been banded than of any other species, namely, 88,000. Other species of which



The generalized migration route of the Short-tailed Shearwater (*Puffinus tenuirostris*) as deduced by Dr D. L. Serventy in 1953 from sight records and museum specimens. The black dots indicate the collecting localities of museum specimens. Recoveries of Short-tailed Shearwaters banded in Australia by Dr Serventy and members of the Australian Bird-Banding Scheme, as indicated on the map by open circles, have supported Dr Serventy's deduction. For the sake of simplicity, recoveries from the east coast of Australia are not shown. [Map after Marshall and Serventy, 1956.]

more than 20,000 have been banded are: Silver Gull (*Larus novaehollandiae*), 76,000; Short-tailed Shearwater (*Puffinus tenuirostris*), 49,000; Crested Tern (*Sterna bergii*), 45,000; Pied Cormorant (*Phalacrocorax varius*), 33,000; and Yellow-faced Honeyeater (*Meliphaga chrysops*), 22,000.

The Eastern Silvereye has also provided the largest number of individuals which have been recovered, namely, 11,300. Other species of which more than 2,000 have been recovered are: Grey Teal (*Anas gibberifrons*), 3,800; Black Duck (*Anas superciliosa*), 3,500; Black-backed Magpie (*Gymnorhina tibicen*), 2,900; and the Silver Gull, 2,900.

Overseas migration

Over the years information on the movement of birds between Australia and other parts of the world has been slowly accumulating. The migration route of the Short-tailed Shearwater (Tasmanian Muttonbird), as shown in the map on page 185, was deduced by Dr D. L. Serventy in 1953 from sight records and museum specimens. Following the large-scale banding of this species, evidence based on the recovery of banded birds has supported this hypothesis. The two recoveries so far reported for the Sooty Shearwater (*Puffinus griseus*) indicate that this species might also make a migratory circuit of the Pacific Ocean similar to that of the Short-tailed Shearwater. The Fleshy-footed Shearwater (*Puffinus carneipes*) has been banded in large numbers on Lord Howe Island and recoveries have shown that the species migrates to the Sea of Japan, where it appears to spend the winter. Banding has confirmed that the Wedge-tailed Shearwater (*Puffinus pacificus*) does not leave Australian waters.

The familiar sight of a Wandering Albatross (*Diomedea exulans*) gliding tirelessly behind or alongside a ship in the Southern Hemisphere always excites admiration. The banding of these birds in New South Wales coastal waters by the Albatross Study Group has resulted in spectacular recoveries from their breeding sites on South Georgia in the South Atlantic Ocean, from Marion, Possession, and Kerguelen Islands in the south Indian Ocean, and from the Auckland Islands in the South Pacific Ocean. This study complements the life-history studies of the Wandering Albatross being undertaken by members of the Australian National Antarctic Research Expeditions on Macquarie Island and of the British Antarctic Survey on South Georgia. Chicks banded in the course of these studies are now returning to breed, the youngest at 9 years old.

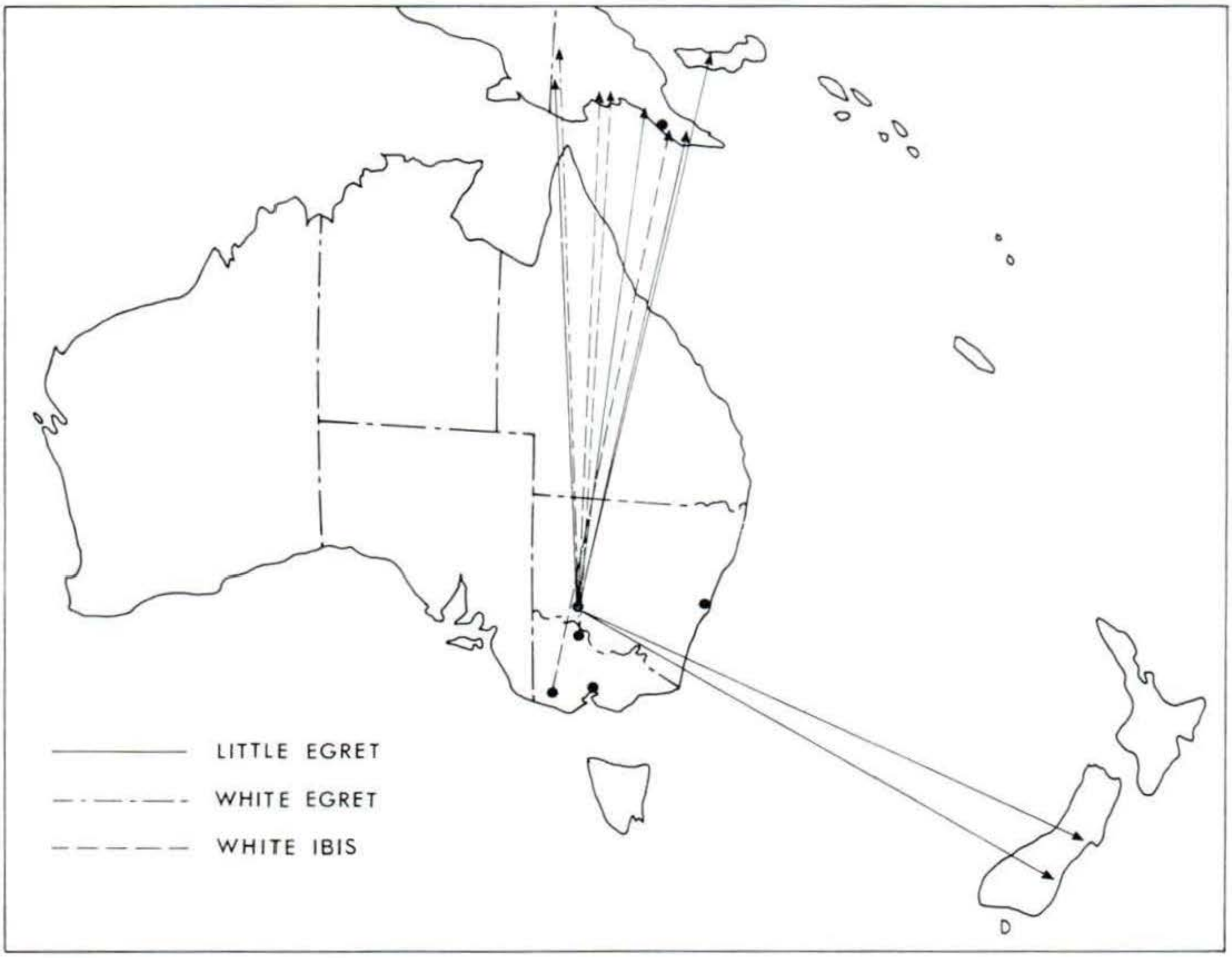
The Giant Petrel (*Macronectes giganteus*) is another major wanderer and is known from banding studies to make a circumpolar movement during the early years of its life. Young birds banded on Macquarie Island have been recovered as far afield as Argentina, Chile, South-west Africa, Australia, New Zealand, Fiji, and Tahiti.

The banding of waders wintering in Australia has resulted in the recovery of a Sharp-tailed Sandpiper (*Erolia acuminata*) in Siberia, an Eastern Curlew (*Numenius madagascariensis*) in South Korea, and a Japanese Snipe (*Gallinago hardwickii*) in Japan, confirming the predicted movements of these species. The banding of water birds revealed some surprises and it has been established that the White Ibis (*Threskiornis molucca*), White Egret (*Egretta alba*), and Little Egret (*Egretta garzetta*) will move between Australia and New Guinea, as shown in the map on page 187. Little Egrets banded in Australia have also been recovered in New Zealand and New Britain.

Determination of the movements of waders and water birds is of practical importance, as many of these species have been incriminated in the epidemiology of insect-borne virus diseases.

Movements within Australia

Information is accruing on the movements of many species within Australia. Results from the large-scale banding of Eastern Silvereyes have shown that while some individuals from Tasmania and Victoria may winter in New South Wales, or even Queensland, others remain resident throughout the year. Migratory and nomadic movements have also been recorded for several species of honeyeaters, including the White-naped Honeyeater (*Melithreptus lunatus*), Yellow-faced Honeyeater (*Meliphaga chrysops*), White-plumed Honeyeater (*M. penicillata*), New Holland Honeyeater (*Meliornis novaehollandiae*), Red Wattle-bird (*Anthochaera carunculata*), Spiny-cheeked



Determination of the movements of waders and water birds is of practical importance, as many of these species are involved in the epidemiology of insect-borne virus diseases. In this map movements are shown of the White Egret (*Egretta alba*) and White Ibis (*Threskiornis molucca*) between Australia and New Guinea, and of the Little Egret (*E. garzetta*) from Australia to New Guinea, New Britain, and New Zealand. [Map after Hitchcock, 1966.]

Honeyeater (*Acanthagenys rufogularis*), and Little Friarbird (*Philemon citreogularis*). With the establishment of additional banding stations operating along the routes already known to be taken by migrating honeyeaters, it is hoped that in the future these movements may be documented more fully.

Results obtained from the banding of waterfowl have shown that while some species, such as the Chestnut Teal (*Anas castanea*), may be somewhat sedentary and have regular breeding seasons, others, such as the Grey Teal (*A. gibberifrons*), are completely nomadic and breed whenever and wherever conditions prove suitable.

The Straw-necked Ibis (*Threskiornis spinicollis*) and White Ibis (*T. molucca*) have also been shown to be highly nomadic, dispersing widely from their breeding colonies.

Some interesting results have come from the banding of birds of prey and it has been shown that the young of these species are highly mobile. Some of the more notable records include: a Swamp Harrier (*Circus approximans*), banded at Antill Ponds, Tasmania, that was poisoned 13 months later at Chatsworth, N.S.W., a distance of 950 miles; a Brown Goshawk (*Accipiter fasciatus*), banded near Geelong, Victoria, that was shot 7 months later at Brewarrina, N.S.W., a distance of 570 miles; a Wedge-tailed Eagle (*Aquila audax*), banded near Canberra, A.C.T., that was shot 8 months later at Cunningham, Queensland, a distance of 535

A small passerine being banded. The data obtained from the banding of these species at regularly operated banding stations are providing valuable information on the seasonal fluctuations and movements of bird populations.

miles; and a Whistling Kite (*Haliastur sphenurus*), banded near Tungkillo, South Australia, that was shot 16 months later at Brooweena, Queensland, a distance of 1,020 miles.

Many birds of prey are being deliberately killed, often by landholders, and banding has given some idea of the magnitude of this loss: of 290 Wedge-tailed Eagles banded, 46 (1 in 6) have been recovered, of which 33 are known to have been shot or trapped; of 175 Brown Goshawks banded, 27 (1 in 6) have been recovered, of which 23 are known to have been shot or trapped. These are very high recovery rates and are only equalled by some species of waterfowl.

The widespread movements within Australia of other species, including gulls, terns, cormorants, and gannets, are also being clearly demonstrated by banding.

Although the scheme is still too young for full consideration to be given to longevity data, the following are the records of the longest elapsed time between banding and recovery, in years, for some species:

Black-browed Albatross (*Diomedea melanophris*), 13·2
Giant Petrel (*Macronectes giganteus*), 13·1
Wandering Albatross (*Diomedea exulans*), 12·6
Black-backed Magpie (*Gymnorhina tibicen*), 12·0
Crested Tern (*Sterna bergii*), 11·7
Wedge-tailed Shearwater (*Puffinus pacificus*), 11·0
Black Duck (*Anas superciliosa*), 11·0
Silver Gull (*Larus novaehollandiae*), 10·5
Pied Goose (*Anseranas semipalmata*), 10·0
Fuscous Honeyeater (*Meliphaga fusca*), 8·8
Eastern Silvereye (*Zosterops lateralis*), 8·5
White-browed Scrub-wren (*Sericornis frontalis*), 7·0
Superb Blue Wren (*Malurus cyaneus*), 5·8
Striated Thornbill (*Acanthiza lineata*), 5·3

With the exception of the Wandering Albatross and Silver Gull, all the above birds were banded as adult birds, so are in fact older than the longevity data indicate.

The Australian Bird-Banding Scheme has made an important contribution to Australian ornithology, and the enthusiastic support being given by individual banders, who have made this work possible, ensures that the contribution will continue to be made. The knowledge being gained is, apart from its purely scientific value, essential for promoting the effective conservation of native species, the management of game-birds, and the control of those which are pests.

[*Photos in this article are by Ederic Slater*.]

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The Talgai cranium encrusted with carbonate, as it appeared to the Trustees of the Australian Museum in 1896 and 1914. [Photo by the late Louis Schaeffer, 3rd September, 1914.]

THE TALGAI CRANIUM: THE VALUE OF ARCHIVES

By N. W. G. MACINTOSH
Challis Professor of Anatomy, University of Sydney
(With grateful acknowledgment to Dr Alex Ritchie, Curator of Fossils at the Australian Museum)

THE Talgai cranium, one of the earliest human remains yet found in Australia, was discovered near Dalrymple Creek on the southeastern Darling Downs, Queensland, sometime in the 1880's. Until about a year ago it was thought that the very first communication made to scientists about the existence of the Talgai cranium and the detached crowns of two of its teeth was a letter dated 1st April, 1914. That letter, from Mr E. H. K. Crawford, the owner of the cranium, to Professor Edgeworth David, of the University of Sydney, asked for appraisal of its value with a view to selling it.

Following the recent revival of interest in the Talgai cranium some original casts were relocated in the Australian Museum and a subsequent search through old registers, correspondence files, curators' reports, and Trustee's minutes has unearthed a wealth of information concerning an earlier, and hitherto unsuspected, chapter in its history. These findings, presented below, illustrate the value of archives and the importance of their preservation.

On 22nd August, 1914, the press reported a meeting of the British Association for the Advancement of Science at which Professors

David and Wilson exhibited the Talgai cranium. Between then and 1925 David wrote frequently to the press and he was quoted in press reports a number of times, sometimes incorrectly. Some of the correspondence between David and Mr Crawford, who sold the cranium to the University of Sydney, has survived. Typescript notes by David on the subject exist in the University archives; these notes, although expressed with caution, credit the cranium with a geological status which apparently was not appreciated by Dr S. A. Smith.

These were the only sources one could consult prior to April, 1918, when Dr S. A. Smith's monograph on "The Fossil Human Skull found at Talgai" was published. Smith said (p. 352) that "under the circumstances of this discovery, no absolutely certain evidence exists as to the exact level at which the skull was located" and (p. 353) "in view of the inconclusive nature of the geological evidence, the anatomical investigation becomes of paramount importance". In summing up his findings, Smith said (p. 381), "In the palate, jaw and teeth, there are concentrated the most primitive characters found in human skulls in these regions"; and, on p. 382, "the geological evidence of the age of the fossil, though more valuable than was thought at the time the skull first came under notice, is admittedly imperfect, since it depends so largely on an untrained observer's narrative of events and conditions existing over thirty years ago. . . . But in the light of the anatomical facts here set forth [i.e., "certain characters more ape-like than have been observed in any living or extinct race, except that of Eoanthropus"], the claim to high geological antiquity—the assignation of this fossil to the Pleistocene — is very strongly supported. . . ."

In other words, Smith stressed doubt as to the geological and historical bona fides of the cranium. At the same time, he claimed bona fides for the antiquity of the cranium on the basis of the uniquely primitive features which he believed he discerned in its palate, jaw, and teeth.

Dubois in 1920, Campbell in 1925 and 1930, and Burkitt in 1927, showed that Smith's interpretation of the teeth could not be sustained. Hellman in 1924 showed that Smith failed to take into account fractures of the jaw and palate and so Smith's interpretations of these needed modification also. The saving comments by Dubois, Burkitt, and Hellman that nevertheless the teeth, jaw, and palate were of a generalized primitive human type, tended to be overlooked or ignored. The significance of the cranium was therefore not only reduced, but reduced excessively.

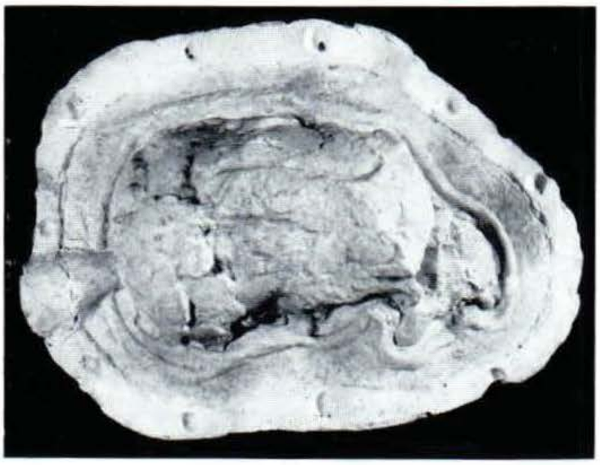
To restore the reputation of the cranium it seemed necessary to give it a genuine history, provided, of course, it was entitled to one. First, every incident relating to its discovery and subsequent adventures needed to be sought and totally substantiated. Secondly, the locus from which it came would have to be rediscovered on the basis of David's notes and the stratum tested for similarity with the composition and colour of the cranium itself and its crust. If these proved convincing, it would be reasonable to spend time and effort in reassessing the anatomy of the cranium; but this would involve taking the cranium apart at its lines of fracture, removing the intervening crust, and reassembling the fragments in edge-to-edge apposition—a daunting task.

Very briefly, one can now say with considerable certainty that geologically the cranium has a minimum antiquity of 13,000 years B.P. and further avenues for testing and perhaps elevating this figure are slowly becoming available.

Anatomically, I rather strongly incline to the view that it has some morphological affinities with *Homo erectus*.

The investigations of what happened to the cranium since its discovery are too complex to be described now, and I think will need to be presented in the form of a book at some future date. A few major items are mentioned here.

In 1954 Mr S. L. Larnach found in the Department of Anatomy, University of Sydney, two series of glass plate negatives, totalling eighty-five, which present more clearly than can be learned from Smith's monograph just how and in what order work was done on the cranium in 1914–1915. Serial numbers from 1367 to 1378 and from 1384 to 1447 are inked on the emulsion margins of these plates. The writing is that of Mr Louis Schaeffer, then Chief Laboratory



The cast mould of the Talgai cranium located at the Australian Museum's Shea's Creek store in May, 1968, by Dr A. Ritchie and Mr R. Witchard, of the Australian Museum, and Dr J. Pickett, of the Mining Museum, Sydney. This provided the starting point for the subsequent finding of five painted casts and numerous archive records in the Australian Museum. Above is a vertex view, and below is a basal view. [Photos: C. V. Turner.]

Assistant and Photographer in the department. The glass plates are not dated and so the problem has been to fit dates to them.

From data in the University of Sydney archives it was deduced that the first series of glass negatives (1367–1378) were made on 3rd and 4th September, 1914. A letter from Mr E. H. K. Crawford requesting return of the cranium had been received on 3rd September, and an emergency rush job of making a photographic record produced these twelve various views of the encrusted cranium.

Purchase of the cranium was made on 26th October and the second series of glass negatives (1384 onwards) apparently began that same day. There appears to have been a sense of urgency in all these events and some of the photographs suffer from this haste. Plates 1384–1387 show guide tapes, preparatory for a saw cut to divide the cranium in half.

Through the courtesy and collaboration of Mr E. H. K. Crawford's daug ter, Mrs Nell Jenkins, and his son, Mr Norman Crawford, I was provided with archival material which indicated that the crown of one of the detached teeth was returned to Mr E. H. K. Crawford, being received by him on 29th November, 1914. Working backwards from this, plates 1388–1390, which are photographs of the detached teeth, were made on 21st November (there are letters to support this deduction).

I had not the slightest proof of when any of the extant casts had been made, although I suspected that the first cast of the encrusted cranium had been made in conjunction with the first series of photographs, i.e., 1367–1378, and this has now been confirmed; moulds were made between 7th and 13th September (see the table below). More importantly, the completion of removing the crust, dividing the cranium, drilling out the interior, and reassembling the two halves would be established by the making of the cast of the cranium after its cleaning. As will also be seen from the table below, these moulds were taken in hand by the Australian Museum on 12th July, 1915.

Hence, in brief, the glass plate negatives recording the technical development and sectioning of the cranium are now dated, and the work itself determined as having been done between 26th October, 1914, and 12th July, 1915—say 8 months.

Dr Ritchie's first discovery was Mould T. 615 (see photos on this page), which he located in the Australian Museum's Shea's Creek store for excess material. Using this item and its entry in the Mould Register as a starting point, he worked backwards through the various archives and produced information which I have abstracted and tabled as follows:

MOULDS re TALGAI	CASTS re TALGAI
Mon. 7 Sept. 1914. Letter by David says that Wilson asked on Sat. night that the cranium and 2 teeth be sent immediately to the Museum for casting. (Report by C. Hedley to Etheridge states matter put in hand at once, mould now completed and skull ready to be returned.) **Sun. 13 Sept. 1914.** Minute by Etheridge; Mr. C. Hedley informs me skull received during my absence and duly put in hand for casting. **Sept. 1914.** T.509 Waste Mould. T.510 Second Waste Mould.	**17 Nov. 1914.** L.1096 from T. 509. (Checked by Ken Mayfield 14.5.1956.)
9 July 1915. David, at request of Smith, asks Etheridge to cast the exterior of the developed cranium; cast of the interior will be done in Dept. of Anatomy. **12 July 1915.** Etheridge agrees. Will keep a copy of former; asks for a copy of latter.	(No record occurs in either Mould or Cast Registers about either of these products.)
	May 1916. L.1318, L.1319 } See Moulds T.509–10. 1 Cast to Syd. Univ. 27.5.1916. 1 Cast to Dr. S. A. Smith. 29.5.1916.
July 1916. T.530. Mould destroyed.	**2 Sept. 1916.** Letter Etheridge to Dr. Smith, Miss King has finished colouring casts for University. £4.4.0. T.530 { L.1324 After cleaning—for Aust. Mus.; L.1325 After cleaning—for Prof. Smith, Manchester.; L.1326 After cleaning—for Mr. Joynton Smith. T.509–10 { L.1327 Before cleaning—Mr. Joynton Smith.; L.1328 Before cleaning—Geol. Dept. Syd. Uni. T.530 { L.1329 After cleaning—Geol. Dept. Syd. Uni.; L.1330 After cleaning—Anat. Dept. Syd. Uni.
June 1928. T.615. (After cleaning) to replace T.530. Prepared from cast presented by W. Watkin Brown.	T.615 L1324 (Stored at Shea's Creek 8 Sept. 1956.—Ken Mayfield.) (Located by Dr. A. Ritchie, May 1968.)

Dr Ritchie then came upon another letter from Etheridge to David, dated 5th July, 1916. It says: "My Dear David, I send some documents for your perusal, which please return when done with. I found these when overhauling the old papers of 1896, and although the occurrence took place within my Curatorship, the whole affair had slipped my memory; evidently Mr. Crawford did not obtain the 'opinion of some Professors' (see his last letter). The whole affair is curious!"

David replied on 6th July, 1915: "My Dear Etheridge, Very many thanks for sending me the interesting correspondence with E. H. K. Crawford, which I now return. He never let on to me that he had placed the skull under offer to the Australian Museum. . . ."

Dr Ritchie, of course, could not let this rest, and within a couple of days located the 1896 correspondence. This reveals an episode in the history of the Talgai cranium which I had never remotely suspected.

Etheridge says the whole affair is "curious"; but it is even more curious than that, because Professors David and Wilson are recorded as having been present (as Trustees) at the Board meeting of the Museum on Tuesday, 6th October, 1896, when the Talgai cranium was examined with a view to purchase, a point which Etheridge either missed or elected not to mention.

It seems best to let the correspondence tell its own story:

28 *Sept*. 1896. R. Etheridge, Curator, to Mr. K. Crawford, Waterloo, New England: "I see from the *Walcha Witness* that you have in your possession, a petrified skull supposed to be that of a blackfellow. I have to ask you, on behalf of the Trustees of the Australian Museum, if you would let me have the loan of it for a short time, for the purpose of examining it, or as a gift to the collection in the Museum if you can see your way to do it."

2 *Oct*. 1896. Mr. E. H. K. Crawford to the Curator, Australian Museum: "Your communication No. 914 dated 28 inst. duly to hand. In reply thereto I desire to inform you that I have forwarded the 'skull' alluded to, to Messrs. Turner & Henderson of Hunter Street Sydney. It will be on view there for some time. I have sent it down in order to ascertain its value. I am in communication with some friends in England on the subject and trust soon to hear their opinion. I would not part with it unless I got a very tempting offer, as I am very fond of collecting curios and have some rather uncommon ones."

3 *Oct*. 1896. R. Etheridge, Curator's Report to the Trustees, Australian Museum, for Sept. 1896, 40 No. 9. (Submitted to meeting of the Board, 6 Oct. 1896): p. 6 *Fossil Human Skull:* "Messrs. Turner & Henderson, the well known stationers, send for exhibition, & sale on behalf of Mr. E. H. Crawford of Waterloo Station, near Walcha, a 'petrified' Aboriginal Skull. It is from the Darling Downs, the calcareous sinter cover leading me to believe that it comes either from a swamp or spring deposit. The sender is open to an offer for its purchase".

Tuesday 6th October 1896. Trustees' meeting. Present: The Crown Trustee (Dr. Cox)—The Auditor General (Mr. Rennie)—Dr. Belisario—Dr. Norton—Dr. Williams—Prof. David—Prof. Wilson—the Curator and the Secretary. *Minute Book* 1896. p. 40 Curator's Report, item 9 (ref. C.70/96): "*Fossil Human Skull* was exhibited. It was agreed to inform the proprietor that the Trustees are ready to favourably consider the purchase of the skull, but would like to know what sum is asked for it."

7 *Oct*. 1896. S. Sinclair, Secretary Aust. Museum, to Messrs. Turner & Henderson, Hunter St.: "On behalf of the Trustees I am to thank you for submitting to them the Fossil Human Skull forwarded to them by Mr. E. H. Crawford. The Trustees are much interested in it & think that the Australian Museum would be a most suitable place to deposit it, as it would be then accessible for public information & scientific description. They would be quite willing to purchase it if your friend would be kind enough to name a price."

8 *Oct*. 1896. Etheridge to E. H. K. Crawford: "On behalf of the Trustees of the Australian Museum, I have the pleasure to acknowledge the receipt of your letter of the 2nd inst. re 'skull'. The skull has been shown to us by Messrs. Turner & Henderson, who have been asked to ascertain from you what value you place on it."

11 *Oct*. 1896. Crawford to The Curator: "I have the honor to acknowledge receipt of yrs dated 8th inst. being No. 941. And in reply thereto to state that owing to the fact of my being in communication with some friends in England about the Skull, I would not like to put any value upon it until I again hear from them. I will be probably sending it home to a brother of mine who is studying Medicine in London."

13 *Oct*. 1896. Sinclair to E. K. Crawford: "Your letter of 11th inst. is to hand, & I note what you say regarding the 'Fossil Human Skull'. We will be glad to hear from you again when you have decided what to do with it. If you should think of sending it out of the Colony, I would be glad if you would allow us first to take casts, photographs, and measurements, and to publish an account of it. For that purpose we would be glad to have details as to where & how it was found. The specimen having been found in Australia, it is fitting that the first description of it should be published in the Colony. I may say your specimen is of great interest to Anthropologists & Palaeontologists, but not so much so from a medical point of view."

31 *Oct.* 1896. Etheridge to E. D. Crawford: "I very much regret to find, on my return from the Country, how little probability there is in our acquiring the 'fossil' skull sent down by you to Messrs. Turner & Henderson. The specimen should most unquestionably be deposited in some one of the Australian Museums, and not sent out of the Country, as its very condition forbids it having anything but a small medical value. Of course, its intrinsic value very much depends on whether or no a reliable history of its discovery, & the details of the latter can be furnished by you. However, I shall be glad to learn your final decision."

30 *Oct.* 1896. R. Etheridge, Curator's Report to the Trustees, Australian Museum, for Oct. 1896, 44 No. 10. (Submitted Meeting Board 3 Nov. 1896) p. 6–7 *Fossil Skull:* "I regret to say that the owner of the 'Fossil' Skull (Mr. G. D. Crawford) exhibited at the last Board cannot be induced to give a definite answer re the sale of the specimen."

Tues. 3 *Nov.* 1896. Trustees' Meeting. Present: The Crown Trustee (Dr. Cox), The Auditor General (Mr. Rennie), Dr. Belisario, Mr. Bradley, Prof. Haswell, Mr. Hill, The Curator and the Secretary. Prof. David sent apology for absence.

Minute Book 1896, p. 43 Curator's Report, item 6: "Fossil Human Skull—owner does not wish to part with it to museum."

18 *Nov.* 1896. Crawford to the Curator: "In reply to yours of the 31st ultimo re fossil skull. I desire to state that when sending it to Messrs. Turner & Henderson, I did so with a view of obtaining (if possible) the opinion of some Professors or others interested in such subjects, as to its real value. I had been informed that it would be considered very valuable in England, hence the reason for writing to my brother in London. I am sorry to say that up to date I have not received any reliable information on the subject. Therefore I am still at a loss as to what to say concerning it. As to its history all I can say is it was found by Mr George Clark 'of Talgai Station Queensland' between 15 & 20 years ago in a gully off Dalrymple Creek near Warwick. He was searching for a suitable place to sink for water when he came upon it laying in the bed of the gully where it had evidently been washed by a flood. I would sell it provided I got its full value, but not unless—you are welcome to take photos of it & measurements—but not castings."

23 *Nov.* 1896. Etheridge to E. K. Crawford, Walcha: "I am in receipt of your letter of Nov. 15th in relation to the fossil skull. The value of the specimen from the Geological standpoint is comparatively small from the fact that it does not possess what we call 'geological history'. Had it been found at any depth in alluvial deposits, or in a cave deposit the matter would have been very different. Its osteological value is still less from the fact of all the characters being concealed by sinter. Will you meet us this far—when you have made up your mind as to price, give the Australian Museum the first refusal."

The *Walcha Witness* commenced in 1889. The Public Library, Sydney, carries copies only from 1898 to 1906. In reply to my enquiry Mr E. L. Hogan, editor of the *Walcha News*, wrote to me on 28th June, 1968, that the *Walcha Witness* and the *Walcha News* were both burnt out some 40 years ago; that as a member of the Walcha Historical Society he had tried to locate early copies, but had had little success.

However, Mr S. L. Larnach made a search for me in the Public Library, Sydney, and on page 744 of the *Sydney Mail*, Saturday, 10th October, 1896, found the following:

"*The Week*. A curiosity in the form of a petrified skull of an aboriginal has been received by Messrs. Turner & Henderson from one of their customers residing at Walcha. It was found some years ago by a boundary-rider at a place called Dalrymple Creek, on the Darling Downs, Queensland. The skull was in the creek. The form of the skull is well preserved though on one side there is a hollow, indicating that its owner had received a blow, which probably killed him. The specimen is heavy and has become a solid mass. Although the teeth of the upper jaw are well preserved, the lower jaw is missing. The shape of the skull—a protruding jaw and low retreating forehead—indicates a nature of almost exclusively animal propensities. This unique relic of past times will be submitted to the authorities of the Museum for inspection."

I doubt if further evidence about this 1896 episode will come to light. It adds to the adventures undergone by the Talgai cranium.

I have already referred to the help of Mrs Nell Jenkins in tracing the location of the cranium over the years; she had told me Mr Crawford managed Waterloo Station, Walcha, from May, 1895, to December, 1898, which dovetails precisely with the archives found by Dr Ritchie.

While these archives have added to the story, they have added another puzzle. The Talgai cranium in its encrusted state looked like no other human fossil cranium on record. If David and Wilson did see it in 1896, I am certain they would have recognized it in 1914 and I am satisfied the description in the *Sydney Mail* identifies it as the same cranium. Were they, in fact, not present, although the minutes say they were? If they did see it, why remain silent in 1914? One can only conclude by saying one gets used to mysteries with the Talgai cranium.

FURTHER READING

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Dubois, E. (1920): "The Proto-Australian Fossil Man of Wadjak", *K. Akademie van Wetenschappen, Amsterdam*, vol. 23, pp. 1013–51.

Hellman, M. (1934): "The Form of the Talgai Palate", *American Journal of Physical Anthropology*", vol. 19, pp. 1–15.

Macintosh, N. W. G. (1967a): "Fossil Man in Australia", *Australian Journal of Science*, vol. 30, no. 3, pp. 86–98. 1967b: "Recent Discoveries of Early Australian Man", *Annals of the Australian College of Dental Surgery*, vol. 1, pp. 104–126.

Smith, S. A. (1918): "The Fossil Human Skull from Talgai, Queensland", *Philosophical Transactions of the Royal Society of London.*

BOOK REVIEWS

ASTRONOMICAL OBJECTS FOR SOUTHERN TELESCOPES, by E. J. Hartung; Melbourne University Press; pages x, 238. Price, $6.75.

The lists of objects in this book have been compiled as a result of many years of experience by Professor Hartung. He has selected just over 1,000 objects from about 4,000 which have been examined by him in the part of the sky accessible to his telescope. A supplementary list of about eighty objects within 40° of the North Pole has been added to increase the usefulness of the book for northern observers. The objects are listed first in order of right ascension. Here the positions are given for 1950 with the variations which enable the positions to be found for other years and with brief description. Then each object is given a more complete description in lists under constellations arranged in alphabetical order. Some general information on the constellations is included and the book ends with an addendum for northern observers.

Some introductory chapters occupy the first forty pages of the book. As is logical, these begin with an account of radiation which provides the means for transmitting the information from the celestial bodies. Then follow chapters on stars, star clusters, galactic nebulae and extra-galactic systems, all of which are represented in the lists of objects. These chapters bring together material to help in the understanding of brief descriptions of the respective objects in the main lists. Chapter 6 is on amateur observing, and in it Professor Hartung gives some very useful information from his long experience as a telescopic observer. This includes some advice on the choice of an instrument and the mounting of it and on the observatory, clothing, lighting, and some accessories to assist observation. A section of half-tone plates shows Professor Hartung's telescope and observatory and thirty of the more interesting and photogenic objects photographed at Mount Stromlo Observatory.

Observers who wish to extend their knowledge of the sky and to make the acquaintance of the objects about which they may read will find this book a most useful reference.—*Harley Wood.*

CHILDREN OF THE DESERT, by Phyl and Noel Wallace. Thomas Nelson, Sydney, 1968; 64 pages. Price, $2.95.

Young children, of course, are "naturals" for the photographer, and Aboriginal children are even more "natural" than most. This book, by a husband and wife from Melbourne who became entranced by and deeply involved with the Pitjantjatjara people of Ernabella Mission, Central Australia, is outstanding because the authors really know these children they photograph and write about so sympathetically.

A handsome layout by Alison Forbes and excellent colour printing (Hong Kong) make this a first-class and reasonably priced gift book for Australia or overseas.

But after browsing appreciatively through it, one is left with the disturbing question: What will become of these lively, intelligent, and very distinctive young personalities? Will they be enabled to lead constructive and fulfilling lives, or will they be condemned to the fringe-dwelling, outcast situation of their parents?—*D. R. Moore.*

Macquarie Island's main colony of King Penguins (*Aptenodytes patagonica*), at Lusitania Bay. This view shows the steep slopes of the plateau and the tussock-covered flats of the southeastern coast of the island. [Photo: E. W. Dawson, New Zealand Oceanographic Institute.]

The Australasian Subantarctic Islands

By J. C. YALDWYN
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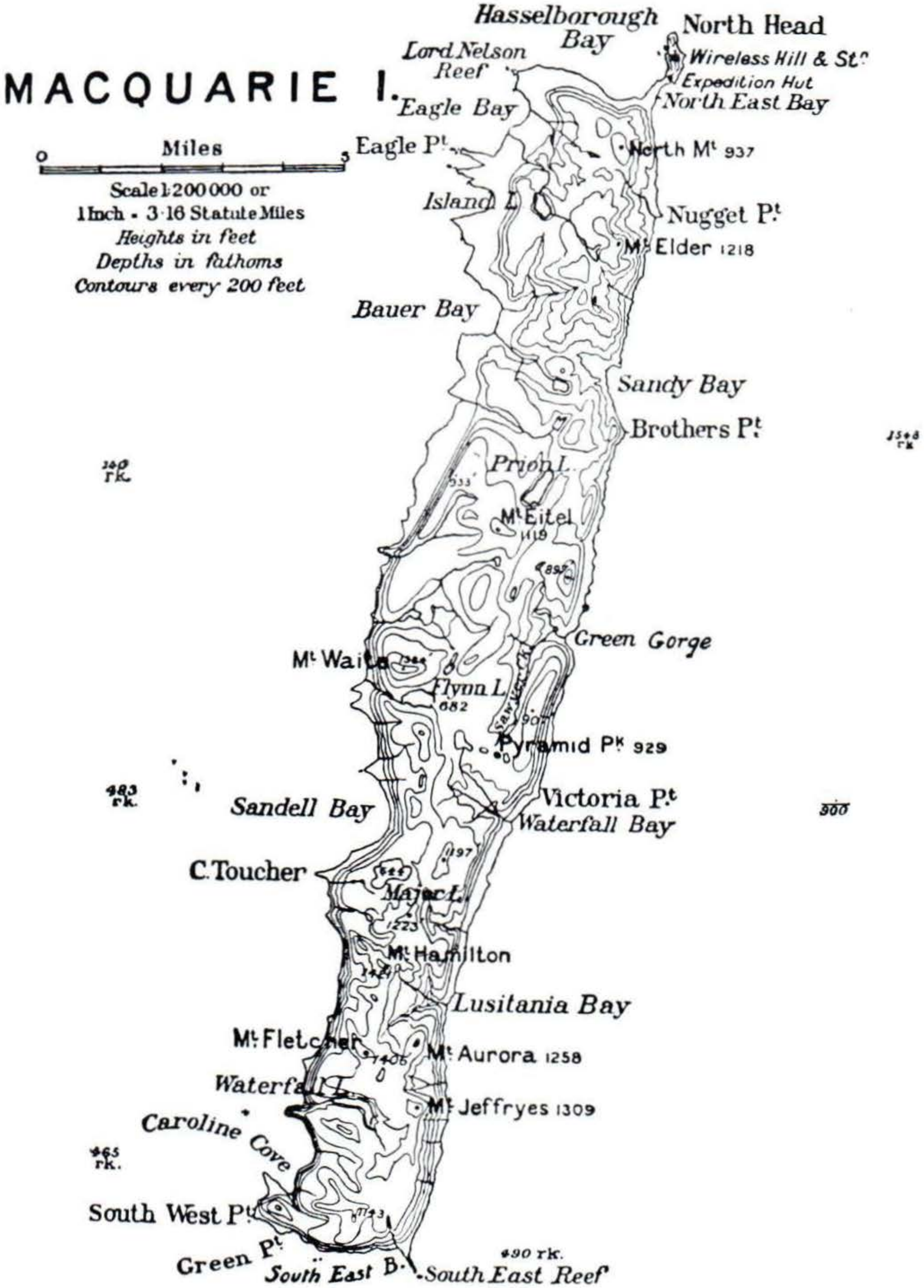
Part 2

This is the concluding part of this article. The first part, in our last issue, dealt mainly with the Auckland Islands and Campbell Island.

Macquarie Island

Macquarie Island lies some 350 miles to the southwest of the Auckland Islands and about 1,400 southeast of Melbourne. It is a long narrow island about 21 miles from north to south, with a width of up to 3 miles and an area of 46 square miles. Though it is a little bigger than Campbell Island (area about 40 square miles), it rises to a height of only 1,423 feet. Macquarie consists largely of an elongated, steep-sided plateau between about 600 and 800 feet high with flat or gently sloping areas and occasional higher hills and dissected valleys. There are narrow coastal strips on the east coast and somewhat wider strips on the west coast. The northern tip of the island consists of an isolated hill separated from the main part of the coast by a low and narrow isthmus, across parts of which waves can sweep during exceptional storms. The Australian National Antarctic Research Expedition permanent station is located at the north end of this isthmus. There are a number of small lakes and shallow tarns on the plateau, most with outlets leading to the west coast. The whole plateau and its hills show evidence of former glaciation, so a



This map is based on a survey by L. R. Blake and was published in the *Australasian Antarctic Expedition* 1911–14 *Scientific Reports*, Pleistocene ice-cap is indicated. The land flora and fauna should be considered, then, as entirely post-glacial.

The climate of Macquarie Island is unexpectedly uniform, with a yearly average rainfall of about 41 inches and a mean annual temperature of about 40° F. Relative humidity is high, varying from 90 to 94 per cent, fogs are common, and average daily hours of sunshine vary from less than half an hour in June to just over 3 hours in February. Such a climate is the most important single factor affecting the subantarctic environment. The lack of any period of warm temperatures, the prevalence of high winds, and the reduced amount of sunshine combine to produce a habitat most unfavourable for plant growth and soil development.

As on the other islands, the fur seals were all but exterminated by about 1820, so that sealers from Sydney, Hobart, and later New Zealand turned to elephant seals, and finally penguins, for oil. With some periods of inactivity when seal numbers were too low to make returns worthwhile, this exploitation continued until after the First World War. The Antarctic explorer Sir Douglas Mawson set up a radio and meteorological station on Macquarie Island in 1911 during the Australasian Antarctic Expedition and this was occupied continuously until 1915. It was during this period that the Commonwealth Fisheries Investigation Ship *Endeavour*, well-known for its marine biological work around eastern and southern Australia, left the island in a dense fog, after landing stores for the 1914 party, and was never heard of again. Mawson visited Macquarie again in 1930 with the British, Australian, and New Zealand Antarctic Research Expedition (BANZARE) and was later able to persuade the Tasmanian Government to terminate the sealing licences and to declare the island a wildlife sanctuary in 1933.

No further scientific expeditions visited Macquarie Island until 1948, when the first Australian National Antarctic Research Expedition (ANARE) party re-established a scientific and meteorological station at the northern end of the island. This station has been permanently manned ever since and has become one of the most important centres for research in subantarctic biology, especially in the fields of seal and sea-bird populations dynamics.

The vegetation of Macquarie Island can be divided into four main types: tussock grassland is found on coastal flats and on all steep, reasonably protected slopes up to a height of about 1,000 feet; subglacial herbfield with a single dominant *Pleurophyllum* species occurs in sheltered valleys and on moderately protected coastal flats and slopes up to about 1,200 feet; peat bogs and fens of various types have developed on coastal terraces and valley floors where the ground is saturated with water to the surface; and tundra or feldmark with low, moss-like cushion plants, which occupies all the areas exposed to high wind velocities—in other words about half the island, including the major part of the upland plateau. Gone here is any trace of the altitudinal vegetation zones of the type described for the Auckland Islands in part 1 of this article. Gone, too, is the floral diversity of the more northern subantarctic islands (as mentioned before, Macquarie Island has only thirty-eight vascular plant species).

The birds of the islands

Seventeen species of albatrosses, mollymawks, and petrels are recorded as breeding at the Auckland Islands. About fifteen of these also occur at Campbell Island, but almost certainly in greatly reduced numbers compared with former abundance; nine breed at Macquarie. On Campbell, sheep have so modified the vegetation and ground surface that burrow-breeding petrels are confined to remote and mainly inaccessible areas. The uniform vegetation resulting from grazing is probably responsible for the high population of Royal Albatross (*Diomedea epomophora*) nesting on the open tussock slopes at Campbell. A conservative estimate gives 4,000 pairs nesting in any one year, but as these large albatrosses breed only every second year the total breeding population of the island is somewhere near 16,000 birds. The albatross breeding at Macquarie Island is the Wanderer (*Diomedia exulans*). This species was killed and eaten by the sealers and there are only about a dozen pairs nesting each year nowadays. Three penguins breed on Campbell and Auckland Islands and four on Macquarie, but only one species, the Rockhopper (*Eudyptes chrysocome*), is common to these three subantarctic islands. Two of the penguins breed in thousands on Macquarie Island, the large King Penguin and the smaller, endemic Royal. Their crowded colonies, with no green vegetation surviving among the massed birds, has been compared to city slums by some observers.

Land and shore birds are varied, but restricted in number, on the Auckland Islands. There are thirty-two breeding species, including some believed extinct, but seven are self-introduced European passerines. Macquarie has ten breeding, or recently extinct, land and shore birds, only three being introduced species. Of special interest are Flightless Duck (*Anas aucklandica*) on Auckland and Campbell Islands; a snipe on the Aucklands; parakeets of the genus *Cyanorhamphus* on the Aucklands and recently extinct on Macquarie, and one or more extinct rails.

Seals

The New Zealand Fur Seal (*Arctocephalus forsteri*) is still present in slowly increasing numbers on all three subantarctic islands but the bulk of the population is now on the southern coasts of the New Zealand mainland. Hooker's Sea-lion (*Neophoca hookeri*) no longer breeds outside the two northern subantarctic islands, and its peak population and dispersal centre is the Auckland Islands, with the Enderby Island colony being by far the largest with about 1,000 animals. This sea-lion, and Antarctic seals such as the Sea-leopard and the Weddell Seal, are recorded as casual visitors to Macquarie. The huge Elephant Seal (*Mirounga leonina*) breeds at Campbell Island, but Macquarie is its population centre in this sector of the subantarctic. There, an estimated 110,000 Sea-elephants indicate the spectacular recovery of this persecuted species during the last half-century.

Sheep, cattle, goats, and cats have been introduced and have run wild on Auckland and Campbell Islands. Pigs are widespread on the main Auckland Island but sheep have now been cleared from this group. Adams Island, in the south of the group, is free from all introduced mammals. There are rabbits of many colours, including black and ginger, on parts of the Aucklands, and also on Macquarie, where they are still slowly and destructively spreading. The Brown Rat is abundant on Campbell but apparently absent from the Aucklands, where mice are abundant in its place. Sheep, cats, rats, and mice all occur wild on Macquarie Island. Feral dogs have been reported from all these subantarctic islands but do not seem to have survived.

The islands' future

What is the future of these interesting islands? Firstly, there is an urgent need to complete floral and faunal surveys, especially on the relatively extensive Auckland Islands. Then, as Professor G. A. Knox, of Canterbury University, recently said in a published symposium on the future of the subantarctic islands, the more detailed study of their biology and ecology can begin in earnest. These islands, with their isolation and their surviving plants and animals, could be ideal open-air laboratories of evolution. Their paramount scientific interest, however, lies in the fact that they represent, in part at least, some of the few remaining island areas that have avoided the destructive activities of man. Therefore, we in Australia and New Zealand have both national and international obligations to maintain and preserve them intact.

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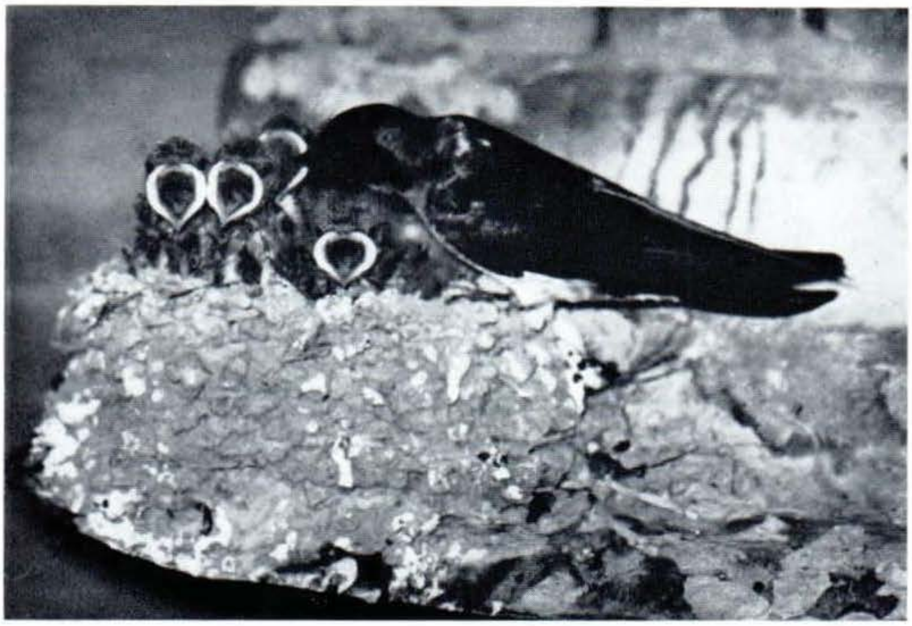

A Welcome Swallow feeding its young in the nest. The nest was constructed in the dark inside a hut. The movement of the nest caused by the landing of the parent produces gaping response in the young. Note that the young are not directing their response towards the parent. [Photo: Author.]

SOCIAL BEHAVIOUR AND ITS EVOLUTION

By JIRO KIKKAWA
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A few years ago, when there was a very severe drought, the University of Queensland pond at St Lucia was one of the few places around Brisbane where water was still present, although there it was amost completely covered with a thick layer of floating vegetation. It was a paradise for swamp hens, grebes, and jacanas, which could anchor their floating nests among weeds, well concealed from casual observers. The jacana, sometimes called the lotus bird, is an aberrant member of the waders and a graceful denizen of lakes and ponds in the tropical and subtropical regions of the world. It has a body length of about 8 inches and extremely long toes of more than 5 inches from front tip to rear. With these long toes the bird walks on floating plants, sometimes with such remarkable speed that careless observers have credited the bird with the ability to walk on water.

As it is such a unique bird and sought after by many of the bird-watchers of the world, ornithology students could be proud of the University of Queensland having a breeding ground of jacanas within the campus. One pair had three small chicks with them that summer, and we often heard the parents' alarm calls. The chicks would react immediately by running to mother and hiding under her wing. The mother was alert and moved about quickly, then suddenly she would start to run. On one occasion, when she stopped some distance away we noticed the chicks apparently emerging out of her. We watched the bird more carefully the next time she started to run. As she stopped and looked at us we saw two pairs of legs sticking out under one of her wings and one pair under the other. She had been carrying three young under her wings! We saw her carry the young in this way several times;

sometimes she would just lift them as they hid under the wing and sometimes she would run to them and pick them up by crouching and spreading her wings.

No other birds are known to have this habit, but many species of waders feign injury to lure enemies away from their nests and terns continuously attack mammalian predators that intrude into their nesting ground. There are, in fact, very many elaborate protective behaviour patterns exhibited in the parental care of birds.

These extraordinary behaviour patterns may be described in dull objective words expressing motor patterns involved, or may be interpreted in terms of motivation, hormonal distribution, and external stimuli. When the latter is done, the parental solicitude, courage, and intelligence of birds, seemingly so persistent and far-sighted, are reduced to intricate patterns of instinctive behaviour, inherited from generation to generation. Strictly speaking, not all of these behaviour patterns are inherited and not one of them is inherited in its entirety. In other words, although the general pattern of such behaviour is stereotyped within a species, there is much variation in minor details which cannot be accounted for entirely by the genetic components. These minor details contain some elements of learning and adjustment.

Ethology

The study of animal behaviour is called ethology, and people who study it from the animal's point of view are identified as ethologists. Ethologists are interested in the behaviour of whole organisms, whereas neurophysiologists are interested in mechanisms of behaviour within organisms and avoid "anecdotes". If you study animal behaviour with an ultimate aim of understanding human behaviour, you are a psychologist and not normally expected to know the biology of animals beyond hens, rats, dogs, and monkeys. Such is, of course, nonsense, and yet it is only recently that students of animal behaviour realized that these divisions are not based on logical consequence but on the different approaches representing different affiliations and traditions within each discipline. Therefore, there is much to be gained by examining themes and methods presented by workers of different fields. In fact, the modern study of animal behaviour is fast becoming inter-disciplinary.

For example, we may ask the following questions in the study of social behaviour. How did such elaborate behaviour as the parental care of birds evolve, and, more generally, how did social co-operation among animals, such as societies of ants and bees and flocks and herds of animals, develop? And how did our own behaviour in complex societies originate? These questions cannot be answered by the anthropomorphism and teleology found in the old art of bird-watching, which we may call "ornithetics" to distinguish it from scientific ornithology. We now must abandon anthropomorphic descriptions which suggest human motives and concerns in animals, and avoid teleological interpretations which imply untested purposiveness in animals.

How, then, do we study the evolution of social behaviour? By social behaviour we mean individual behaviour that potentially or actually affects the behaviour of other individuals. In other words, it has to do with more than one animal, and we are interested primarily in the members of the same species which form a communicator-recipient system in their social behaviour. Social systems that result from individual social behaviour also evolve as well as act as selective agents of individual behaviour, but this aspect will not be dealt with here.

The theory of evolution, simply stated, attempts to explain the following processes: (1) the origin of genetic variation in a population, (2) the inheritance of the stored variability, and (3) the erosion of variation by selection and errors of sampling (mating). Just as great morphological diversity of organisms is produced in this way, physiological and behavioural properties emerge from the same processes. The only difference is the greater interaction between the innate and non-genetic components in the latter. Therefore, depending on whether the behaviour in question is largely innate or largely learned, the mechanisms of evolution to be sought are different. The evolution of man's social behaviour is almost entirely cultural and, although component patterns may be inherited genetically, cultural transmission in the social environment has the generating power of evolution. Of course, cultural evolution is not entirely man's edifice; higher animals can also transmit habits culturally. For example, a local population of muskrats in America learned to store Indian corn in winter and thereby survived food shortages through several winters. However, after one particularly severe drought most of the local population was wiped out. The generation, which survived, did not know about the corn and so did not utilize it. Consequently, they suffered greater mortality through the following winter. Similarly, Japanese workers have recorded the spreading of a potato-washing habit among monkeys in a wild population, after a single individual developed the habit or copied it from man. If the advantage of such habits is persistent, their cultural transmission through generations or any genetic change of behaviour patterns in this direction will be favoured by natural selection.

A hand-reared male Zebra Finch courting a child. [Photo: Author.]

Imprinting

In the study of interaction between experiences and innate social behaviour, ethologists and psychologists have recently drawn together to analyse an extraordinary form of learning called "imprinting". At first ethologists made systematic observations of imprinting. Heinroth found that young geese reared from the egg in isolation produced a "following" response to their human keeper or to the first relatively large moving object they saw. They follow man or these objects as they would their parents. Imprinting need happen for only a few hours or even only a few minutes for the young bird to accept a man as its proper associate and to retain him for the rest of its life. They take to human beings as both parent-companions and fellow members of the species, and at maturity will even direct their sexual behaviour at man.

Imprinting produces this "following" response in many species of birds, although this tendency seems stronger in more social species than in solitary species. The Zebra Finch, a very social species, could be made to associate with human beings and not to respond to the behaviour and calls of its own kind. One such bird even sang a courtship song at the sight of a man and attempted to copulate with his fingertips and ear lobes. If young birds are reared together they will be imprinted to each other so that instinctive social behaviour will be directed at nestmates. The original notion that imprinting is strictly limited in time and direction and is not reversible does not always hold. In some species, at least, the imprintable period is much longer than previously thought, and further, is affected by other forms of learning, such as habituation and conditioning. What makes it so rigid seems to be that the development of a fear response inhibits the ability of imprinting, which under natural conditions helps young birds to be imprinted to one kind of moving object—the parents.

However, if overt fear responses are reduced by a drug such as chlorpromazene the sensitive period for imprinting may be extended. In the same way, habituation may remove the fear response to humans who provide food for the birds in isolation. As a result of frequent feedings, young birds may be imprinted to new foster parents and lose the image of their true parents to which they were initially imprinted.

Significance of imprinting

Since all innate social behaviour requires recognition of fellow members and imprinting seems to contribute much to this function, it has great significance in the study of social maladjustment and mis-orientation. At the same time, since manifestation of social instinct depends on this peculiar form of learning, especially in many higher animals with well developed sociality and parental care, the study of imprinting has a promising future in revealing the releasing mechanisms of innate social behaviour.

Some American psychologists studied the infant-mother reaction in the laboratory by depriving new-born rhesus monkeys of their real mothers and providing them with substitute mothers made of various materials. These monkeys showed a preference for a soft terry-towelling "mother" over a wire-frame "mother" when offered the choice between the two, even though a milk bottle was provided on the wire-frame. In their adult life an extraordinary interference with their instinctive behaviour in reproduction was found. They showed abnormalities in their responsiveness to the opposite sex, not only amongst themselves but also to normal individuals which were known to mate successfully in the past. Many of these motherless monkeys did not succeed in bearing progeny and those that did turned out to be very poor mothers themselves, ignoring or ill-treating their own young. The innate social behaviour pattern of mating was thus modified by experience.

Influence of experience

Among wild monkeys or Zebra Finches the dependent young will not survive if they are deprived of their parents (they are rarely adopted) and natural selection must operate strongly against the inheritance of even a slight propensity for abnormal behaviour in reproduction. Psychologists have also demonstrated that many of the variations in normal sexual behaviour in guinea-pigs are genetic and it is possible to establish different breeds regarding the components of the sexual act. Yet they could also interfere with the normal mating behaviour of individual rats by conditioning, and produced homosexually oriented rats! All this means is that even such innate social behaviour, so important in the maintenance of species, can be influenced by experience, early experiences sometimes resulting in failure to reproduce.

Needless to say, not all instincts are apparent when animals are born. In fact, many instinctive behaviour patterns required for survival and reproduction are not functional until they are "matured". For example, young birds start pecking at various objects while they are still fed by parents and long before they can eat by themselves. The act of pecking is innate, but when it is first elicited it cannot satisfy the biological need of the bird.

Moreover, many instincts are matured in a particular order. Animals, like most of us, cannot do more than one thing at a time, and they are only capable of doing it when in the "mood". They have to be internally "motivated". Therefore, maturing of instincts means that motivation does not occur, or is prevented, until an appropriate time. Early motivation is weak or imperfect, although play sometimes functions as an outlet through which its proper act is facilitated. In the case of change in the instinctive response to the same stimulus, nervous mechanisms are suddenly altered. Most of the song birds spend about a fortnight in the nest, during which time they are imprinted to their parents and develop fear responses to other moving objects that approach the nest. Up till about 10 days old their response is to crouch flat and motionless in the nest. After that the same external stimulus makes them fly out of the nest. This premature leaving is an innate response as much as crouching. The adaptive significance of the behaviour is not hard to appreciate if you think of the chances of their survival. While they are still small, leaving the nest means certain death and, although they may all be killed in the nest, by adhering to the nest there may be a slight chance that the predator will not take all of them or that the parents may return in time to save one or two of them. On the other hand, when they are old enough to fly a few feet at a time, the chance of survival is greater outside the nest than inside when the nest is raided by a predator. When the danger is gone the parents will return to call them from their hiding places and lead them to safety. Admittedly, life is not easy for prematurely fledged young, which are to suffer increased hazards, but they would still have a better chance of survival than if they stayed in the nest at the time of the attack.

Patterns less rigid

In social behaviour co-ordinated innate patterns are not as rigid as the sudden change of the fear response, because the selective forces exerted are not rigid and because, as in imprinting, the interaction between the animal and its social environment is important in survival and successful reproduction. For example, young birds, after leaving the nest, stop gaping sooner if they are fed infrequently and given a chance to peck at food themselves than if they are fed frequently so that they are never strongly motivated towards feeding by themselves. Feeding requires certain skill which has to be learned, and this training is necessary before they can completely drop their earlier instinctive response of gaping. It is not difficult to see the advantage of not having the rigid timetable of change-over of instinctive acts when maturing depends on variable environmental conditions and parental responses.

Thus the natural selection of innate social behaviour is complex, involving interactions between communicators and recipients, both of which are independently affected by the maturing processes of instinctive behaviour and experiences in various environmental conditions.

Origin of innate social behaviour

Let us now consider the origin of such behaviour. We have seen that animals cannot do more than one thing at a time. They are, at any given time, engaged in one activity which involves only a few different movements. For example, they may be sleeping, drinking, or chasing other animals from the territory, but there are not many ways of sleeping, drinking, or chasing. They use certain basic motor patterns which may be varied in different situations. Even in a monkey the number of all behavioural patterns, including significant variations, is about 200. The instinctive acts that produce instinctive reactions in other individuals are not very many. When an inventory of such acts is made for any species, we find that many components of such behaviour patterns are almost identical or similar to other innate behaviour patterns which are not social. In other words, in their origin the communicatory behaviour patterns seem to be borrowed from the instinct to which they were initially exclusive and functional. Fluffing of feathers, which is normally a response of birds to cold weather, seems irrelevant when it is produced in front of an aggressive bird, but there are many irrelevant acts of this nature in social behaviour. The male Zebra Finch, during courtship, may suddenly wipe its beak on a perch; a depressed girl may unconsciously go to a dressing table, and a puzzled man may scratch his head. Such irrelevant activities are often displaced from instinctive toileting behaviour —care of body surface. Supposing someone watching you comprehended such an out-of-context act as a signal and unconsciously responded to it with behaviour displaced from some other instinct, would it be appropriate to the situation? If you can imagine such a situation, it is not hard to understand the significance of the displaced activity in the evolution of social behaviour. We may now say that displacement activities are probable sources of innate social behaviour. There are other conceivable sources, such as intention movements which co-ordinate group behaviour and ambivalent behaviour which shows conflicting tendencies of different drives. Attempts have been made to explain the origin of complicated displays and the parental care of animals in terms of these sources, but the principles of the ritualization of these derived activities are far from understood. All we can say at this stage is that the study of evolution of social behaviour has a strong foundation built by ethologists and is now beginning to flourish with contributions from workers in many different fields.

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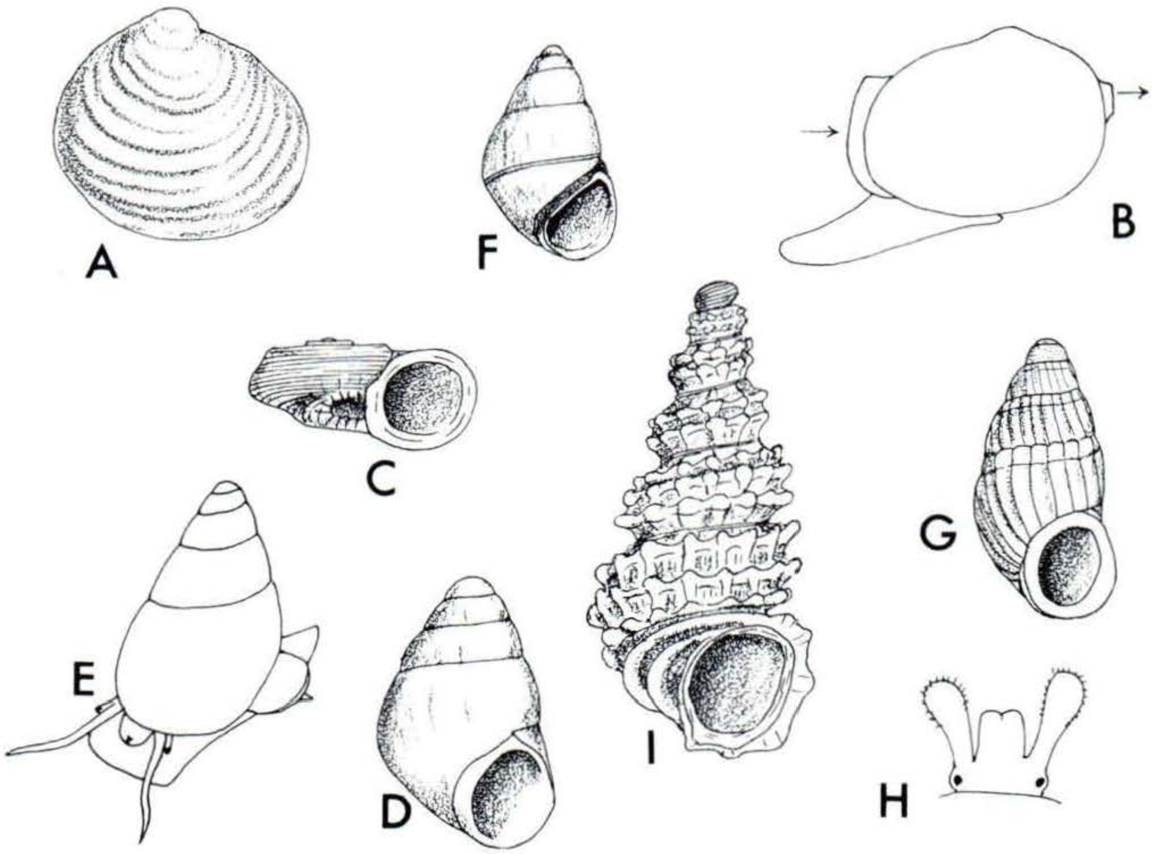


Fig. 1: A, *Lasaea australis;* B, the animal of *Lasaea* species (the arrows show the direction of water currents); C, *Lodderena minima;* D, *Crassitoniella flammea;* E, the animal of *Eatoniella* species; F, *Notoscrobs* (*Microfossa*) *incidata;* G, *Estea olivacea;* H, head of *Estea* species; I, *Merelina cheilostoma.*

MINUTE MOLLUSCA

By W. F. PONDER
Curator of Molluscs, Australian Museum

MANY people have at some time been interested in gathering shells. Some are enthusiastic collectors, carefully fossicking at every opportunity for rare and delightful molluscs. There are, however, only a few collectors who notice those tiny shells less than about 3 mm high, which exist in such a profusion of species of indescribable delicacy and form. Fronds of seaweed and the undersurfaces of stones may have tiny gastropods clinging to them, or minute bivalves hanging by a few gossamer-fine threads.

A few minutes spent rinsing seaweed or brushing the undersides of stones in a bucket of water is a most productive way of obtaining quantities of living material. Subsequent picking over the residue with the aid of a hand lens or low-powered microscope will often reveal a great variety of species. Sublittoral forms may be gathered directly by dredging or indirectly by sorting the fine beach drift known as shell sand.

The storage of micromolluscs presents few problems. One of the easiest and cheapest methods is to use glass tubing which can be broken into short lengths after nicking with a file. The specimens and labels can be placed in the pieces of tubing, which are then plugged with cotton-wool. The label should have the information facing outwards so that it can be read without having to be removed from the tube. It is also a good idea to keep some live-collected material preserved in 70 per cent alcohol. These specimens can also be stored in glass tubing plugged with cotton-wool and the tubes placed in a large, wide-necked bottle filled with alcohol.

The following discussion was written with the New South Wales fauna in mind. The student of micromolluscs in this area has a great advantage over those in other States because of the excellent publications of the late Mr Charles F. Laseron.

Space does not permit even a list of all the kinds of minute molluscs likely to be encountered on the Australian seashore, but brief mention of the most important and interesting families will be made.

There are several families of the Bivalvia that contain mostly small species. Of these, the superfamily Leptonacea is the most important and contains the families Leptonidae, Erycinidae, and Galeommatidae. They are particularly interesting because some species develop commensal or even parasitic relationships with other animals, usually crustaceans, other molluscs, echinoderms, or worms. The shells of many of the species are very thin and fragile and, in a few of the parasitic forms, have become internal and vestigial. Thus, a sort of bivalve slug has been developed. Most species, however, are free living, one of the commonest being the pink *Lasaea australis* (fig. 1, A), which is found nestling in profusion in crevices, under stones, and in compact coralline weed. If some specimens of *Lasaea* are placed in a dish of seawater, the narrow foot on which they crawl about like gastropods (fig. 1, B) can be seen to emerge. In addition, a short siphon appears in front through which a stream of water is drawn into the mollusc. This is unlike the condition in most bivalves, which draw in water behind. Efficient mobility, coupled with temporary byssal fixation and the anterior inhalent water supply, are characteristics shared by all leptonaceans, and have been the chief factors which have made possible their successful adoption of commensalism.

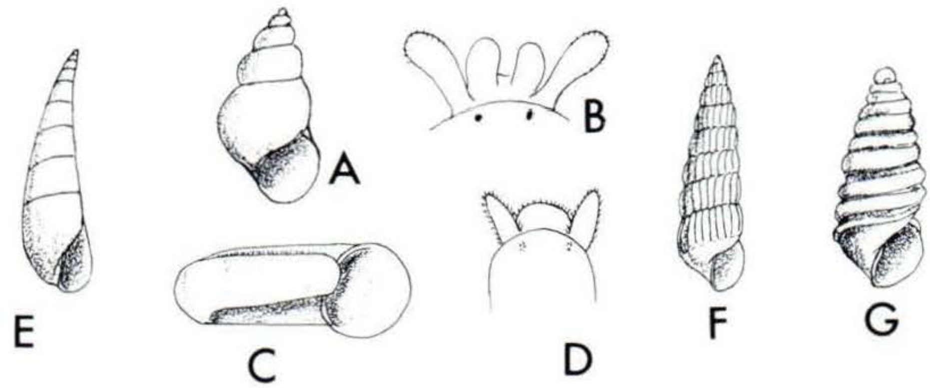
The most characteristic minute gastropod groups living on southern Australian shores are the families Rissoidae and Eatoniellidae. *Rissoina*, a thick-shelled rissoid with a tall spire and peculiar D-shaped aperture, is probably familiar to most shell collectors, as the species of this genus are readily observable by the naked eye. The animal has an extensible snout with which it thrusts its way through the sand and detritus as it feeds. Its food consists of foraminiferans and fragments of coralline algae which are relatively huge in relation to the animals' mouth. The stomach is especially modified to receive and store these large food particles. A similar type of stomach and feeding habits are found in a number of genera of the Rissoidae (fig. 2) which are placed in a separate subfamily, the Rissoininae. Another subfamily, the Anabathroninae, contains abundant forms like *Estea* species (fig. 1, G) and *Notoscrobs* (*Microfossa*) *incidata* (fig. 1, F). These are solid, pupate or conical shells with heavy apertures and are red, brown or yellow in colour. Their tentacles are characteristically short with swollen ends (fig. 1, H). This feature helps to distinguish the Anabathroninae from the true rissoids, which have long, parallel-sided tentacles. The true rissoids (Rissoinae) are not common in Australia, though they are dominant forms in the Northern Hemisphere. The animals in these two subfamilies are microherbivores, or microdetritus feeders.

Many species of small molluscs are able to crawl beneath the surface film but this ability is especially marked in the rissoids and the eatoniellids. In addition, they can spin threads of mucus which they are able to crawl down.

The eatoniellids (fig. 1, D, E) are related to the Littorinidae, the periwinkle family, whereas the Rissoidae are placed in a separate superfamily. The eatoniellids, like the rissoids, are furnished with special pedal glands which produce copious quantities of sticky mucus. This enables them to cling successfully to seaweeds, even on surf-beaten shores. They feed on minute plants and detritus covering the surface on which they live. Their shells are smooth and conical, having all of the features of simplicity. The animals of this family have long tentacles (fig. 1, E), which lash up and down as they move about. The operculum bears a strong peg, to which is attached a powerful retractor muscle. A similar structure has been developed independently on the opercula of several other families of minute prosobranchs and in one group of larger molluscs, the neritids.

The Cyclostrematidae have depressed, usually white shells which are variously

Fig. 2: A, *Rissoella (Heterorissoa) punicea;* B, head of *Rissoella* species; C, *Helisalia liliputia;* D, head of *Omalogyra* species; E, *Curveulima* species; F, *Chemnitzia* species; G, *Oscilla tasmanica.*



sculptured or smooth (fig. 1, C). Although there are many species and genera recorded, they are not usually commonly encountered. The Vitrinellidae closely resemble the cyclostrematids but are allied to the rissoids, whereas the latter family is related to the top shells (trochids). Vitrinellids have one or two pallial tentacles emerging from the shell aperture, while the cyclostrematid animal has the foot fringed with a number of tentacles. The placement of many species and genera currently in these two families is in doubt because of the general similarity of their shells, but observations on the living animals would help to rectify this state of affairs.

Two interesting families that show rather uncertain relationships with the sea slug group are the Omalogyridae and Rissoellidae. Neither of these two families is included in recent lists of Australian mollusca, although both are actually represented in the fauna. The globose, glassy-shelled species known as *Heterorissoa* (fig. 2, A) belong in the Rissoellidae, while the discoidal, reddish-brown species of *Helisalia* are omalogyrids. Both genera are common living on seaweed in N.S.W. The characteristic head structures of both of these families are shown in figs 2, B, D.

Two groups of parasitic gastropods, the Eulimidae and the Pyramidellidae are superficially similar to one another, with their tall, spired shells and small size. The Eulimidae, which are true prosobranchs, have a glassy, smooth shell (fig. 2, E) and are equipped with a long proboscis. They usually feed suctorially on specific host species, frequently echinoderms. Some forms closely allied to the eulimids have lost the foot and are permanently attached to the host, while others have become internal parasites. The pyramidellids, however, unlike the eulimids, show a remarkable diversity of shell form, both in sculpture and in shape (figs 2, F, G). They are, in most cases, readily recognized by their peculiar reversed embryonic whorls and plait on the inner part of the aperture. These features, together with their anatomy, show that they are related to the opisthobranch gastropods. The living animals usually have their eyes placed on the inner sides of triangular tentacles, while the eulimids and the rest of the prosobranchs have the eyes on the outer sides of elongate tentacles. Most of the Pyramidellidae also appear to be parasitic, feeding suctorially, like the eulimids, on echinoderms, but also on worms and molluscs, with their long proboscis. The hosts of these parasites are very poorly known in Australasia and any observations on host-parasite relations would be valuable information.

Some families of which the members are typically of large size have produced minute species, presumably by neoteny. This is a process in which a juvenile stage becomes sexually mature and thus retains the advantages of the juvenile form—in this instance, small size and greater mobility. The genera *Chlamydella* and *Cyclopecten* of the Pectinidae (scallops) and *Cuna* in the Crassatellidae are clear-cut examples of this phenomenon. Some families have probably been derived by neoteny, an example being the Condylocardiidae from the bivalve family Carditidae.

Small size enables many environments to be colonized that would otherwise be inaccessible to molluscs. Crevices, algal turf, the filaments of fine algae, beneath closely packed stones, and other unlikely habitats become available to a small animal.

In addition to enhancing the opportunity for commensal and parasitic modes of life, otherwise inaccessible food supplies are made available. Some sea slugs have even become members of the interstitial fauna and slide between sand grains on beaches along with the other highly-specialized animals of this environment. Some have lost all outward molluscan appearances and resemble minute worms.

Much work needs to be done on the systematics and biology of the minute Mollusca of Australia. References are very scattered and identification of material is greatly hindered by inadequate descriptions and illustrations of described species.

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

FURTHER READING

The following papers by C. F. Laseron are among the more important publications dealing with the New South Wales micromollusca:

"Review of the Rissoidae of New South Wales", *Records of the Australian Museum*, vol. 22, no. 3, pp. 257–287, 1950.

"The New South Wales Pyramidellidae and the genus *Mathilda*", *Records of the Australian Museum*, vol. 22, no. 4, pp. 298–334, 1951.

"Minute Bivalves from New South Wales", *Records of the Australian Museum*, vol. 23, no. 2, pp. 33–53, 1953.

"Revision of the Liotiidae of New South Wales", *Australian Zoologist*, vol. 12, no. 1, pp. 1–25, 1954.

"A Revision of the New South Wales Leptonidae—Mollusca: Pelecypoda", *Records of the Australian Museum*, vol. 24, no. 2, pp. 7–21, 1956.

MEET OUR CONTRIBUTORS . . .

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WINSTON F. PONDER joined the staff of the Australian Museum as Curator of Molluscs in 1968. He is a New Zealander, and graduated at the University of Auckland. Close contact with the malacologists A. W. B. Powell, J. E. Morton, R. K. Dell, and C. A. Fleming ensured a well-rounded approach to his studies on Mollusca. Last year Dr Ponder was awarded the Hamilton Prize by the Royal Society of New Zealand.

DAVID PURCHASE has been secretary of the Australian Bird-Banding Scheme since January, 1967. He joined the CSIRO Division of Wildlife Research in 1957, and soon became closely associated with bat-banding, then in its infancy in Australia. He was appointed a biologist with the Australian National Antarctic Research Expedition in 1962, and spent 29 months on Macquarie Island, where he carried out a long-term population study of the Royal Penguin. This study involved a large-scale banding programme.

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