

AUSTRALIAN NATURAL HISTORY



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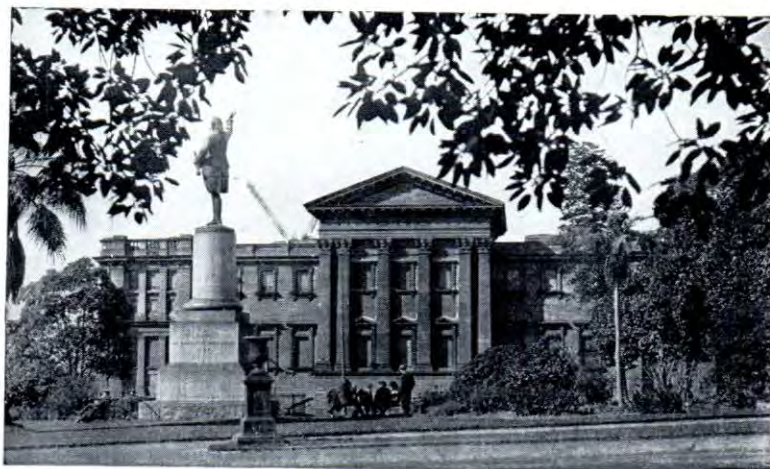
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● **FRONT COVER:** A Dor Beetle (*Blackburnium* sp.). This is one of the many species of the Family Geotrupidae to be found in Australia. Beetles of this family generally excavate burrows in the ground which they fill with pellets of animal dung that serve as food for their larvae. No observations have been made, however, with the majority of Australian species. The length of this reddish-brown insect is about three-eighths of an inch. [Photo: Howard Hughes.]

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JUNE 15, 1965

Collecting in the Coral Sea

By DONALD F. McMICHAEL and JOHN C. YALDWYN

"Few ships have passed through this sea without making the discovery of some new bank of coral; and it is probable that several other patches of reef, yet unknown, will be found in it, especially on the Caledonian side. This space might be very appropriately called the Corallian Sea". — Matthew Flinders, "A Voyage to Terra Australis," 1814 (lines written after the loss of H.M.S. "Porpoise" and the ship "Cato" on Wreck Reef in 1803).

Robinson Crusoe isles in a tropic sea—gently waving palm trees under a yellow moon—dusky maidens with garlands of exotic flowers. No, it wasn't like that. The small coral islands which are scattered in the Coral Sea a hundred or more miles off the coast of Queensland, beyond the outer Barrier Reef, have no palm trees, dusky maidens, or any Robinson Crusoe-like inhabitants. Instead they are populated by millions of sea-birds, and covered with a variety of plants (some of which do have attractive flowers), most of these being species widely distributed through the oceanic

islands of the Pacific. Completely uninhabited, they stand like empty fortresses against the endless battering of the surrounding sea, posing a fearsome hazard to navigation in former days and claiming more than their share of wrecks over the centuries.

An account of the bird life of these remote islands has already been given by K. A. Hindwood in a previous issue of *Australian Natural History* (Vol. XIV, No. 10, page 305; June, 1964). One of us was able to accompany the 1960 Sovereignty Cruise of H.M.A.S. *Gascoyne*, which called at a number of these cays and reefs, but on that occasion only a fleeting visit could be paid and superficial collecting of marine life undertaken. However, this was enough to whet the appetite of a marine biologist, and arrangements were made with the Hydrographic Office of the Royal Australian Navy to join the 1964 cruise, with the idea of spending a longer period on some of the islands, to enable comprehensive collecting to be done. This was envisaged as part of a continuing programme of research on the marine fauna of the



The long, sandy, north-western beach of North-east Herald Cay, looking towards the curved sand-spit at the northern end of the islet, with the authors' camp and aluminium boat under the N.S.W. State flag. The tent is at the edge of a narrow grass zone, and a fringe of the low tree *Messerschmidia argentea* is visible beyond. [Photo: J. C. Yaldwyn.]

Coral Sea and Queensland coasts, which has included the Australian Museum's 1962 Swain Reefs Expedition, of which a general account appeared in *Australian Natural History* some time ago (Vol. XIV, No. 7, page 210; September, 1963).

With the help of the officers and men of H.M.A.S. *Gascoyne* the authors were landed on West Diamond Islet, for a period of eight days, and later on North-east Herald Cay, for a similar period. Knowing that we would be completely isolated from the ship and from the mainland during this time, we laid careful plans to ensure that all necessary gear, food, water, and first-aid equipment were on hand. The Marine Department of Hawker-De Havilland was most helpful in lending a 12-foot aluminium boat for use while on the islands, and an outboard motor was borrowed from the C.S.I.R.O., thus allowing us to move freely within the lagoons of the islands visited. We established camp on the upper edge of the sandy beach in each case, where the prevailing easterly to south-easterly winds kept our camp cool during the long cloud-

less days when temperatures rose well into the nineties.

Structure Of Islands

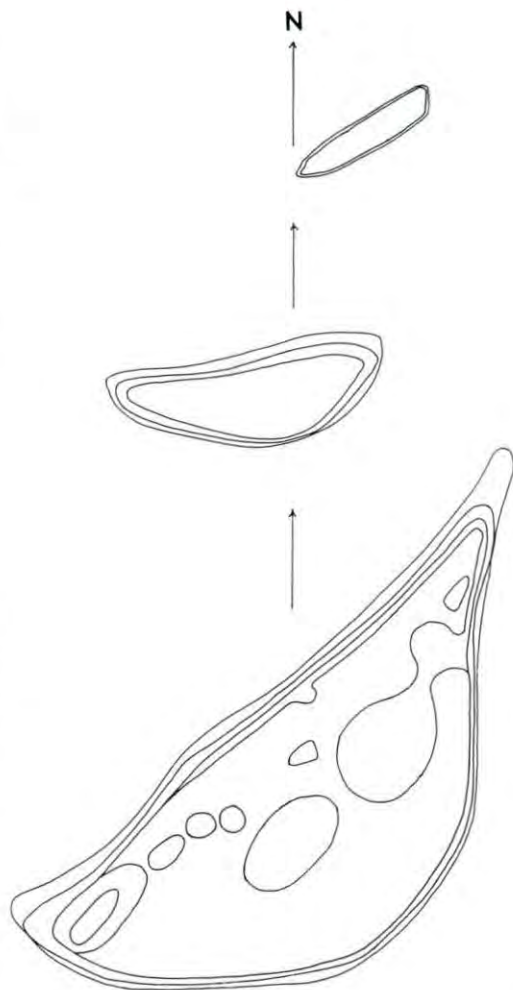
First impressions of the islands were that they were very similar in general geography to the coral cays in the Swain Reefs, visited in 1962. This was later confirmed by detailed mapping, which showed that all the islands have roughly the same structure and orientation. They are elongate in a south-west to north-east direction, with a long sandy beach facing the north-west aspect. The greater portion of the south-east shore is lined with a very characteristic beach-rock, formed of compacted coral sand, shell and other material; beach-rock of this type is found on practically all tropical coral islands. The islands are all rather low, being formed of piled-up coral sand and rock boulders, so that the maximum height to which they can accumulate is governed by the power of the storm waves which cast material up from the surrounding reef. Both islands have fairly steeply sloping shorelines, but relatively flat tops, at a level of about 15 feet above high-tide mark.

They are both well vegetated, and, in contrast to Gillett Cay, Swain Reefs, which was covered with only four species of low herbs and grasses, these islands bore a variety of plants, numbering 12 or more species. West Diamond Islet was marked by an outer fringe of the low tree *Messerschmidia*, better known in Australia under the old name *Tournefortia*. Within this fringe, which was only a few yards in width, was a large open herb-field, about the size of a football field, and covered with a complex mosaic of plants, among which various sea-birds had made their nests. This island also had two small clumps of the tree known as Milky Mangrove. North-east Herald Cay had a similar narrow *Messerschmidia* fringe, but inside this was a dense forest of the large, fragile-limbed tree known as *Pisonia*, or *Heimerliodendron*.

Dense Forest

Once within this forest, a different world was encountered, with broad tree trunks spaced about 10 feet apart, growing from a bare earthy floor, riddled with mutton-bird burrows, traps for the unwary visitor. The leafy canopies of the *Pisonia* trees, meeting overhead, provided a shady, cool and strangely silent environment, seemingly remote from the glaring tropic sun and crashing surf beyond. The only noise was the chattering of White-capped Noddy Terns, nesting in the upper branches of the trees, and Common Noddies, nesting in the lower, major branches of the same trees, which arose in alarm as two blundering intruders passed close by, and made courageous mock attacks on them in defence of their nests and young.

Each coral cay was situated close to the north-western side of a roughly round coral reef, and there were several such cays and reefs in both the Diamond and Herald groups. Each group of islands was found to be situated on a bank, rising up from the surrounding oceanic depths, to a plateau at about 30 fathoms below the surface. The age of these islands can only be guessed at, but it must be reckoned in thousands of years, for they represent enormous accumulations of material from the reefs surrounding them and the well-developed forests found on some of them must have taken centuries to form.



Outline maps of three coral cays, drawn to the same scale. Top: Gillett Cay, Swain Reefs. Centre: West Diamond Islet. Bottom: North-east Herald Cay, which is about 1,200 yards long. The lines within the outline of each cay represent vegetation zones. These cays are many miles apart, but this map shows their similar orientation, elongate in a south-west to north-east direction, with a long sandy beach facing the north-west aspect. [Map by Helen Ashton.]

The reefs themselves are a mile or two in diameter, and, unlike most coral reefs within the Great Barrier Reef system, did not become exposed at low tide. Instead, their outer edges were covered by 3 feet of water, and closer to the islands this increased to about 10 or 15 feet, with large coral growths

A view within the dense *Pisonia* (or *Heimerliodendron grandis*) forest in the centre of North-east Herald Cay. These trees grow to 20 feet or more in height, and on this islet contain numerous nests of both Common and White-capped Noddy Terns. Note the bare forest floor, riddled with the nesting burrows of the Wedge-tailed Shearwater or Mutton Bird, *Puffinus pacificus*. [Photo: J. C. Yaldwyn.]



rising to shallower depths, and deeper channels and pools here and there. On the north-western side of the reefs, large sandy patches were found where no coral growths occurred, while in other areas the reef was composed of a flat, rock-like surface, covered with the coralline algae which form such an inconspicuous but very important part of coral reefs. Nearer the shore, the outcrops of coral gave way to dead coral patches and eventually to practically bare beach-rock, cut across by crevices in which sheltered numerous shells, crabs and other invertebrates.

The marine life of the reefs was not as rich as that to be found within the Barrier Reef, where many continental species are represented. Out in the middle of the Coral Sea, the fauna is limited to forms with larval stages capable of drifting over many miles of open ocean, and consequently some groups are absent. Nonetheless, it contains many interesting species including some not known from the Queensland coastal islands. The clarity of the water, situated so far from sources of mud and other contaminants affecting visibility, was almost unbelievable. This made us feel somewhat more secure than we otherwise might have done, since it allowed a wary eye to be kept for sharks which could be spotted at a considerable distance. Gaudily coloured fish were abundant everywhere and made underwater collecting an entertaining experience, even though some species defied every effort we made to catch specimens for the Museum



Shells from the Coral Sea.—Top: *Harpa harpa* L. (left) and *Latirus barclayi* Reeve, both commonly used by land hermit crabs. Centre, from left to right: *Oliva sericea* Röding, *Nassarius* (*Alectrion*) *papillosa* L. and *Conus episcopus* Brug., all inhabitants of the sand and coral pools on the reef flat. Bottom: *Drupa morum* Röding (left) and *Vasum turbinellus* L., both inhabitants of the sub-littoral beach-rock. About half natural size. [Photo: C. V. Turner.]

collections. Eventually, through the use of chemicals and explosives, we were able to secure a good series of fish, but there were many more species which escaped us and which will entice one or other of us back again some day.

Remarkable Crabs

Perhaps the most spectacular features of the biology of the marine invertebrates were to be found among the crabs. Lining the beach-rock areas were two species of grapsid crabs, occurring in thousands and scuttling around to stare with stalked eyes at the intruding zoologists. On a previous visit to the Herald Cays, one of us had observed a curious pattern of behaviour in which two crabs were engaged in a wrestling match. They apparently rushed at each other, grappling with the large-clawed front legs or arms, then separated for short spells. During these breaks, fluid was squirted in well-directed jets from among the mouthparts, like two little boys firing water-pistols at each other. We spent some time on North-east Herald Cay watching these crabs with binoculars from a distance in the hope of observing this strange behaviour once again, but were unsuccessful. Possibly, this was due to the fact that we were a month later in the year than on the previous visit, and the actions may have been linked with seasonal mating behaviour.

An even more interesting group of crabs was found in the leaf litter and grass in and around the *Messerschmidia* fringe. Here, during the heat of the day, the grotesque land hermit-crabs of the genus *Coenobita* lay quiescent in their protective, but borrowed, shells. At night, these weird red creatures would roam abroad, in search of dead animals for food, and make visits to the edge of the sea to refresh their supplies of salt water, necessary to keep their gills moist and functional. When seen in the light of a lantern as we sat working in the tent at night, these lumbering animals, walking on bent-over legs, with quivering antennae and prominent eyes fixed on us, seemed like creatures from another world. While walking around the beach in search of shells one evening, we were startled to see some hundreds of individual *Coenobitas* streaming from the *Messerschmidia* fringe in a narrow corridor down to the water, and moving directly back up to the sheltering trees again. The phenomenon was so marked on an otherwise bare beach, that one could not help but be reminded of a mass of pedestrians streaming across a busy city street when the traffic lights change, or perhaps even of the Israelites crossing the Red Sea. The bright red coloration of the *Coenobitas* made them a conspicuous feature at any time, and in massed array they were most impressive. Of more practical importance was the fact that

Two species of active grapsid crabs are conspicuous on the intertidal beach-rock area of the Coral Sea cays. The largest, *Grapsus tenuicrustatus*, illustrated at right, grows to 3 inches in width (excluding legs) in this area, but is apparently not found on the better-known Barrier Reef islands. There the smaller, but closely allied, *G. albolineatus* is found in similar situations, though both occur together on the beach-rock of these open ocean cays. [Photo: C. V. Turner.]



the Coenobitas were excellent shell collectors. Not only were they wearing a rich variety of empty gastropod shells, but some of these included species rarely found elsewhere during our visit and were gladly seized for the conchological collection.

Other material collected included corals from the outer reefs and shallow water patches, commensal shrimps from large clams (*Tridacna* and *Hippopus*), sea-urchins, brittle-stars and, as well, a representative sample of all the insect species found associated with the vegetation and nesting sea-birds. The variety of insects found on the small, isolated cays came as a great surprise to us; at least 36 different kinds were taken, ranging from a sphinx

moth to silverfish, from a praying mantis to small weevils. Even a butterfly, believed to be the Common Egg-fly or Blue Moon, *Hypolimnas bolina*, was seen in flight, but not taken, over West Diamond Islet.

All these collections, including the big series of fish and shells mentioned previously, were brought back safely to Sydney on the *Gascoyne* and unpacked at the Museum. Their preparation, examination and identification, in conjunction with similar material from the Swain Reefs and other tropical areas, will go on slowly over many years as one segment of the Australian Museum's self-imposed task of understanding and classifying the varied fauna of the Australian region.

BOOK REVIEW

RECORDS OF THE AMERICAN-AUSTRALIAN SCIENTIFIC EXPEDITION TO ARNHEM LAND, VOL. 4 (ZOOLOGY); published October, 1964; editor, R. L. Specht; general editor, C. P. Mountford; 533 pages, 92 plates (five in colour), 13 figures; price, £6 6s.

The fourth and last volume of the 1948 American-Australian Scientific Expedition to Arnhem Land deals with the zoological collections made by the three zoologists on the expedition and their helpers, and includes a chapter on the history of collecting in the area.

As can be expected, this volume is very uneven, both in the collections made, and in their treatment. The fishes are the largest section dealt with, and form half the volume. Some 14,300 specimens of fishes were collected (the epilogue to the four volumes states 30,000, and separates fishes and birds from "animals"), comprising 240 species, with gobies, wrasses, and some other families not being dealt with. Dr. R. R. Miller clearly made excellent fish collections, and these have been extremely carefully worked up by W. R. Taylor, of the Smithsonian Institution. He has made keys to all the groups, and a number of species have black and white plates. This work is an extremely useful addition to Australian ichthyology. It is nevertheless extremely difficult to understand why, in a work that seems to have been done with such care, the author made no attempt to visit Australian collections, where much of the type material of species from Arnhem Land are housed, as well as other collections from the area.

The amphibians (49 specimens of 10 species) are reported on by F. J. Mitchell. This is an amplification of the preliminary report by Mitchell in 1955 (*Records of the South Australian Museum*, 11: 373-408), and suffers from the fact that its manuscript was received over eight years before

the publication of this volume and many nomenclatural changes have been made during this time. It is clear from the relatively small number of species reported on here from this rich and interesting area that collections of reptiles and amphibia formed a relatively small portion of the expedition's efforts.

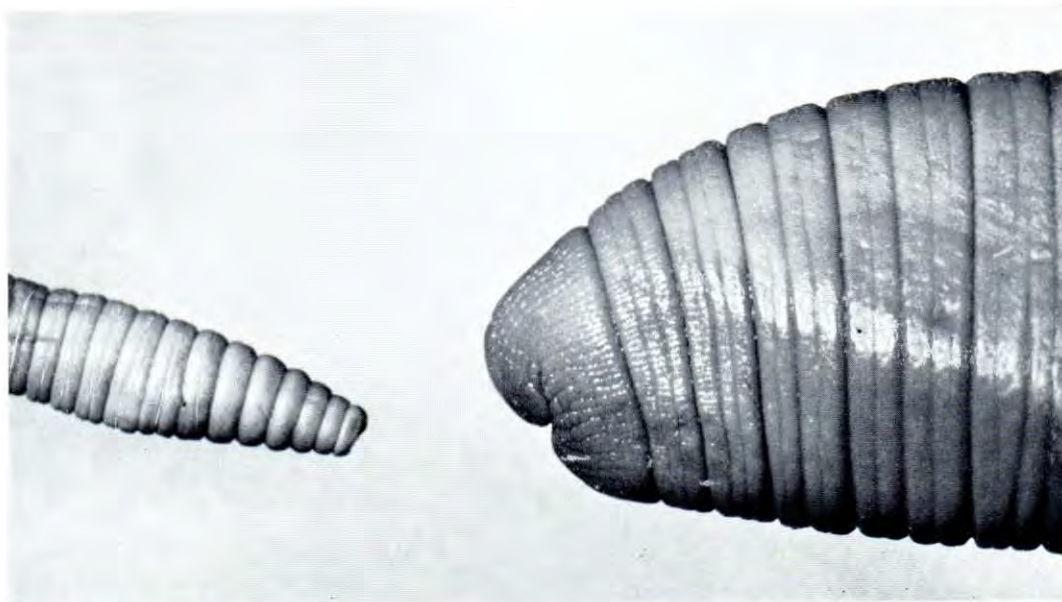
The bird collection (828 specimens, 191 species and sub-species) was collected and described by H. G. Deignan, who considers the most valuable results to be new locality records, extension of known ranges, and information on moulting, breeding condition, and migrations, as "knowledge of the extent of the Territorian avifauna has been for many years virtually complete". This latter statement came as a surprise to this reviewer, in view of the situation in the other groups.

The mammal collection (501 specimens of 57 species and sub-species), collected and described by D. H. Johnson, is quite considerable, and all mammal material from Arnhem Land in the U.S. National Museum collections was also included. In this useful report it is again a pity that material from this area in Australian museums was not made use of.

Of invertebrate material only molluscs are dealt with, and the collection (175 specimens of 105 species) is a slight one. Useful black-and-white or coloured illustrations of the majority of species are given.

It is unfortunate that no attempts have been made to interpret the zoological collections from a zoogeographic viewpoint, for with Pleistocene northern connections this area should afford exceptionally useful information on New Guinean-Australian faunal links.

Considering what could have been done, this book leaves this reviewer with a feeling of disappointment, in spite of the useful studies of some groups.—F.H.T.



Contrast in size is shown in this photo of two Australian native species of earthworms: a usual-sized worm "face to face" with a giant-sized *Digaster longmani* from Kyogle, New South Wales. [Photo: Howard Hughes.]

Recognizing Australian Earthworms

By B. G. M. JAMIESON

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THE title of this article might raise the question "Who would want to be able to distinguish one species of earthworm from another?" There are, however, many situations where this ability is useful, as the following examples will show. We know that earthworms are characteristic of fertile soils and recently experiments have been carried out by agricultural scientists in the vicinity of Deniliquin, N.S.W., to find whether earthworms intentionally introduced into irrigated pastures could improve the quality of the soil. A substantial improvement was noted. In this experiment it was necessary to know the species of the "cultivator" earthworm so that a similar use could be made of populations of the same species in other regions. Furthermore, the species used was not effective in certain clay soils and therefore an ability to recognize

it made it possible to avoid wasteful attempts to introduce it into similar unsuitable soils.

Earthworms are not only studied in relation to the soil, however. Scientists are interested in their anatomy, in their behaviour, in their physiology and in other aspects of their biology. These studies are not only of interest in their own right but also because of the light they shed on problems in other animals, including man. Recently a medical physiologist asked the author to identify local earthworms used in studies of the nervous system which may prove of value in helping to understand the working of the human brain. In these studies it was essential that the physiologist did not confuse the species with which he was dealing as there was considerable variation in the structures under investigation

in the various species. A wool scientist has been studying properties of the cuticle of an earthworm as part of a research project on natural fibres. Above all, biologists want to distinguish the species of earthworm through simple curiosity and a desire to increase man's awareness of the world in which he lives.

Earthworm "Farming"

There is a further large group of people who are interested in identifying earthworms—earthworm "farmers" and those fishermen who prefer to collect, or to raise, their own worms for bait. Earthworms are "cultivated" mainly for sale as bait, for use in increasing soil fertility or for supplying teaching institutions with study material. The earthworm farmer has to know which species are easily farmed, and which are not and, of the former, which are suitable for sale. The fisherman is well aware that some species are good bait whereas others seem repellent to fish. The British "Common Earthworm", *Lumbricus terrestris*, has been found to flourish in Australian earthworm farms and is of value, but some native earthworms have been found to be more suitable as bait and can be successfully farmed; an example is *Megascolex dorsalis*, which is sold in bait-shops in Melbourne.

It is not surprising, therefore, that the Australian Museum receives many inquiries as to how to distinguish the different species of Australian earthworms. It is hoped that the following account will enable the interested reader to recognize some of the commoner species of the local earthworm fauna while providing some additional information on their biology.

Classification Of Earthworms

Approximately 3,000 species of earthworms are known. It comes as a surprise, if one has not worked on the class, that so many different forms of so "simple" an animal as the earthworm can exist. The apparent simplicity of structure of earthworms is, however, largely confined to the exterior of the body and is correlated with their burrowing habit and their mode of feeding. They burrow by passing successive waves of contraction and relaxation along the musculature of the body wall and do not require external appendages other than the protrusible bristles or setae which

are typical of the segmented worms or annelids. The earthworms belong to the Class Oligochaeta, a name which means "few bristles" and refers to the paucity of setae in each segment compared with the numerous setae of the marine annelids, of the Class Polychaeta. They feed by passing soil through the gut, from which nourishment is extracted, or by eating organic debris, including leaves, which accumulate on the surface of the soil. This method of feeding does not necessitate a high development of sense organs or of food-catching structures and earthworms never possess the often very remarkable and versatile "head" appendages developed in some of the free-swimming, carnivorous, marine polychaetes or in filter-feeding types such as the Feather Duster Worms.

The internal structure of the earthworms, particularly of the reproductive, excretory and circulatory systems, is, on the other hand, often very complex and shows sufficient diversity to merit recognition of four major families. Two of these, the Lumbricidae and the Megascolecidae, occur widely in Australia.

The family Lumbricidae includes *Lumbricus terrestris*, which, though qualifying as the most studied earthworm, hardly deserves its title, "the Common Earthworm". Even in Britain and other northern temperate countries in which, alone, the family is native, there is a far more abundant species, *Allolobophora caliginosa*. The latter is probably also the commoner of the two in Australia. *Lumbricus terrestris* is all too often used in Australian schools as a typical example of an earthworm although its occurrence in Australia is due to introduction by man and despite the availability of native species of the great Family Megascolecidae.

Lumbricid earthworms are distinguishable from those of other families in having the openings of the male reproductive ducts on segment 15, well in front of a glandular swelling of the skin called the clitellum. A clitellum is typical of earthworms and, incidentally, of leeches, and is responsible for producing the envelope or cocoon in which the eggs are deposited. That of *Lumbricus terrestris* embraces segments 32 to 36 or 37. The openings of the female reproductive ducts lie in front of the male pores, on

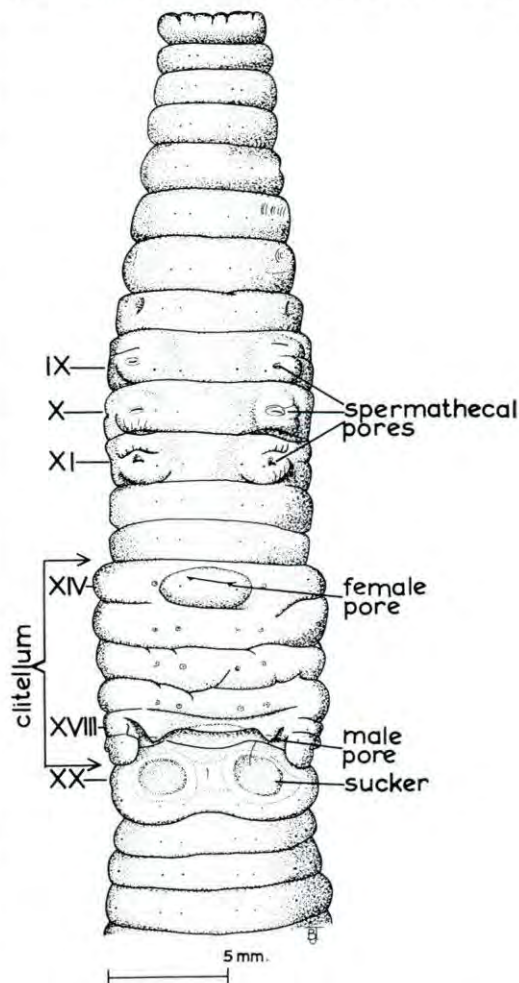
segment 14. This location of the female pores is normal in all families of earthworms. Several species of lumbricid earthworms have been introduced into Australia, usually accidentally in soil around plants, and are common in cultivated soil, especially in gardens. Using the criteria given above, the reader may distinguish them, even with the naked eye, from species of the native Family Megascolecidae which is discussed below.

Megascolecids occur throughout the countries of the southern hemisphere and in Asia. The Australian species can be distinguished from lumbricids by the location of the male pores on segment 18, or on segments 17 and 19 also, and the fact that the hind border of the clitellum is on or in front of these segments. Its anterior border usually lies in segment 13 or 14. If, therefore, less than 18 segments can be counted between the front end of a worm and its clitellum and the latter ends in the vicinity of segment 18, it is probably a megascolecid, whereas if many more segments lie between the front end and the clitellum and "bumps" due to the male pores are visible well in front of this, it is a lumbricid.

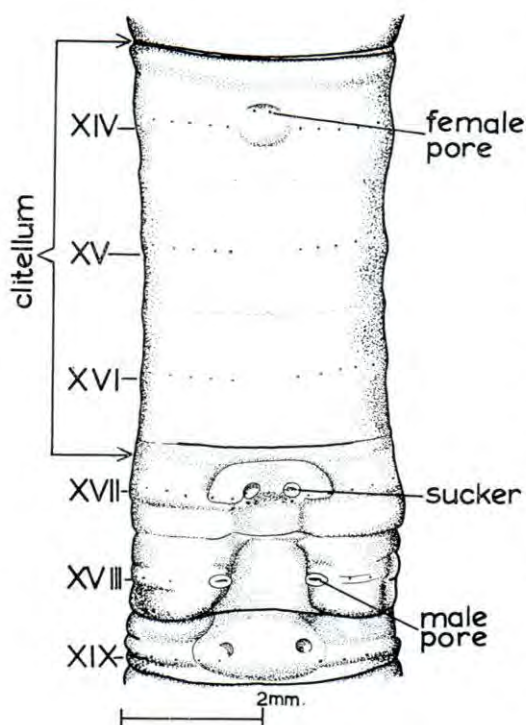
The Megascolecidae include the giant earthworm *Megascolides australis*, which was first recorded by Professor McCoy in 1878 and was later described in great detail by Professor Sir Baldwin Spencer, who was an early authority on Australian earthworms in addition to his other zoological and anthropological interests. This species is known only from Gippsland, Victoria, but there have been reports of giant earthworms in other States. Recently giant earthworms collected in the vicinity of Kyogle in northern New South Wales and thought possibly to be *M. australis* were shown to belong to the species *Digaster longmani*. Another megascolecid, *Digaster*, is so called because it is somewhat unusual in possessing two gizzards. One of the giant Kyogle specimens measured by Miss E. C. Pope, of the Australian Museum, was 5 feet 5 inches long and about an inch thick when suspended, alive, by the tail. Giant Megascolecid earthworms are also known from Ceylon, tropical Africa and South America.

The megascolecid earthworm which is perhaps most widely known to inhabitants

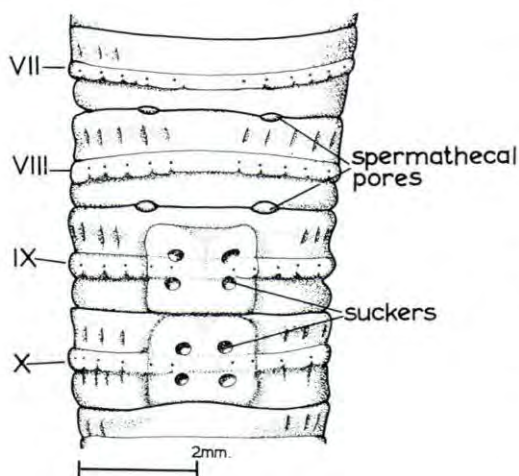
of N.S.W. is the purple "Squirter Earthworm", *Didymogaster sylvaticus*. This worm is found in coastal N.S.W., seemingly wherever there is subtropical rain-forest or, at least, Cabbage Tree Palms. It burrows deep into rotting logs or lies in leaf mould, usually under stones or logs, and is readily recognizable by its rich purple colour, its unusually stout form relative to its length of about 6 inches, and its habit when molested of ejecting jets of body fluid to a height of a foot or more from "dorsal pores" on its back. It is rather exceptional in the family in having the pores of the spermathecae (sacs which store sperm obtained from a partner in mating) located on the segments instead of between them.



The Squirter Earthworm, *Didymogaster sylvaticus*.



Above: the underside of the body of *Megascolex tenax* in the region of the male pores. Below: the suckers and squarish pads of *Megascolex tenax*.



There is a pair of spermathecal pores on each of segments 9, 10 and 11, each pair being visible as a minute mound. As its name suggests, *Didymogaster sylvaticus* shares with *Digaster* the distinction of having two gizzards. It occupies a somewhat isolated position in terms of classification and no other species of the genus is known.

Most Australian megascolecid appear to be unsuited to cultivated soils, possibly because of the competition they there experience from introduced lumbricids. A sample of garden earthworms is likely, therefore, to consist predominantly, if not wholly, of lumbricids. However, most gardeners in N.S.W. will have observed a fairly slender but muscular light-brown earthworm, from 4 to 6 inches long, which, when brought to the surface, moves off rapidly with an eel-like motion, bending the body vigorously from side to side as it progresses. This worm is a megascolecid which belongs to the genus *Pheretima*, the biggest genus of earthworms, with over 300 species. It may be identified by the presence of only a single female pore which is situated in the middle of the under-surface of segment 14, the presence of a ring-shaped clitellum embracing this segment and segments 15 and 16, and the arrangement of its setae in a ring around each segment and not merely on the under-surface as in lumbricids and many megascolecids. (The setae may be detected as a roughness if the animal is stroked from tail to head.) The unpaired female pore is very rare in Australian worms. The species found in Sydney gardens is *Pheretima diffringens*.

Earthworms As World Travellers

Pheretima diffringens is a great traveller, that is to say, it shows a greater ability to colonize when introduced into a country than do most earthworms. The species was named for specimens found at Plas Machynlleth in Montgomeryshire, North Wales, and its known distribution now includes, among other places, South America, southern U.S.A., South Africa, Indonesia, Burma, India, Ceylon and China, besides Australia. The original home of the species is unknown but the genus *Pheretima* seems to belong to south-east Asia.

The success of *P. diffringens* as a colonizer may be due in part to the fact that most of

its excretory organs or "nephridia" discharge into the gut. This permits resorption by the gut of water which would be lost if all the urine were discharged to the exterior, and earthworms are very dependent on moisture. There is a possibility, also, that it is capable of "virgin birth" or parthenogenesis, which is known to occur in many of its rival lumbricids. Both these features have obvious advantages for a would-be pioneer.

Another species which appears to wander is *Megascolex tenax*. This species, which is found in sclerophyllous bushland around Sydney, has been reported from the Marquesas Islands. It is a fairly large worm, commonly about 4 inches long, and is recognizable by the presence of four suckers on the lower surface of each of segments 9 and 10, those of each segment being arranged on a squarish pad which has an appearance reminiscent of a poker dice. Sometimes there are only two suckers on each segment. The pores of the spermathecae are paired between segments 7 and 8 and 8 and 9. *Megascolex* is one of the largest genera of earthworms and includes some 70 native Australian species.

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

VISITORS TO MUSEUM

Two recent visitors to the Australian Museum were ichthyologists Dr. T. Abe, of Tokyo, and Mr. W. P. Davis, of the University of Florida's Institute of Marine Sciences, Miami. Dr. Abe, one of Japan's noted ichthyologists, is a classic systematist and comparative anatomist. Mr. Davis is working with two other "undersea" scientists on the ecology and behaviour of fishes. This group pioneered nocturnal diving in coral reef areas (see National Geographic, Vol. 125, No. 1, of January, 1964). Mr. Davis worked in the Australian Museum for 10 days before joining the United States research vessel *Te Vega*, for a three-months cruise from Singapore to Tahiti.

BOOK REVIEW

THE WORLD OF THE FIRST AUSTRALIANS: AN INTRODUCTION TO THE TRADITIONAL LIFE OF THE AUSTRALIAN ABORIGINES, by R. M. and C. H. Berndt; Ure Smith, Sydney; 509 pages; plates. Price, £4 5s.

Some idea of how extensive our knowledge of the Aborigines and their customs is to-day may be gained by comparing this notable modern survey of the subject with those of Worsnop and others published before 1900. Even so, there is much more information to be recorded before the rituals, mythology and customs are lost to the Aborigines themselves.

The Drs. Berndt have written many scientific papers and books arising from their unrivalled first-hand experience of Aboriginal social and ritual customs. In this work they have relied mainly on their field work among the Aborigines in a vast area of Australia, from western New South Wales to Western Australia and from South Australia to Cape York, carried out during the past 25 years. They have learnt several Aboriginal languages in which they prefer to work with the Aborigines. In this work, too, they have consulted the writings of authorities in various aspects of Aboriginal culture and have quoted liberally from such sources. They acknowledge the fact that no anthropologist can be an authority on every aspect of Aboriginal life and culture to-day, so specialized has the whole field of study and research become, and have therefore set out to make the present book "complementary and supplementary to Elkin's *Australian Aborigines* and McCarthy's *Australia's Aborigines*," and where the same subjects are dealt with they have treated them with a different focus.

This book consists of 14 chapters, beginning with the origin, archaeology, physical and cultural similarity and diversity of the Aborigines. It then describes their social organization and structure, the basis of their economic life, and their life-cycle from coming into being to death. Religious belief and practice include totemism, mythology and ritual, followed by an account of magic and sorcery and of law and order. Art and aesthetic expression include oral literature, dancing and dramatic performances and the visual arts. Death and the aftermath, and the Aborigines to-day, are the final sections, together with a chapter on the genetic picture by Dr. R. L. Kirk.

The book is notable for the extraordinarily wide field it covers, the detail in which customs are described, and the great depth of philosophic interpretation and scientific reasoning with which these customs are analysed. As it is the result of research among the living people that can never be repeated on the same scale, and is written by two of our foremost authorities, it is a book that should be read, and will certainly be enjoyed, by everyone interested in our Aborigines. It is well printed and illustrated.—F. D. McCarthy.



A 30-foot Whale Shark which was washed ashore at Anna Bay, N.S.W., in April, 1964. The gill-slits are seen just behind the fisherman.

THE WHALE SHARK IN NEW SOUTH WALES

By G. P. WHITLEY

THE Whale Shark, *Rhincodon typus*, is the largest shark in the world, credibly reported as reaching a length of more than 60 feet and many thousands of pounds in weight. The size at which sexual maturity is reached is not known, but the shark does lay eggs. A large embryo, 13½ inches long, has been described from an egg trawled in the Gulf of Mexico.

The appearance of this giant is unmistakable. The head is broad and blunt, the mouth being terminal instead of undershot as in other sharks; there are thousands of minute conical teeth; strong keels run along the body, and the greenish-grey general colour is adorned with conspicuous white spots and lines.

The Whale Shark is harmless to man, since it feeds, like some whales, on small floating animals and plants, which it sieves through a remarkable modification of its gill-structures. The species is known from a very wide range of tropical and warm seas but was not officially noticed from Australia until April 23, 1938, when Mr. Harold Christiansen saw one when fishing off Jervis Bay, New South Wales, a long way south of its typical haunts. He estimated its length as about 25 feet, for it was longer than his launch.

Further sightings (tabulated here for the first time) were reported from New South Wales as follows:—

Date Seen	Where	Estimated length in feet
1936	Off Broughton Island (N. and A. Mitchell)	No estimate
1938, April 23	Jervis Bay	25
1939, February 5	Wollongong	20
1948, early February	Broughton Island	40
1949, March or April	Off Beecroft Head, with several pilot fish around mouth	16
1952, mid-March	Two or three miles off North Head, Sydney	27
1953, February 3	Wreck Bay	30
1953, April 13	Off Clovelly	19
1954, February 14	Off Sydney	20
1954, March 1 (two seen)	Five miles off Maroubra, heading north	15
1954, March 27	Quarter mile off Wooli	20
1955, February 20	14 miles off Maroubra	35
1957, May 13	Off Port Stephens	35
1958, February 23	Off Port Hacking	20
1958, March 29	Sydney Heads	No estimate
1963, March	N.S.W.	15
1963, April 22	Broom's Head, North Coast	25
1963, May	Woolgoolga	25
1963, July	Near Lake Burrill	No estimate
1963 (month not known)	Grafton	21½
1964, April 12	South of Anna Bay	30
1965, February 16	Bare Island, Botany Bay	25½
1965, March 24	Near Anna Bay, female	16

American servicemen captured one in New Guinea waters during World War II, and Hans Hass told me he had seen one off the Great Barrier Reef. Mr. George Coates also made sketches and notes of a 30-foot Whale Shark at Kelso and Slasher Reefs, off Townsville, Queensland, in October, 1955 and 1956. A school of about 30 huge Whale Sharks was reported near Murray Island, Queensland, early in 1963.

In his book on game fishing, Athel D'Ombrian says the Whale Shark has been seen on many occasions off Port Stephens. It will be noticed from the tabulation that New South Wales occurrences were mainly in February, March or April, with two in May. Estimates of their lengths were from 15 to 40 feet.

Several Washed Ashore

But these Whale Sharks, because of their giant size, eluded biologists who were keen to observe them at close quarters, until, in recent years, two dead ones were washed ashore at remote parts of the New South Wales coastline. The first was reported to me by Mr. A. A. Cameron in April, 1963, from Broom's Head, northern New South Wales; it was 25 feet long, but unfortunately it was washed out to sea again. Then in April, 1964, another was washed ashore two miles south of Cemetery Point, Anna Bay, New South Wales, where it was studied by Mr. Athel D'Ombrian, the well-known

Maitland naturalist and angler. Circumstances prevented me from visiting the locality, but Mr. D'Ombrian kindly provided the Australian Museum with photographs from which our illustrations are selected, specimens of skin and teeth, and a number of measurements of scientific interest, as follows:—

Tip of tail to tip of snout, 30 ft.; V of tail to tip of snout, 27 ft. 3 in.; width of head at eye, 5 ft.; tip of snout to front of dorsal, 13 ft.



The 4-ft. wide mouth of the Whale Shark at Anna Bay is held open by Mr. Athel D'Ombrian, naturalist and angler.



The Whale Shark which stranded itself on Bare Island, Botany Bay. [Photo: Howard Hughes.]

10 in.; height of dorsal, 2 ft. 5 in.; width of dorsal at base, 4 ft. 1 in.; front of dorsal to front of 2nd dorsal, 6 ft. 8 in.; back of dorsal to front of 2nd dorsal, 3 ft. 7 in.; height of 2nd dorsal, 11 in.; width of 2nd dorsal at base, 1 ft. 9 in.; front of 2nd dorsal to base of tail, 4 ft.; pectoral along outside edge, 6 ft. 6 in.; width of pectoral, 3 ft. 3 in.; top lobe of caudal fin, 7 ft. 4 in.; bottom lobe of caudal fin, 4 ft. 4 in.; width of tail, tip to tip of lobes, 8 ft. 4 in.; girth, as near as possible, 16 ft.; width of caudal peduncle, 1 ft. 10 in.; front of ventral fin to front of anal fin, 4 ft. 10 in.; front of anal fin to lower tail lobe base, 4 ft. 2 in.; length of anal at base, 2 ft. 5 in.; length of ventral at base, 1 ft. 8 in.; number of ridges, one along back, three on each side; their distance apart at middle of body—lower 8 in., middle 9 in., top 27 in.; length of gill-slits—2 ft. 1½ in., 2 ft. 9 in., 3 ft. 6 in., 3 ft. 6 in., 3 ft. 7 in. (starting from nearest to the tail); width of gill-slits—2½ in., 4 in., 6 in., 8 in. (starting from nearest to tail); size of larger spots, 2½ to 2¾ in.; width of eye, 1½ in.

The fish was a male. Part of both claspers had been cut off, and it did not look like a knife cut. It was possibly done by a small shark.

The estimated weight was between 6½ and 7 tons (worked out by formula).

After this article was written, a Whale Shark stranded itself on Bare Island, Botany Bay, N.S.W., on 16th February, 1965. It was 25½ feet long, its mouth was 5 feet wide, its head 8 feet 4 inches long, and the girth of its body about 16 feet.

Since then, two larger ones have been encountered by skin-divers near Montague Island, N.S.W., and a smaller female was stranded near Anna Bay, so that, instead of being a great rarity, it seems that the Whale Shark is a regular visitor to New South Wales.



The Curator's office in the Macleay Museum, showing three mahogany cabinets which housed Sir Alexander Macleay's collection. In the foreground is the 100-draw mahogany entomological desk. All were constructed about 1780.

The Macleay Museum at the University of Sydney

By JENNY ANDERSON
Curator of the Macleay Museum

SIR WILLIAM MACLEAY presented the Macleay Museum to the University of Sydney in 1888. The collections were moved to the University from Sir William's home, Elizabeth Bay House, Elizabeth Bay, in 1889.

The Macleay Museum contains the oldest collections of natural history in Australia.

The collection today consists of: insects, approximately 1 million specimens in 900 drawers; fish, 9,000 specimens in 1,600 glass bottles; mammals, 1,500 specimens; shells, 70 drawers; birds, 9,000 specimens; reptiles, 2,000 specimens; a large collection of corals, sponges, echinoderms and other invertebrates; a small collection of plant

and animal fossils and fossil casts; an ethnology collection of 2,000 specimens.

History Of The Collection

The Macleay Museum collections represent the work of three generations of the Macleay family, together with more recent acquisitions.

Sir Alexander Macleay (1767-1848)

Sir Alexander Macleay was the first member of the family to interest himself in natural history. He came to Australia as first Colonial Secretary in 1825, bringing with him from England his collection of insects. This was reported to be the finest and the most extensive in the possession of

any private individual. The Chippendale cabinets in which these insects were stored were specially made and fitted with entomological drawers. Each drawer was of a different wood selected from all parts of the world. There was also a mahogany desk into which Sir Alexander had fitted 100 insect drawers. This desk and the cabinets are still in the Curator's office.

Sir Alexander's collection is of enormous historical interest, for before he left England he purchased large sections of the most

with the insects which he collected while in Sumatra, and Sir John Bowring gave him those which he collected in Hong Kong.

Even though Sir Alexander published no descriptions of insects, there were many type specimens in the collections that Sir Alexander purchased, and other insects were described from his own collection. Thus Leach and Vigors described insects that Sir Alexander had received from Madras, Brazil and North America, and Boisduval and Marsham types were purchased by Sir Alexander. In those days it was not the practice to label the insect just described as the type; consequently many lie, as yet unrecognized, in the collection.



The oldest dated insect in the Macleay Museum, an orthopteran (Superfamily Acridoidea). The inscription reads: "A curious insect from Barbary, the only one known of its kind in England. Geo. Edwards, 1756." Length, 7.5 centimetres.

famous insect collections of his time, and added them to his own collection of British and foreign insects.

The collections which he purchased were those of Dru Drury, Edward Donovan, Sir Ashton Lever, Thomas Marsham, John Francillon and General Thomas Davies. The collection of Sir Ashton Lever contained many insects presented to Lever by Captain James Cook. John Francillon's collection contained specimens collected and presented to Francillon by Surgeon General White, who came to Australia in the First Fleet under Captain Phillip in 1788. Sir Stamford Raffles presented Sir Alexander

William Sharp Macleay (1792-1864)

William Sharp Macleay was the second of his family to contribute to the collection. He inherited his father's collection and continued to add to it extensively during his lifetime. He spent 10 years in the Court of Justice in Cuba and filled his leisure hours collecting marine crustacea and insects. Many of his specimens which were stored in a Havana mahogany cabinet were destroyed by carpet beetles, but others which were sorted into different cabinets are still in the Macleay Museum.

Soon after his arrival in Sydney in 1839, he was presented with a collection of insects by his friend Captain P. P. King. Captain King had gathered these specimens while exploring the coasts of Australia (then called New Holland) in 1818 and 1822. These insects were described by W. S. Macleay and most are still present in the Macleay Museum collections.

The insects collected on Charles Sturt's second voyage down the Murrumbidgee in 1829 are also in the Macleay. Sir George Macleay, the brother of William Sharp, accompanied Sturt on this expedition.

Sir William Macleay (1820-1892)

Sir William Macleay was the third and most famous member of the family to be associated with the Macleay collections. He was responsible for expanding the collection and finally presenting it to the University.

Sir William came to Australia with his cousin W. S. Macleay when only 19 years old and was sent straight to the family property on the Murrumbidgee where he remained for 15 years. At the end of this period he could afford to install an overseer and so moved to Sydney permanently. Until then he had little time to interest himself in natural history.

He inherited the family collection of 480 drawers of insects on the death of William Sharp in 1864. To this date the collection had been mainly entomological, but Sir William decided to diversify and expand it. He wrote:—

"I have hitherto confined my attention entirely to the Articulata, but it is now my intention to make my collection as perfect as possible in all branches of the Animal Kingdom."

Expansion Of The Macleay Collection

The first addition to his collection was a fine selection of bird skins from Wagga. Sir William was so pleased with them that he immediately set out to find and employ permanent collectors. George Masters left the Colonial (Australian) Museum in 1874 and went to work for Sir William, ultimately becoming the first Curator of the Macleay Museum. He collected for Sir William at Port Denison, Wagga and many other localities in Queensland, South Australia and Western Australia. W. W. Froggatt collected for Macleay along the coast of Western Australia and Edward Spalding collected at Port Darwin, the Endeavour River and Cleveland Bay. Mr. Damel collected for him in Fiji.

Sir William organised and financed two sea voyages so that he could collect specimens systematically.

The ketch *Peahen* was hired and John Brazier was put in charge of dredging up and down the coast. Sir William and George Masters used the *Peahen* in Port Jackson to dredge and net many of the marine specimens that Sir William later described.

The barque *Chevert* was purchased for £3,000 in 1875 and was remodelled. Sir William and his crew set sail for New Guinea to collect and explore.

Little exploration was done on the voyage, for the *Chevert* proved to be a most

unsuitable ship for the conditions met in Torres Strait. However, the collecting part of the venture was very successful and yielded some of the Museum's most valuable specimens. One specimen is a Darnley Island, Torres Strait, mummy—really a desiccated man—painted in red ochre with pearl-shell eyes and strapped to a palm frame. Others are specimens of snakes, lizards and insects, some the first known from New Guinea. The Torres Strait masks and native implements that were collected are now very rare, for soon after Sir William's party returned to Australia missionaries came to the Torres Strait islands and the natives made no more masks or implements of that type.

Sir William Macleay became most interested in fish after this voyage to New Guinea, for he realised how little work had been done on them. He collected 13,000 specimens and described many new species. He was often seen at the Sydney Fish Markets in the early mornings, with top hat and gloves, walking up and down the rows of stalls, examining the fish and searching for new and interesting specimens.

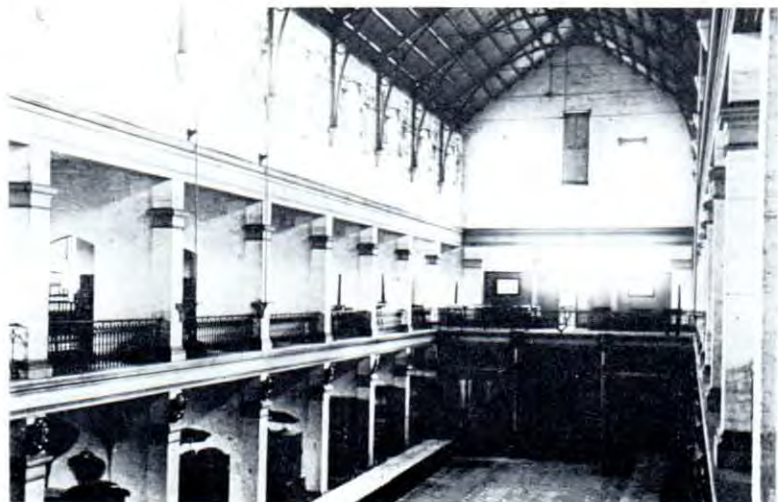
The huge and growing collection began to test the resources of Elizabeth Bay House. Temporary sheds were erected in the beautiful garden to store the overflow. But Sir William still worried over the care and safety of the collection. He had no heir, so was most anxious that the collections should go where they would most benefit the nation. So he decided to give the combined Macleay collections to the University of Sydney.

The Macleay Museum Goes To The University Of Sydney

The Senate gratefully accepted Sir William's gift of his collections, part of his library and an endowment of £6,000 for the stipend of the Curator, and agreed to the conditions attached to the gift. They were:—

1. That the present Curator (George Masters) be continued in office.
2. That the endowment of £6,000 for the salary of the Curator be used for this and no other purpose.

The Macleay Museum, about 1900. [Photo: University of Sydney Archives.]



3. That the Museum should be made easily accessible to students of natural history and members of the Linnean Society of New South Wales.

By an Act of Parliament, £16,000 was made available to erect a suitable building to house the collection. The Macleay building was originally constructed of stone, cement and steel, with a minimum of wood to reduce fire risk. When Sir William had inspected the building and facilities with George Masters, and approved them, the collections were moved in.

Towards the end of 1890 the Museum was ready to be opened to the public and, as can be seen from the photo, it was a not unimpressive sight.

Unfortunately, all was not to stay. Sir William died in 1891, and later followed the First World War. Funds were scarce and trained staff hard to find. George Masters died in 1912—gone was the last influential person concerned with the Museum's welfare. The biggest blow to the Museum, from which it has not yet recovered, came in 1917 when the University encroached on the Macleay building. A multitude of departments used the altered building over the years and it is now occupied by the Botany Department and the Plant Physiology Unit.

A reporter, who visited the altered Macleay building in 1921, wrote:—

The building was altered and there was a space of 10 by 20 feet in the floor of the gallery at the time of construction and by means of a special crane the cases were hauled from the main floor and gallery up into this attic and when the attic was as full of cases as could conveniently be packed in there, the floor was filled with concrete, so that to all intents and purposes, hermetically sealed in an attic, the existence of which could not be suspected by a casual visitor to what should be the Macleay Museum . . . The attic is badly lighted and there are no blinds on the windows . . . The specimens are in serious danger of being irreparably damaged by the intense heat of the corrugated iron roof. The cases are so closely packed together there is just sufficient room to walk between.

In the turmoil of moving specimens and storing them, many did perish and many were lost or borrowed and never returned, for no proper records were kept over this period. It was reported that the Museum was cleaned out only once a year and that those involved dreaded the day! Alcohol in some of the less accessible specimen bottles had not been changed for 50 years. The glass-fronted cabinets and the jars stored in them were so encrusted with dust that it was impossible to see if there was any alcohol in a jar, let alone a specimen.

This state of chaos greeted Miss Elizabeth Hahn when she was appointed Curator in 1958, and she immediately set about to restore the Museum to its former state. She sorted and reorganized specimens, moved cabinets and tackled the horrifying cleaning job with very little assistance.

The Macleay Museum gallery, 1965.



The Museum Today

Today the Macleay Museum is functioning again, old specimens thought lost forever have been found and identified and it is pleasing to find that so many are still in excellent condition. Some additions have been made to the collection in recent years. Of interest is a small collection of New Guinea native wearing apparel and implements, which was given to the Museum in 1963. It came from Camden Park, Menangle, the old Macarthur Onslow home- stead. It was collected by Captain Arthur Onslow when he accompanied Sir William Macleay on the *Chevert* Expedition.

The Macleay Museum is to go to a new home, probably in about five years' time—to the new School of Biological Sciences building, which is to be called "The Macleay Laboratories".

We may anticipate that it will then be more accessible as a research collection and that the original intentions of Sir William Macleay will be fulfilled.

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[All photos in this article, except where otherwise stated, are by the Department of Illustration, University of Sydney.]

Vocal Communication in Frogs

By M. J. LITTLEJOHN

Zoology Department, University of Melbourne

THE vocabulary of frogs is limited to only a few relatively simple sound signals and these are mainly associated with reproductive behaviour. The most conspicuous of these is the mating call which is produced by the male and serves primarily to attract a reproductively ripe female of the same species to the calling male. A secondary effect may be that of aggregating the males into a compact breeding chorus, or, conversely, their spacing into individual breeding territories. When making this call the frog forces air from the lungs over a pair of vocal cords, then through the mouth cavity into a large inflated vocal sac under the throat. This vocal sac acts as a resonator and influences the quality and loudness of the call. During a calling cycle the mouth is kept closed and the nostrils sealed off so that the air is contained in a closed system, being pumped from lungs to vocal sac and back.

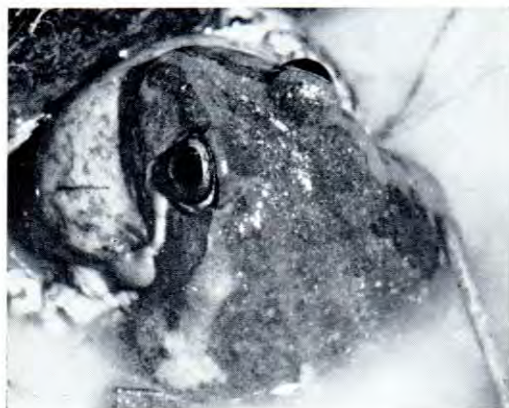
Two other sound signals are commonly produced by frogs, namely release calls and distress calls. The former function in sex identification and are usually much softer than the mating call. Release calls are normally produced when a male or a non-breeding female is contacted by another frog, and serve to reduce the opportunity for breeding males to clasp individuals other than ripe females. Distress calls may be heard when frogs of either sex are captured or violently disturbed. They are usually loud and made with the mouth open, possibly functioning to startle the predator. These two types of calls are less general in occurrence and are not so species-characteristic as the almost ubiquitous mating call. Nor have they been studied to any extent. Accordingly, the following discussion will be restricted to the mating call.

Recording And Analysis

In order to objectively study and compare animal sounds they must first be recorded and then physically analyzed. In



Above: *Hyla caerulea* calling from an elevated position in marginal vegetation. [Photo: Author.]
Below: *Limnodynastes dorsalis* calling from shallow water. [Photo: A. A. Martin.]



our work, recordings are normally obtained in the field, using a battery-operated tape recorder. The first step is to locate a calling frog and to position the microphone as close as possible to minimize background noise. After recording a sequence of calls, the specimen is collected for identification and future reference. Since some charac-

teristics of the call are influenced by temperature this is carefully determined in the immediate area of the frog. In the laboratory the recordings are played back and analyzed on an oscilloscope or a sound spectrograph so that the sounds can be accurately described. The types of traces obtained from these instruments are shown in the accompanying figures.

Depending on the particular call structure, a selection of the following characteristics might be measured: fundamental frequency (determined by the natural vibration period of the vocal cords); harmonic content; dominant or carrier frequencies (various body cavities, particularly the vocal sac, have their resonant frequencies and the closest harmonics are emphasized); and frequency modulation. These are the spectral properties of the sound. Values fall below 4,000 cycles per second for most species.

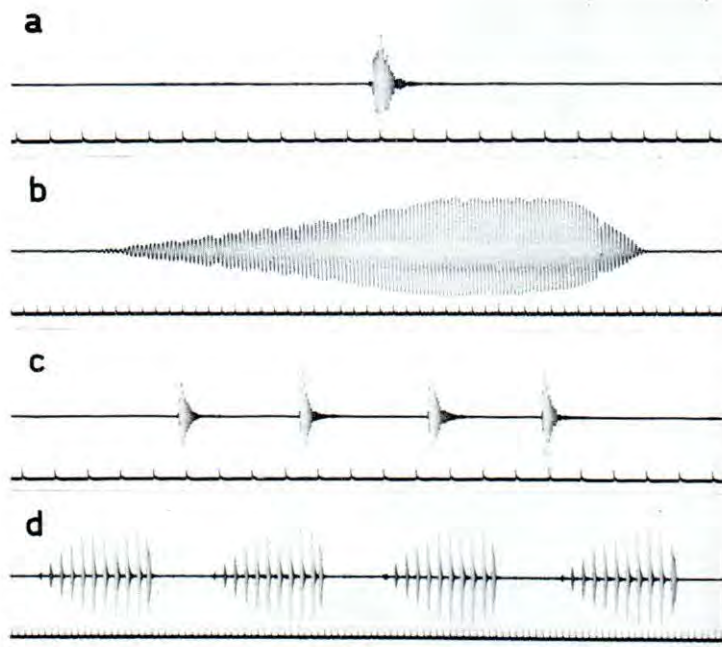
In addition to the frequency components are those of duration, repetition and amplitude modulation—the temporal characteristics of the sound. Thus, the call may be a short, single pulse of sound, a sustained note of simple envelope shape, composed

of a series of pulses (trilled), or of a series of “bursts” of pulses. Examples of these types of sounds are shown in an accompanying illustration. In addition, the calls may be repeated in a regular manner and a call repetition rate can be determined.

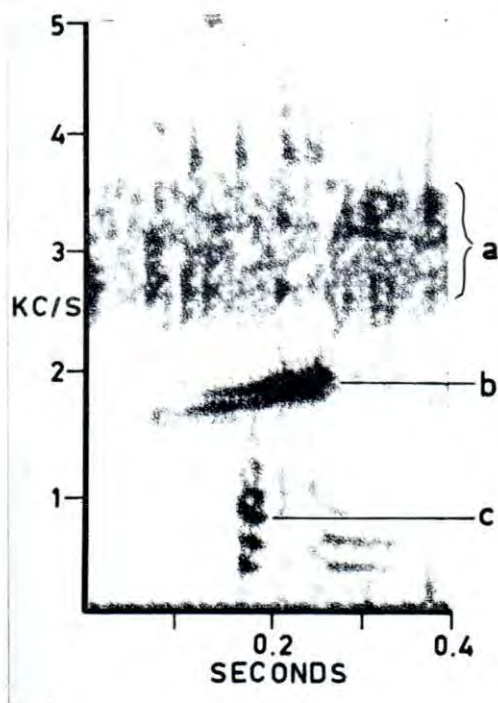
Problems Of Sound Communication

It is usual for several species of frogs to utilize the same general breeding site at the same time. As many as seven species have been found calling in close proximity. If the male's mating call is to be effective in attracting the right female then it must be quite distinctive and not confused through interference or masking by the calls of other species. Because of its main role in reproduction the mating call acts as an important species-isolating mechanism. The characteristic call of the male, and the specific response of a female to the call of her own species, together ensure the reproductive efficiency of the species. This importance is perhaps greatest between closely related species where hybridization may be possible, for this could lead to a breakdown in the well-adapted genetic systems of these forms. The isolating function of the call

Oscillograms showing temporal characteristics of mating calls. The time marker below each trace indicates 0.01 second intervals. (a) Single pulse of *Limnodynastes tasmaniensis*, Yan Yean, Victoria. (b) Sustained note of *Heleioporus australiacus*, Greenmount, Western Australia. (c) Pulsed call of *Uperoleia rugosa*, Savernake, New South Wales. (d) Segment of call of *Hyla ewingi*, showing repeated bursts of pulses, Yan Yean, Vic.



has been demonstrated in some North American species by means of call discrimination tests. In these experiments female frogs, simultaneously presented with recorded calls of their own and another closely related species, were found to move only towards the call of their own species.



Audiospectrogram showing frequency stratification in a spring chorus at Yan Yean, Vic. (a) Chorus of *Crinia signifera*; (b) One note from the call of *Hyla verreauxi*; (c) Single pulsed call of *Limnodynastes peroni*.

Detailed investigations of call variation, and of the structure of calls of hybrid frogs, indicate that these sounds are genetically based (instinctive) and that learning plays little, if any, part in their development.

How can the problems of interference (noise) be minimized and efficient vocal communication established? An analysis of call structure and calling behaviour leads to the following suggestions:—

(a) Spatial separation: Different calling positions may be utilized by each species, e.g., in open water, from cover of emergent vegetation, on the banks, or from elevated positions in the marginal vegetation. Within one of these particular calling sites the males might aggregate into several compact single species breeding choruses.

(b) Frequency separation: Overlap may be minimized by utilizing different frequency bands within the frog audio-spectrum in conjunction with a frequency discrimination mechanism in the female auditory system. However, dominant frequency appears to be correlated with body size, larger frogs having lower frequencies. But closely related species are usually about the same size and may not be able to exploit this means of overcoming interference.

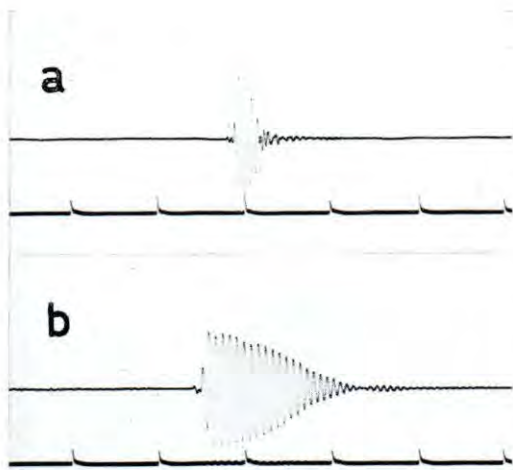
(c) Temporal differentiation: Because of the possible limitations of the frog ear in frequency discrimination, and of the influence of body size on the broad frequency range of a frog's call, temporal differentiation may provide the only method by which sound signals can achieve distinctiveness.

Natural Populations

The means whereby these problems are actually overcome in natural populations



Audiospectrograms of calls of *Neobatrachus pictus* and *N. centralis* recorded in a mixed chorus near Ouyen, Vic.



Oscillograms of single-pulsed calls of (a) *Neobatrachus sutor* and (b) *N. wilsmorei*, recorded at Gnoolowa Hill, Western Australia. The time marker below each trace indicates 0.01 second intervals.

may be illustrated by examining some examples of the calling behaviour of related species which breed in the same habitats at the same time.

Two species of burrowing frogs, *Neobatrachus sutor* and *N. wilsmorei*, have overlapping ranges in the Murchison area of Western Australia. They utilize temporary ponds for breeding and both species may breed at the same time. In these situations *N. sutor* calls from the banks, just out of the water, and *N. wilsmorei* calls while floating in open water. Their calls each consist of a single, short pulse of sound ("click") of approximately the same dominant frequency (1,500 cycles per second). However, the calls of *N. sutor* are repeated at about 150 per minute, while those of *N. wilsmorei* are repeated at about 40 per minute. The differences in call repetition rate appear to provide the specificity, while the different calling positions may reduce the sound interference.

Another pair of species of this genus, *N. pictus* and *N. centralis*, occur together in western Victoria and south-eastern South Australia. Both breed in temporary ponds and call while floating in open water. Their mating calls are of the trilled type, but that of *N. pictus* is of shorter duration, higher pitch and about half the trill rate of the call

of *N. centralis*. No spatial separation appears evident in the breeding choruses and efficient communication is presumed to depend on the differences in frequency and trill rate.

The types of call differentiation seen in these two species pairs are of wide occurrence in frogs, and many more examples could be cited. In general, it may be said that because of the specific reproductive function of the mating call, its distinctness is at a premium. This is achieved by each species having a call which differs from those of other species in the area in temporal or spectral characters, or a combination of these. In some cases the efficiency of vocal communication is further increased by the spatial separation of species at a particular breeding site.

BOOK REVIEWS

NEW ZEALAND BIRDS AND FLOWERS, compiled by D. W. Sinclair, Wellington; published by A. H. and A. W. Reed; second impression, 1963; price, 10/-.

This is, as it states, a picture book to serve as an introduction to some of the birds and flowers of New Zealand.

The plates from coloured photos are good and the text is simple and direct.

A useful list of books for further study is given inside the back cover. Inside the front cover all the plates are listed with the common and scientific names. It certainly achieves its aims.—H. J. de S. D.

BIRDS OF NEW ZEALAND, by Gordon R. Williams; published in 1963 by A. H. and A. W. Reed; price, 23/6.

This is similar to the first-mentioned book, but more detailed, and pictures 50 different species, giving a good cross-section of New Zealand birds. The useful introduction gives an outline of the history of New Zealand bird life and position in geological history and how the bird fauna arose. Forty species of land- and fresh water-inhabiting birds have become extinct since Europeans arrived, but only five since 1800. These losses have not necessarily been due to man's activities.

The life history and habits of each species are well covered by the text, and include notes on incubation and fledgling periods, which are rarely found in any book on Australian birds.—H. J. de S. D.



Looking north along the Main Divide from the top of Mt. Kosciusko (7,314 feet): foreground, gneissic granite; middle distance, on the right, mostly schist and quartzite; on the left, part of the great hollow of the Wilkinson cirque. The crest of the ridge in the middle, Mueller's Peak, is on the Main Divide of eastern Australia, separating Snowy (right) and Murray waters. In the distance the level skyline indicates the old peneplain surface with the monadnock of Mt. Jagungal (6,764 feet) rising above it. [Photo: J. L. Shellshear.]

THE GEOLOGY OF KOSCIUSKO

By W. R. BROWNE,

Former Reader in Geology at the University of Sydney

THE area here described comprises the country from Jagungal, 22 miles north of Mt. Kosciusko, to Dead Horse Gap, 5 miles south of it, with a width of 30 miles between the Indi (Upper Murray) River on the west and the Eucumbene-Snowy on the east. It includes the highest land in the Australian Commonwealth, culminating in Mt. Kosciusko (7,314 feet).

Sedimentary Rocks

Though the rocks composing it are very old the country reached its present altitude not more than one million years ago. The predominant rock is granite, which in the form of molten magma was forced into a series of sedimentary rocks belonging to what is called the Ordovician System, about 450 million years old. These consisted

originally of muds and fine sands laid down on a slowly sinking sea-floor, which had been consolidated, folded by earth-movements and metamorphosed into slates, schists and quartzites before being invaded and disrupted by the granite magma. They now appear as isolated belts, with bedding-planes contorted or steeply dipping, and in places contain the marine animal fossils known as graptolites, characteristic of Ordovician rocks all over the world. One belt crops out on the road near the Summit between Seaman's Hut and Rawson Pass and trends N.N.E., passing east of Lake Albina and west of Blue Lake. A wider belt is crossed by the Alpine Way at Leatherbarrel Creek and other outcrops are found farther west. Smaller masses of these rocks are enclosed in the granite, one of them on the very summit of Mt. Kosciusko.

Sedimentary rocks belonging to the next succeeding systems, the Silurian and Devonian, do not appear in the Kosciusko area but are seen farther north. Silurian limestones with corals, bivalves and other marine animal fossils crop out at Yarrangobilly and on the Cooleman Plain, and gently folded Devonian limestones and shales are exposed on the steep road leading down to The Ravine on Yarrangobilly River. These beds once covered the whole of the Kosciusko area but have been completely eroded away.

Granites

The granites are of various geological ages. The oldest, probably emplaced during the folding of the Ordovician beds, has been observed at and around Geehi Flat. It is a medium-grained rock rather rich in black mica (biotite). Next in age, and apparently related to the folding of the Silurian rocks, is a coarse-grained grey rock, weathering typically into great tors and boulders and displaying a gneissic or parallel arrangement of the constituent minerals which may be very distinct or virtually absent. This rock is very widely distributed indeed and forms most of the plateau. A very siliceous phase of it with a very strong foliation makes the summit of Mt. Kosciusko and extends for a few miles north and south, and a somewhat similar rock forms a belt passing N.N.E. through Mt. Etheridge to the Blue Lake and Mt. Twynam. There are also younger granites, pos-

sibly belonging to the epoch of folding of the Devonian strata. A medium-grained type without foliation forms the Snowy valley around Jindabyne and extends west and south-west along the Alpine Way. In general it is relatively easily weathered and eroded and tends to form low ground. An intrusion of this type into the gneissic granite accounts for the local widening of the Snowy valley at Island Bend and for a few miles downstream, also for the depression known as Big Boggy at the head of the Crackenback River. A coarser, somewhat siliceous type is the massive granite around Khancoban, and north and east of Tom Groggin the Alpine Way traverses massive granite and associated porphyries.

Following the Devonian folding the sea retreated to the east and, it would seem, never returned to the area, which has been dry land ever since. It probably experienced successive elevations followed by long intervals of erosion until most of the old sediments, many thousands of feet thick in the aggregate, were removed and the granites, which had crystallized at considerable depths, were exposed at the surface. As a result there is a great gap in the geological record, amounting to more than 300 million years, until we come to the Kainozoic Era, which began some 60 to 65 million years ago. During the second period of this era, known as the Oligocene (35 million years ago), the land-surface was deluged with flows of basalt lava which filled valleys, swamps and lake-depressions and com-

Granite at Blue Lake, smoothed, fluted and scored by a glacier moving from right to left.
[Photo: E. F. Pittman.]



The schist at the back of Club Lake, showing steeply-dipping bedding planes and snow patches.
[Photo: Author.]



pletely buried their deposits of boulders, gravel, sand, clay and peat. Around Kosciusko the only traces of this vulcanism are basalt dykes (e.g., at the back of Club Lake, east of Mt. Townsend and at Island Bend) which may have been feeders to flows, but at Kiandra, Cabramurra and elsewhere there are extensive remnants of basalt resting on the sediments.

The Kosciusko Epoch

By the end of the Miocene Period (13 million years ago) the whole area had been worn down to the condition of a peneplain—or gently undulating lowland surface of erosion—with occasional relics of the previous surface, known as monadnocks, rising above it. Then began a series of uplifts, punctuated by stillstands, that reached a climax towards the end of the next period, the Pliocene, and were responsible for raising the Kosciusko area to its present altitude. Appropriately enough, the time occupied by the final uplifts has been named the Kosciusko Epoch. Between the Indi and Eucumbene-Snowy Rivers the peneplain was raised differentially along fault-planes to form a series of giant steps running approximately north-south and culminating in what is now the Summit plateau at 7,000 feet, the whole forming what is known as a horst. The steps have been

very much modified by river-erosion, but on the eastern side one of them, at Wilson Valley (4,800 feet), is traversed by the Summit road, and there are others at 5,500 and 5,800 feet and higher altitudes. From Kosciusko or Twynam the horizontal skyline indicative of the uplifted peneplain may be seen, particularly to the north, where Jagungal (6,764 feet) rises above it as a monadnock. Mts. Kosciusko, Townsend, Twynam, Ramshead and other peaks rising above the general level are likewise monadnocks.

On the west the descent is very steep, being in places 5,800 feet in less than 5 miles, and erosion by a multitude of mountain torrents has obliterated the steps almost completely, but in the north-west the ridges of Grey Mare Range, The Dargals and others, separated by deep submeridional gorges, are seen as relics of great steps descending towards the Indi.

In the south-east the surface descends by a series of fault-steps tilted to the north-west. The position of one fault-plane is marked by the straight stretch of the Summit road between Digger's Creek and Spencer's Creek; the very straight course of Crackenback River and Dead Horse Creek marks another parallel fault, and others are approximately indicated by the Wellondibby and Mowamba Rivers.



Above: Blue Lake, 90 feet deep, occupies a rock-basin quarried out by a glacier descending from the back. [Photo: E. F. Pittman.] Below: From near Olsen's Lookout, looking south across Geehi River towards Mt. Townsend (7,250 feet), showing dissection by tributaries of the Murray River through a vertical range of more than 5,000 feet. [Photo: Author.]



North of Jagungal the uplifted peneplain descends rather rapidly to below 6,000 feet, and on the south beyond Cascade Creek it drops abruptly to 4,600 feet. A fine view of this level of the peneplain, surmounted by the monadnock of The Pilot (6,005 feet), may be had from The Pilot Lookout on the Alpine Way.

Glaciation

During the Pleistocene Ice Age, which ended some 11,000 years ago, the plateau down to and below the 5,000-foot level was glaciated. Evidences of glaciation, most easily recognizable at the higher altitudes, consist of erratic boulders of granite and quartzite that have been carried far from their outcrops; moraines, like the David, Helms and Townsend moraines; the varve-clays of Trapyard Creek; U-shaped valleys with moraine deposits on their floors; hanging valleys; cirques or armchair valleys like the Wilkinson, Mawson and Twynam cirques, and others containing lakes like Cootapatamba, Albina and Blue Lake; and ice-grooved pavements, as at Lake Albina

and Blue Lake. The moraines contain boulders upwards of 25 feet long and stones of quartzite with flattened facets bearing glacial scratches. Glaciation may have extended as far north as Jagungal.

Since the glaciers melted frost-weathering has been active in various ways, particularly at the highest levels, e.g., in breaking up the surface rocks into accumulations of angular boulders, as on the top of Mt. Kosciusko; and on the floors of many glaciated valleys are peat-bogs, some of which may date back to the Great Ice Age.

The magnificent gorges of the Indi, Snowy and Crackenback Rivers, more than 2,000 feet deep, and of their numerous tributaries great and small, have been excavated in the uplifted peneplain since and as a result of the Kosciusko uplifts. Some appreciation of the stupendous amount of the erosion accomplished may be gained by looking north and north-west from Mt. Townsend or Mt. Twynam. Valley-erosion is still proceeding, though now in some degree modified by the works of man.

NEW FRUIT-FLY FOUND ON MANGROVES

This fruit-fly species was first noticed in the summer of 1964-65 in a mangrove swamp near Sydney. Female flies were seen on the fruit of the Grey Mangrove, *Avicennia marina*, some apparently laying eggs. Fruit brought to the Museum were found to contain larvae or pupae of this fly, and many flies were thus obtained. The reason this species has not been recorded and named before is that insects inhabiting mangroves in Australia have been little studied. As this fly has never been found in cultivated fruits it is not classed as harmful. Of over 130 Australian fruit-fly species only a few are regarded as pests. [Photo: A. Healy.]





The Cobequid Fish Culture Station, Oxford Junction, Nova Scotia, Canada, which produced the Atlantic Salmon eggs for New South Wales.

ATLANTIC SALMON FOR NEW SOUTH WALES

By DONALD D. FRANCOIS
N.S.W. State Fisheries

IN February, 1963, and again in February, 1964, 100,000 Atlantic Salmon, *Salmo salar*, eggs were imported by the N.S.W. State Fisheries from Nova Scotia, Canada. It is over a century since the first successful attempt to transport the eggs of this species and Brown Trout, *Salmo trutta*, was made in 1864 by Mr. J. A. Youl aboard the *Norfolk* (two earlier attempts in 1860 and 1862 were failures). The basic technique of shipping the ova in moss, refrigerated with ice, is the same today as in Mr. Youl's time, but advances in transportation and our scientific knowledge have made the process quick and reliable. The eggs on the *Norfolk*, for example, were packed in moss in 200 boxes and surrounded with 32 tons of ice for the 80-day voyage. By contrast, the recent shipments took four days by air, in light containers.

The aim of Youl's and subsequent shipments of Atlantic Salmon was to establish sea-runs of this fish similar to those in England. Whilst the young salmon did well in the fresh waters of Tasmania they did not return to these streams after migration to the sea and the attempt to establish the species was a failure. This was most likely due to unfavourable ocean currents around southern Australia.

Salmo salar is the classic salmon of the British Isles, Scandinavia, and north-eastern United States and Canada. It should not be confused with the Pacific salmon which belong to the genus *Oncorhynchus* and are indigenous to the North Pacific Ocean. As the generic name *Salmo* implies, Atlantic Salmon are more closely related to Brown Trout, *Salmo trutta*, and Rainbow Trout, *Salmo gairdneri*, than the Pacific salmon.

Atlantic Salmon, unlike nearly all the Pacific salmon, do not die after spawning. Atlantic Salmon can be best likened to Steelhead Trout, a "race" of Rainbow Trout that migrate to the sea and return to fresh water to spawn, in that they are actually sea-running trout. A major taxonomic difference between the true salmon and the trouts is the number of rays in the anal fin, *Oncorhynchus* generally having more than 13 rays and *Salmo* 12 or fewer (there may be some overlap).

Whilst the Atlantic Salmon is typically a sea-run fish, spending its adult life in the sea and returning to fresh water to spawn, completely landlocked populations are common. The lake inhabited is thus analogous to the ocean with respect to the fishes' migrations. It is interesting to note that some landlocked populations spawn in both inlets and outlets of the lakes they inhabit. Although many of these landlocked populations appear different and have been given different names, such as "Ouanchie" and "Sebago Salmon", the current opinion is that they are all *Salmo salar* and that the observed differences are infra specific manifestations resulting from isolation. Kokanee Salmon, *Oncorhynchus nerka kennerlyi*, is the only Pacific salmon that also thrives without returning to the sea.

The current attempt to establish landlocked Atlantic Salmon populations in New South Wales involves releases of small salmon in the Goodradigbee drainage of Burrinjuck Dam and the rearing of salmon at the State's two hatcheries as potential brood stock. Releases of the valuable salmon fingerlings are being restricted to the Goodradigbee system, as Burrinjuck Dam is considered to have the most favorable conditions for this species. In addition to being a large impoundment, Burrinjuck affords excellent spawning grounds for salmonids and has an abundance of large forage. If, and when, Atlantic Salmon become established in Burrinjuck and we have a domestic source of eggs, releases of salmon will be made in other impoundments.

The N.S.W. State Fisheries has been motivated by several reasons in the present experiment. Atlantic Salmon are famous for their sporting qualities and fine flavour.

They will taken an artificial fly and offer a spectacular fight, averaging four or five jumps with the odd fish coming out of the water 10 or 12 times. Over 100 years ago Mr. H. Cholmondeley-Pennell, in a rather dramatic vein, stated in his *Modern Practical Angler*:—

I unhesitatingly assert that there is no single moment with horse or gun into which is concentrated such a thrill of hope, fear, expectation, and exultation as that of the rise and successful striking of a heavy Salmon. I have seen men literally unable to stand, or to hold their rod, from sheer excitement.

It is doubtful whether New South Wales anglers will find themselves prostrate on the ground with excitement from hooking an Atlantic Salmon, but anyone fortunate to land one will probably concede that it tops both Brown and Rainbow Trout for sport.

Adult Atlantic Salmon have a slightly higher lethal temperature than Brown or Rainbow Trout, and young salmon thrive in water temperatures that are marginal or too warm for trout. In Fall Creek, Ithaca, New York State, for example, fingerling salmon grow rapidly and do very well in summer water temperatures that are commonly in the 80's. If, and this is a big if, these fish can be successfully established in some of the larger impoundments in N.S.W., which are at present marginal for trout and indigenous warm-water fishes because of water temperatures, it is possible that the mediocre fishing in these waters may be considerably improved.

In the majority of cases where trout have been introduced into waters containing Atlantic Salmon, or where attempts have been made to introduce salmon to waters inhabited by trout, the salmon have suffered. For example, Branch Lake in central Maine, U.S.A., supported a substantial salmon fishery which disappeared after the introduction of Brown Trout. Maine fishery biologists also have been unsuccessful in attempts to reintroduce salmon in many waters containing residual populations of Brown Trout. However, in Lake Cayuga, a large (30 miles by 1 mile) and deep (400 to 500 feet) lake in central New York State, large salmon are being caught as a result of releases of fingerlings raised from the ova of sea-run salmon. The lake supports many species of cold and warm fishes

including Northern Pike, Large-mouth and Small-mouth Bass and other sunfishes, Rainbow Trout, Yellow Perch, catfish, sturgeon, garfish, sea lampreys, bowfins, freshwater herrings, smelt, whitefish and suckers, to name but a few. Spawning areas for salmon are very restricted and stocking is required. In many respects this lake is similar to Burrinjuck Reservoir, which also supports trout as well as warm-water fishes. In N.S.W., competition with native species will be almost non-existent and successful competition with trout, whilst unlikely, would result in more pounds of a more desirable fish being available to the angler.

Introductions of exotic plants and animals to Australia are quite understandably a subject which causes much concern to people interested in conserving our native flora and fauna. Many introductions, however, have worked out particularly well and have contributed in no small way to making Australia the country it is today. I refer, of course, to many domestic animals and most agricultural products. Other introductions have had both detrimental and beneficial effects. The introduction of trout might fall into this category. Whilst this introduction resulted in the severe restriction of several small cold-water species of fishes it has also provided thousands of Australians with food, sport and recreation.

If the proposed introduction is carefully investigated and there is some independent control, we can be reasonably certain that the result will not be undesirable.

In the case of fishes, the Commonwealth-State Fisheries Conference, representing all States and several Commonwealth Departments, has two committees which make recommendations on importations. One committee concerns itself with aquarium fishes and the other, chaired by Mr. A. Dunbavin Butcher, Director, Fisheries and Wildlife Department, Victoria, deals with food and sport fishes. As was the case with N.S.W.'s importation of Atlantic Salmon, any request to import food or sport fishes must come before this committee which then makes recommendations to Conference. Importations are subject to prophylactic treatments to safeguard against the entry of disease and parasites.

Research carried out at the N.S.W. Inland Fisheries Research Station at Narrandera has demonstrated that the changing character of our inland water system, primarily through the erection of dams and weirs, is making them unsuitable for many native food and sport fishes. The Murray River above Yarrawonga is an excellent example. Golden Perch, *Plectroplites ambiguus*, require water temperatures of approximately 75°F. or higher and a rising river for breeding. The degree of billabong and backwater flooding determines the success of the spawning through the amount of plankton production. The Murray River upwards from Yarrawonga no longer provides these conditions and this fish is virtually non-existent in this part of the river.

If fishing is to be provided in such marginal waters two approaches can be used. One is the operation of very costly and dubiously effective hatcheries for our native fishes and the other is the importation of a fish or fishes that will do well under the existing conditions. From information at present before them, the New South Wales fishery authorities favour the latter approach and when sufficient information is available recommendations to the Minister for a suitable introduction will probably be made.



Checking the water temperature at the temporary hatchery erected in 1963, on Saw Pit Creek.

Members of the Yass Acclimitization Society releasing salmon fry in Micalong Creek, a tributary of the Goodradigbee River.



The recent importations of salmon ova presented one serious technical difficulty in that the ova arrived from the Canadian winter into the Australian summer and the water temperatures at both N.S.W. hatcheries were too high. This was alleviated by erecting temporary hatcheries on cold water sources. The first shipment of ova was hatched at Saw Pit Creek on the Mt. Kosciusko Road, where water temperatures averaged 15°F. to 20°F. colder than at the Gaden Hatchery. Because Atlantic Salmon fry and fingerlings will not feed properly unless the water temperature is approximately 50°F. or warmer and the water at the Gaden Hatchery is under 50°F. for seven months of the year, severe losses of the tiny fish were experienced with the early onset of cold water conditions. It is interesting to note that the Thredbo River is colder than the River Phillip in Nova Scotia. The River Phillip provides water and salmon to the Cobequid Fish Culture Station which supplied N.S.W. with eggs. Only 17,000 salmon from the first shipment survived the winter. Of these, 9,000 were liberated in October, 1963, in Micalong Creek, a tributary of the Goodradigbee River which flows into Burrinjuck Dam. The remainder of the fry were retained at the hatcheries as potential brood stock.

Because of the unfavourable timing in respect to seasons and the very cold water temperatures at the Gaden Hatchery the second shipment was hatched in a small cold creek in a patch of rain-forest near the Dutton Hatchery, near New England National Park. The warmer water at the Dutton Hatchery resulted in 65,000 2-2½ inch salmon surviving the winter. Of these, 25,000 were released in Micalong Creek and the Goodradigbee River. Further releases of this shipment are planned for the autumn and spring.

The Atlantic Salmon eggs being used in this programme have been supplied free of charge by the Canadian Department of Fisheries through Dr. A. L. Pritchard and Dr. R. R. Logie. Further shipments are planned for 1965 and 1966, by which time it is hoped that N.S.W. will have its own supply of eggs.

From the limited background information presented it should be evident to the reader that it is quite a gamble as to whether Atlantic Salmon will become established in any New South Wales waters. However, it is a gamble which cannot seriously affect the present fisheries and which could possibly enhance angling in N.S.W. With luck, we may be able to establish some small self-perpetuating populations of salmon that will add variety to the cold water fishery and offer a "challenge fish" to the angler.

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