The
AUSTRALIAN MUSEUM MAGAZINE

Vol. XIII, No. 10 Price—THREE SHILLINGS

Whale marking is a valuable aid to the study of the biology of these mammals. Here a gunner is preparing to shoot a mark, a stainless steel dart, into the dorsal muscles of a Humpback Whale off the Queensland coast. An article on whale marking appears on page 309.

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● Mr. B. J. Marlow, Curator of Mammals at the Australian Museum and author of the article "Whale Marking" in this issue, took the photo on our front cover when he was on a C.S.I.R.O. whale-marking expedition off Moreton Island, Queensland, last September. The gunner in the photo is Mr. E. Madely, of the C.S.I.R.O.

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WHALE MARKING

By B. J. MARLOW

THE marking of animals to indicate ownership probably extends back in time to the origin of domestication of animals. During the present century the science of ecology has flourished, and with it many techniques for the marking of animals so that they can be recognised individually have been developed. These marking techniques have been applied to mammals, birds, reptiles, fish and insects. Three main methods of marking are recognised—mutilation, tagging and the use of dyes.

Mutilations include such operations as ear-notching, toe-clipping and branding, which have the advantage of being permanent but may cause discomfort or hamper the movements of the animal. Tagging involves the attachment of some mark, made normally of non-corrodible metal, to the animal, often in the form of a band around the leg or a tag attached to the ear. These marks suffer the disadvantage of tending to hamper the movements of the animal and may become detached. Dyeing has been applied mainly to mammals and birds and, although it often permits the recognition of an individual at a distance, it is the least permanent method since the mark is lost when the animal moults.

Many features in the biology of animals can be studied when marked individuals are introduced into the population, and without such marking these aspects of ecology would not lend themselves to investigation. Thus, movements and rate of displacement can be detected by the recovery of marked animals, since the original locality and date of marking are known. If young animals of known age are marked, valuable data on life-histories and the rate of development can be obtained. Similarly, if adults are marked during known stages of their reproductive cycles much useful information can be accumulated regarding the rate and frequency of reproduction and also of the physiological processes involved. Finally, by comparing the number of marked animals introduced into the population with the percentage of marked animals taken in subsequent samples, it is possible to estimate the size of the population and to obtain indications of increase or decline in the numbers of the animals.

Successful conservation and management of animals of economic importance cannot be effected without a sound knowledge of the ecology of the species in question, and for this reason a serious programme of

Below: A whale mark with its cartridge attached. This whole unit is inserted in the breech of a 12-gauge shotgun. Above: A mark after it has been fired. The whole mark enters the dorsal muscles of the whale and is recovered when the mammal has been killed and is being processed on a factory ship or at a shore station. [In the early days of whale marking marks were returned via the Admiralty instead of the British Museum (Natural History), as at present.]

Photo.—Howard Hughes.

whale marking has been in operation since 1926.

General Principles Of Whale Marking

Whales are marked with a stainless steel dart, about 12 ins. long and with a blunt lead point. This mark bears a serial number and the words "Reward for Return to Discovery, British Museum (Natural History) London." The marks are fired into the dorsal muscles of whales from a specially modified shot-gun and are recovered later when the whale has been killed and is being processed on a factory ship or shore station.

Marking is confined mainly to the large whales of economic importance, such as whalebone whales and sperm whales, and about eight countries are involved in whale-marking programmes. All British Commonwealth countries use the "Discovery" mark described above. The larger species of whales, such as blue whales and fin whales, are marked during the season in the Antarctic, while around Australia and New Zealand marking is confined to the humpback whale (*Megaptera novaeangliae*).

The Biology Of Humpback Whales

Humpback whales of the Southern hemisphere spend the summer in the Antarctic, where they feed on the enormous shoals of "krill", a small shrimp-like crustacean (*Euphausia superba*), which is filtered out of the water through the baleen plates present in the mouths of all whalebone whales. With the approach of autumn, the whales migrate north to sub-tropical waters where breeding occurs and the calves are born during the early winter. The whales spend the whole of the winter in these warmer waters and during this time the adults do not feed. In the spring, the animals turn south again and head for their feeding-grounds in the Antarctic. The period of gestation is about a year, so that the calf is born in sub-tropical waters in the winter which follows fertilisation. Young whales do not possess the thick coat of blubber at birth and would thus be unable to withstand the freezing temperatures in the Antarctic. This layer of fat is laid down quickly during suckling, which lasts for about 11 months. The cow does not mate while lactating, so a single calf is normally born only every second year.

The populations of humpback whales in the Antarctic are separated into five distinct groups which do not normally intermingle and which migrate independently to those areas that lie approximately due north. The area which lies south of Western Australia is known as IV, while that south of eastern Australia is V. The recovery of marked whales has shown that those taken at Carnarvon have come from area IV while those taken in New South Wales, Queensland and New Zealand have come from area V. (See map)

Marking Techniques In Australia

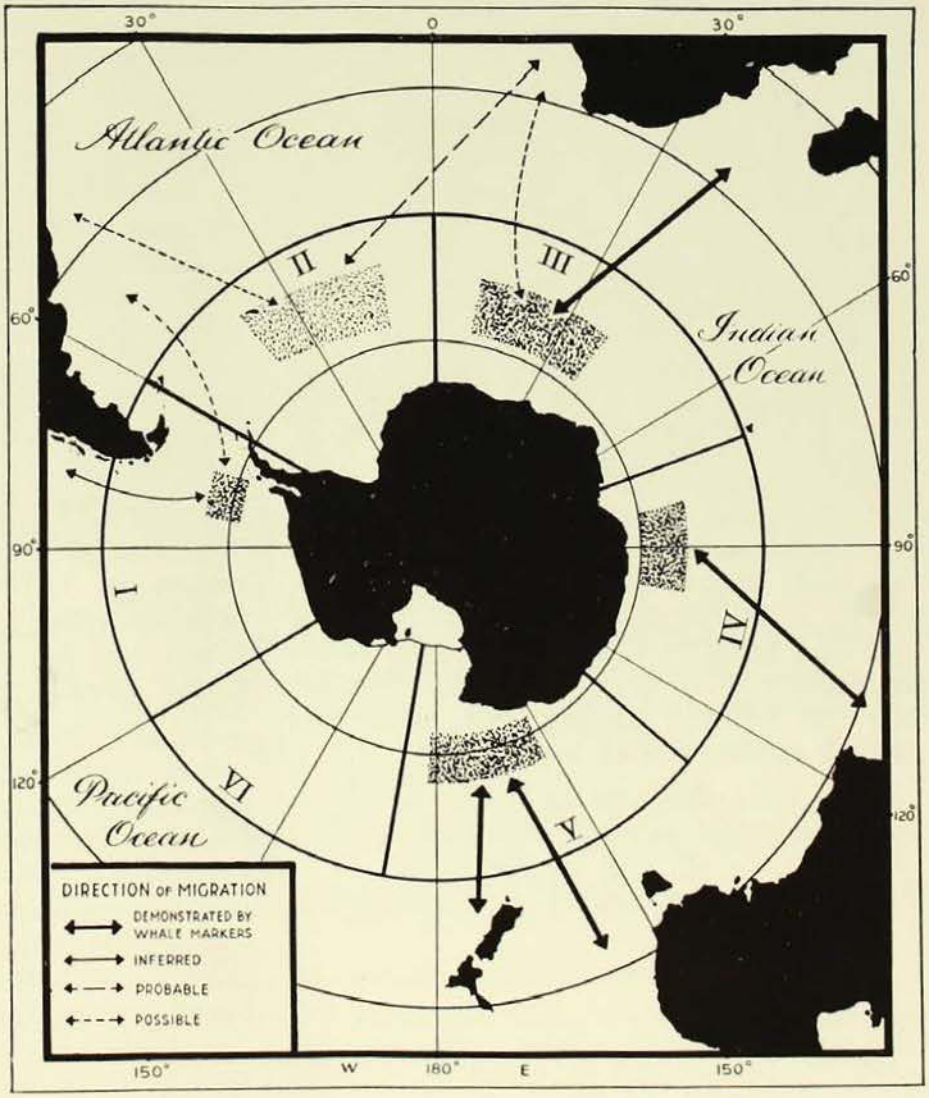
In eastern Australia marking of humpback whales starts in September after the catching season from the shore stations has finished. At this time whales are migrating south to the Antarctic to the summer feeding-grounds, and many of the females

are accompanied by suckling calves or yearlings.

Marking operations are carried out from the open fore-deck of a cabin cruiser during the hours of daylight, while night is spent at anchorage in the shelter of land. A crew of three is the minimum required, consisting of two gunners and a skipper-coxswain.

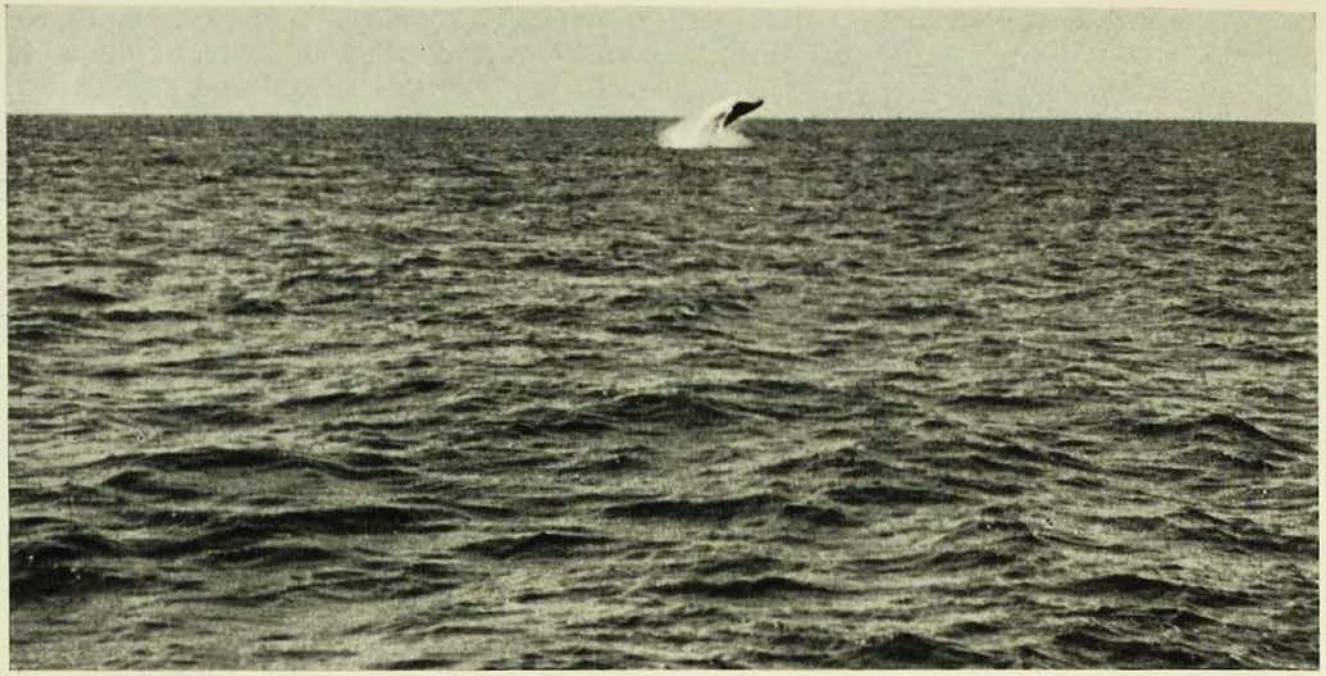
Whales are found by watching for their conspicuous spoutings, which are really the condensation of the water vapour in the breath. They may be also seen lying on the surface of the water lazily waving a long flipper which is characteristic of the humpback whale. On occasion these whales may "breach", i.e., leap clear out of the water, falling back with an enormous splash which can be seen for some distance. The success of whale marking depends to a great extent on the weather; in moderate seas it is very difficult to see the spouts above the waves, while on calm days it is possible to see spouts over a great distance. Humpback whales appear to be highly gregarious, and may be found in groups of up to 10 individuals. Solitary specimens are rare, and the numbers most frequently encountered are twos, threes and fives.

It is essential to steer as close as possible to the whales, and the maximum range over which they can be marked is less than 30 feet. A far closer approach is possible when the animals are in larger groups of about five individuals. When first approached the whales swim just below the surface and rise at frequent intervals to breathe. The head is the first to emerge, and as soon as the large blow-holes at the back of the head clear the water the animal spouts. It then rolls forward and the short triangular dorsal fin breaks the surface and then disappears. If hard-pressed, the animal may sound deeply, this behaviour being indicated by the



This map (after MacIntosh) shows five areas in the Antarctic, each with its separate population of Humpback Whales. The lines represent the main migration routes of this species.

Map by David Rae.



A Humpback Whale "breaching" (leaping clear out of the water) off Moreton Island, Queensland.

Photo.—Author.

broad tail flukes being brought clear of the water just before the whale slides vertically down. After sounding the whale stays submerged for up to 10 minutes and may often change direction below the surface.

The whale marks, with their attached cartridges, are loaded into a specially designed 12-gauge shot-gun fitted with both a fore and back sight. For successful marking it is essential to fire the mark into the large muscles of the back immediately below the dorsal fin, and it must be completely embedded. A mark which is protruding is counted as a miss, as it will eventually work its way out if it only penetrates the blubber. The greatest success in marking is obtained with fairly large groups of whales in shallow water. In this situation, the animals can be seen continually as light green shapes below the surface, and since they herd together they can be kept turning in a circle and marked as they rise to breathe.

It is most desirable to mark new-born calves whenever possible, but this is often difficult, since the calf frequently comes to the surface on that side of its mother which is away from the launch.

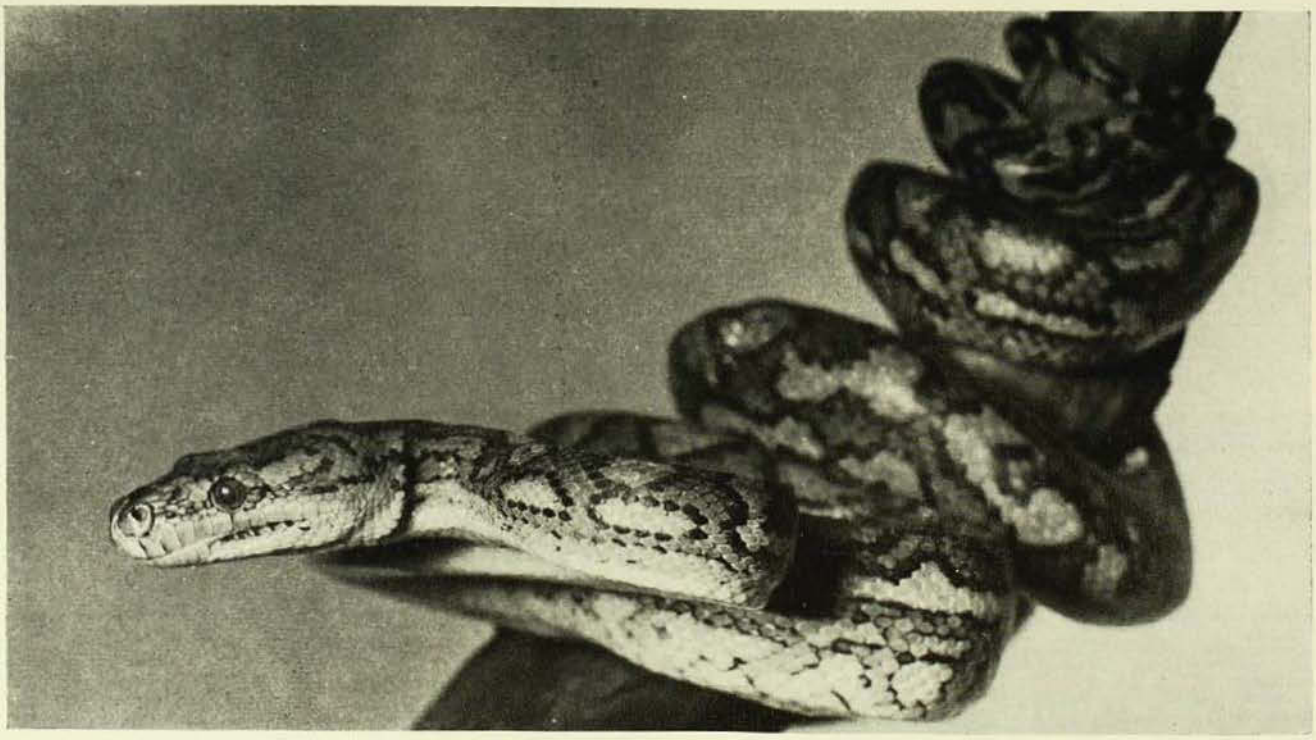
In recent years new information on the biology of whales has resulted from the recovery of marked whales. The age of specimens is normally estimated by examining the bands which are laid down on the baleen plates or on the wax plugs from the inner ear, but to date these age-finding techniques have not been standardised against marked specimens of known age. This could only be done by examining the ear plugs and baleen of a series of whales which had been marked as new-born calves. It was formerly believed that humpbacks were sexually mature at the age of about two years, but investigation of two recently-captured specimens which had been marked showed that this was greatly under-estimated and that they are probably not mature until they are about four years old.

Similarly, recent data from marked whales in 1959 showed that a transition between areas IV and V in the Antarctic, which had not been suspected, was in fact taking place.

Certain improvements in marking techniques would greatly facilitate the accumulation of data on whale biology. These include a mechanism to prevent excessive entry of the mark into whale calves, as they may often sustain severe injury during marking. Furthermore, the recovery rate of marks is very low, and on many occasions they are found subsequently in the "cookers" after the ability to relate the mark to a particular specimen or its organs has been missed.

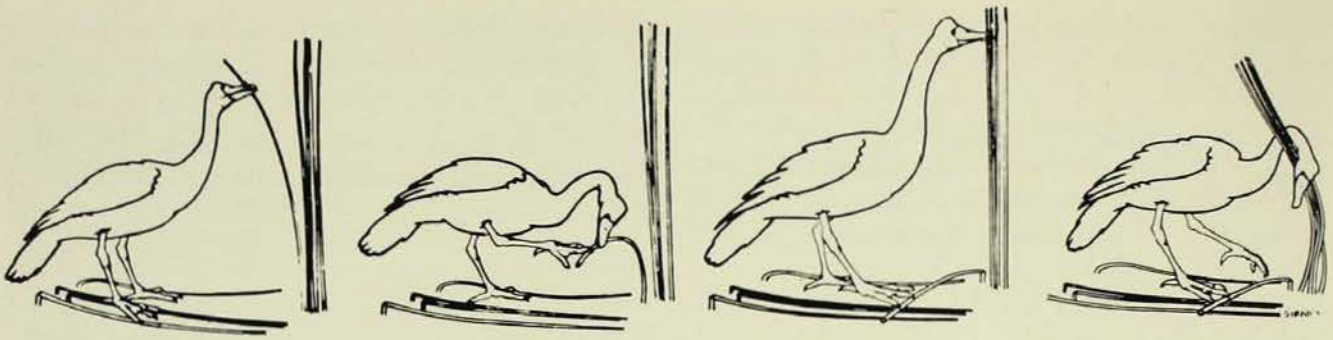
To offset these disadvantages, whale biologists in C.S.I.R.O. devised a mark which was attached to a "stopper" by a stainless steel spring that not only slowed down the entry of the marker into the whale but also provided a mechanism for easier detection. This was done by filling the marker with a fat-soluble stain which coloured the surrounding blubber, while at the same time the "stopper" remained on the outside and was connected by its spring to the embedded marker.

Much useful information on the biology of whales has thus been obtained from the marking programmes that have been carried out throughout the world, but much still remains to be discovered. In particular the rate of successful marking of calves and their subsequent recovery needs to be increased so that the rate of change in structures which are used for the ageing of whales may be standardised against animals of known age, an operation which has not so far been carried out.



Recent investigations by Mr. Harold G. Cogger, Assistant Curator of Reptiles at the Australian Museum, and Mr. Alex Holmes, an amateur herpetologist, have shown that large Carpet Snakes (*Morelia spilotes variegata* Gray) can absorb solar heat on a fine day, conserve much of it and maintain their body temperature well above that of their surroundings during the following cold night. This conservation of heat is accomplished by tightly coiling their bodies, thus reducing the surface area available for loss of bodily heat. Mr. Cogger and Mr. Holmes estimate that the surface area exposed to the surrounding atmosphere when the snake is coiled is only about 30-50 per cent. that of the surface area when the snake is uncoiled. It is thought that this method of heat conservation may be important in the maintenance of digestive processes and in the incubation of the eggs. Most members of the Python family, to which Carpet Snakes belong, are known to incubate their eggs, and it is thought that they, too, may be able to absorb and conserve solar heat. Carpet Snakes, a specimen of which is shown above, are found all over Australia except the far south-eastern corner and coastal N.S.W.

Photo.—Howard Hughes.



Magpie Geese use their bills, necks and feet in building nests in rush swamps.

Drawn by G. Binsted.

MAGPIE GOOSE BEHAVIOUR

By S. J. J. F. DAVIES

Wildlife Survey Section, C.S.I.R.O., Nedlands, W.A.

NATURAL history had its origins in simple studies of animal life. People wanted to know where animals lived, what they ate, when they bred, and how many of them there were. Out of these questions arose the science of ecology—scientific natural history as it has been called. More recently people have begun to ask why animals do these things. It no longer seems sufficient to say, for example, that a bird nests in only one particular type of habitat when there are several available. People want to know why each individual bird in the population chooses that habitat rather than any other; the study of the reactions of individual animals to their environment and to other animals has become the science of animal behaviour.

Ecology and animal behaviour must always be closely related, and ideally should be studied side by side. Between 1956 and 1959 I was privileged to assist the C.S.I.R.O. Wildlife Survey Section in their ecological study of the Magpie Goose (*Anseranas semipalmata* (Latham)) at Humpty Doo, near Darwin, Northern Territory, an account of which has already been published in this Magazine (Vol. xii., pp. 348-351). At Humpty Doo I had the opportunity to observe the behaviour of wild geese and to rear birds for controlled experiments on their behaviour.

Very soon after the beautiful little grey and chestnut Magpie Geese are born in the rush swamp they begin to peck at objects around the nest. The action of pecking is clearly inborn, for it developed normally in goslings kept by themselves from the moment of hatching, but it also seemed that goslings might have an inborn tendency to peck at some objects more than others.

In order to see whether such a tendency really existed, a large number of goose eggs were collected from the breeding swamps and incubated in an oven. When the goslings hatched they were inexperienced (that is, unfed), so that if any tendency to peck at some objects more than at others was present in them, it was probably inborn.

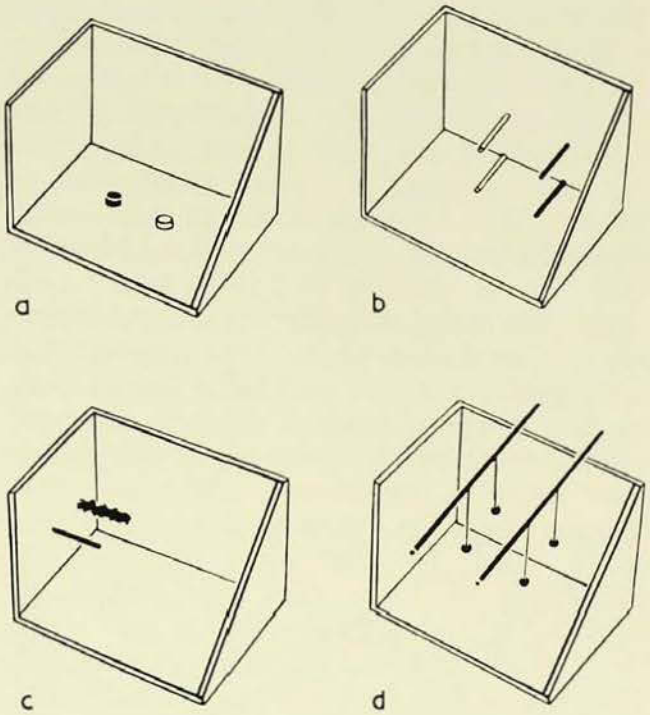
The goslings were presented with each of the four experimental situations shown overleaf, set up in boxes painted light grey inside, so that black objects were darker than the background and white ones lighter than it. In (a) an object darker than the background was presented at the same time as one lighter than it. The same was done in (b), but here high and low objects were also compared. In (c) a rough object was present beside a smooth one. Finally, in (d) four coloured pendants—green, yellow, blue, and red—were hung above the goslings.

The goslings were placed in the boxes two at a time and each gosling was tested twice in all four situations, on the first and second day of life, before it was allowed food or water. Goslings eat very little until they are two or three days old, and the period of fasting did not appear to harm them.

When the number of pecks made by the goslings at each of the objects was added up, it was evident that goslings do possess very strong tendencies to peck more at some types of object than others. Thus they pecked much more at light objects than dark ones, and more at high ones than low ones. They also pecked very much more at the yellow and green pendants than at the blue and red ones, but they did not appear to discriminate between rough and smooth.

Since pecking in goslings is, at first, a feeding response, it was very interesting to find, when some gizzards of wild goslings were examined, that they fed almost exclusively on the seed-heads of swamp grasses and sedges. These objects fit the inborn preferences of the goslings, shown by the experiments, almost perfectly. They are light green or yellow, hanging a little above water-level, and contrasting with the dark green shoots of the dominant swamp plant, *Eleocharis*.

In this way the ecology and the behaviour of the goslings dovetail to give the little goose the best possible chance of beginning to feed as soon as it leaves the nest.



Drawn by G. Binsted.

Above: Newly-hatched goslings were placed in boxes of this type to see if they had an inborn tendency to peck more at some of the objects in the boxes than at others.

Right: Goslings leaving their nest in a rush slanting swamp.

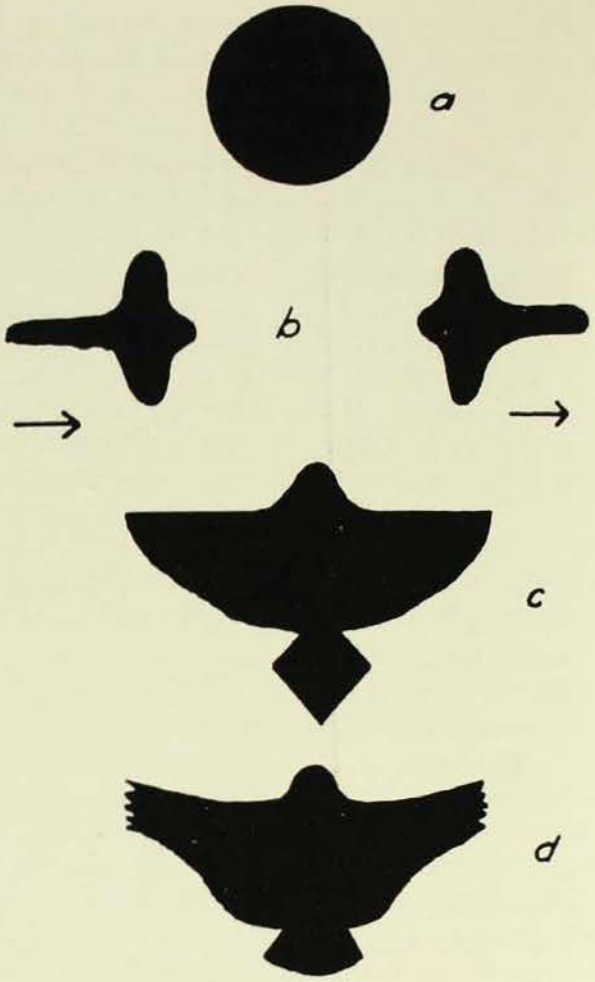
Photo.—Author.

Response to Hawks

When a flock of wild geese was alarmed, all the birds clustered together and assumed an alert posture with upstretched neck, and they might, if they were sufficiently frightened, fly off as a flock. The clustering that preceded flight was a very characteristic action and it was therefore easy to tell when a flock became alarmed. Now the White-breasted Sea-eagle (*Haliaeëtus leucogaster*) was the only bird that consistently evoked intense alarm and flight in the flocks whenever it appeared. The discrimination between the Sea-eagle and the nine other birds of prey that are found around Humpty Doo was so striking that it seemed worth while examining the response experimentally. Overseas workers have shown that some geese recognise particular hawks both by their shape in relation to their direction of movement and by their size in relation to their speed of movement. Assuming that Magpie Geese use the same cues, the experiments tried to find out whether the recognition of these cues was inborn or whether the young geese learned that when these shapes appeared the older, experienced members of the flock always alarmed and flew off and thus came to associate the shapes themselves with fleeing.

Two flocks of young, inexperienced geese were available, neither of which had ever been with adult birds. A wire was stretched across the yard in which they lived, and every day one or other of the shapes shown on this page was pulled along it on a pulley at more or less constant speed. The results were very interesting. Despite the variety of shapes used (some of which seem completely meaningless, e.g. the disc, and others quite realistic, e.g. d, which is a silhouette of a sea-eagle) the birds responded to them all by alerting, usually clustering and often moving away. There was no discrimination between shapes or, when (c) was used in two sizes, between sizes in relation to rate of movement.

Thus, the indications seem to be that geese do have to learn to recognise their avian predators; and that it is a question not of learning to flee from a particular shape, but of learning *not* to flee from every shape that passes overhead, gradually learning that some are "safe" and others



These silhouettes were used to study the alarm responses of Magpie Goose flocks: (a) disc; (b) shapes representing a falcon or a duck, depending on direction of movement; (c) an eagle shape; (d) a sea-eagle shape.

Drawn by the author.

"dangerous" by associating the shapes with the responses of older birds in the flock.

Magpie Geese are strange birds in many ways, but one of their most surprising attributes is that many of the ganders have two wives. Both these geese lay in the same nest and all three birds incubate and lead the brood. Although the three birds remain together throughout the year, the first signs of breeding are seen when the swamps are beginning to grow early in the wet season, about two months before any eggs are laid. The geese then start nest-building, but the early nests are just clumps of rushes bent over to provide the geese with a platform in the swamp on which they can stand to preen and court. As the swamps grow and the gonads of the birds develop the platforms become more elaborate; several

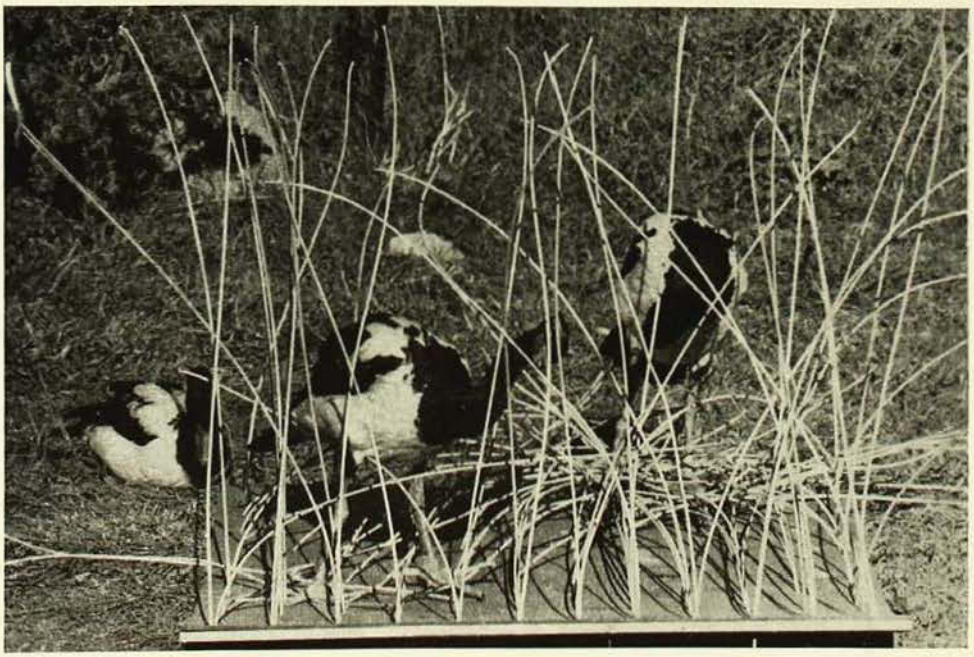
clumps of rushes are involved and are woven into a substantial stage. Each of these stages is used only once by the geese, and sometimes a trio will build two, side by side, when they cannot all fit on to one. After they have built a stage and used it for a little while they move on and build another somewhere else in the swamp.

Shortly before the geese are ready to lay, stage-building becomes more elaborate. When the stage has been built other rushes, broken off at water-level or wholly uprooted, are dragged on to it. At first only a few loose shoots are added, but later the pile is much larger. Even so, each stage is used only once, until one day, early in the morning, a stage is built, a large quantity of loose rushes is pulled on to it, and one of the geese lays an egg on it. Thereafter, both females lay each day and the clutch is rapidly completed while more rushes are added to form a deep, thick cup.

A goose has a very characteristic way of building these stages of bent-over rushes. It fixes its eye on the top of a rush shoot, leans forward and grasps it in its bill, bends its neck downwards until it can reach the shoot with its foot, and then tramples the shoot into the rushes that are already bent down. If the goose is dealing with several shoots at a time it will encircle them with its neck and bend them down that way. The actions are shown in the drawing. Much to my amazement I once saw a two-day-old gosling perform this whole series of actions, an observation that suggests the actions are inborn, and not learned by the goose in its lifetime. Further, geese will attempt to build with anything that has a strong up-and-down component; I have seen inexperienced birds try to build with rain drops.

The stages and nests are not evenly distributed throughout the swamp, but are concentrated in areas of *Eleocharis* where the rushes are within a certain range of density and height. Evidently the geese carefully choose the spots where they build, and this observation prompted a series of experiments to see whether the choice was an inborn discrimination or a discrimination based on the experience of each individual goose. These experiments were initially carried out on five birds, hand-reared from birth, that had never been in a goose swamp or anything like one, and were repeated on three similarly reared geese two years later.

To see how these geese reacted to various densities of swamp, they were presented with an artificial swamp, a yard-square board, punched with evenly-spaced holes through which basketry fibres could be pushed, as shown in the photo. Much of the general appearance of a swamp was reproduced by this model. In any case, the geese responded to it and built actively. It had the advantage that the density could be varied, either by sticking more fibres into the board or removing them.



Magpie Geese building in an artificial swamp. For explanation see text.

Photo.—Author.

Both sets of experiments gave the same results. At first the geese built at the same intensity in all densities, but after a number of trials (seven presentations of each density in the first series and 15 in the second) they built very much more actively in the densest than in the thinnest, with intermediate scores in intermediate densities. One similar experiment in which the height was varied gave a similar result. The birds came to build with greatest intensity in the tallest swamp. Apparently, therefore, the geese do have to learn how to choose the parts of the swamps in which to build.

Although this may seem to be a remarkable conclusion, it is possible to suggest a quite simple method by which such learning might occur. Suppose the completion of a satisfactory stage—that is, one that supports the bird adequately—acts as a reward to the goose. Satisfactory stages can be completed more quickly in dense than in thin swamps, and indeed below a critical density it is physically impossible for the goose to build a stage at all. Rewarded by the rapid completion of satisfactory stages, the bird comes to recognize density as a characteristic of a swamp, and no longer responds equally to all up-and-down habitats, but responds most intensely to those that have the characteristics of swamps in which it has previously built satisfactory stages. Presumably physical factors set an upper limit to the range of suitable density and height, but no such limit was reached in any of these experiments.

Learning And Instinct

It seems that in many of the complete behaviour patterns of animals both learnt actions and inborn, or instinctive, actions are blended together to form a perfect whole. One of the greatest satisfactions in carrying out these experiments has been to see the beautiful way in which learning and instinct combine to produce behaviour that is highly adapted to the life of the goose. Each of the experiments illustrates, wholly or in part, this process of combination. The inborn tendency to peck at certain types of object prompts the goslings to peck at a group of objects that includes their potential food. Their learning concentrates pecking on to seed-heads in general and later to the seed-heads of certain grasses. Young geese have an inborn tendency to flee from any bird passing overhead and have to learn to discriminate between harmless and dangerous kinds. The inborn tendency to build nests in up-and-down environments becomes restricted by learning until building is almost confined to swamps with particular characteristics. It is no longer possible to dismiss all animal behaviour as instinctive. Indeed, it is probably more realistic to think of instinct as the tutor of an animal's education.

"LIFE THROUGH THE AGES"

"Life Through the Ages", a coloured chart showing the progress of life through geological time, has just been published by the Australian Museum.

The chart (34 in. x 24 in.) relies on illustrations more than on wording, and is designed for hanging in schools so that it may be seen by all children, whether they are studying the biological sciences or not. It can also be used as an aid in the teaching of science, and will be of value to lay people interested in biological subjects.

The chart illustrates the kinds of life that have existed from the primitive invertebrates of more than 800 million years ago to the present. It shows the geological periods and their durations.

It is on sale at the Museum, price 6/- (6/9 *posted*).

ABORIGINAL RELICS OF THE HAWKESBURY SANDSTONE

By FREDERICK D. McCARTHY

NO other capital city in Australia is situated in an area that contains such a wealth of Aboriginal relics on their original sites as does the Hawkesbury sandstone district surrounding Sydney. These relics are plentiful there because the way of life and culture of the local tribes included traits which required expression on large surface areas, in caves and in other ways, and the local sandstone provided a perfect medium for this purpose.

Perhaps the best known of these relics are the rock engravings which were made on the flat and undulating exposures of sandstone on the ridges and in the gorges and valleys of this rugged formation. To date we have catalogued over 600 separate groups of this art, scattered between the Royal National Park in the south, the Hunter River in the north, the Blue Mountains in the west and the coast in the east. They are concentrated very thickly in Warringah Shire and Kuring-gai Chase National Park—and were so, formerly, around the shores of Port Jackson—but many fine groups are known in other localities. More groups are being discovered as the sparsely settled plateau north of the Hawkesbury River is explored for them.

In making these engravings the artist probably first drew on the rock the outline of the subject with ochre, clay or a stick. He then made a series of punctures, from half an inch to an inch in diameter and up to three-eighths of an inch (but usually about one-eighth) deep, along this outline. These punctures or pits are separated by up to an inch in some figures, but more commonly they overlap to form a continuous groove. In some of the more important figures the groove was rubbed with an abrading stone generation after generation, producting grooves up to two inches wide, in one group, four inches wide and two inches deep. This was no doubt because they had a comparatively short span of life before weathering away.

Part of an Aboriginal rock engraving, 19 ft. long, of a culture hero in Kuring-gai Chase National Park, near Sydney. It has an emu-like head, body and leg, human hands and one human foot.

The kind of implement used for the puncturing is unknown, but it may have been a sharp-cornered piece of ironstone or sandstone, a whelk shell, or some similar pointed implement. To date, no special tool has been identified in this area that would be suitable for the purpose.

In fact, one of the mysteries to be solved in connection with the rock engravings of Australia as a whole is to define the kinds of implements used for the various techniques.

Engravings Of Heroes

The motifs vary considerably. They centre around gigantic anthropomorphs of men and women which represent the great creator and other spirits, the mythology of whom was never recorded during the rapid demise of the local tribes after Phillip's Fleet had founded Sydney. The male heroes hold shields, axes, clubs and boomerangs, are decorated in striped and other designs, and wear chest and head ornaments. Their

Rock engraving of a shield of a type made from mangrove wood and painted white with crossed lines in red. The pits or punctures overlapping each other, as explained on the previous page, are clearly seen.

wives may be depicted with them, and they are usually smaller figures than their husbands. Several huge figures of female spirit beings are also known. The footprints of these heroes may lead to their figures, which are usually set among various mammals (of which kangaroos, wallabies, koalas, wombats and echidnas are the commonest), emus and a few other birds, goannas, snakes and various weapons. Invertebrates like insects, crabs and shells are rarely represented, as is also the case with plants, the collection of which was in the sphere of the women.

As a whole, the engravings illustrate hunting, fishing, disposal of the dead, corroborees and other activities, and the totems of the local groups and clans. It appears probable that some of them featured in hunting-magic and other forms of magic. It is also possible that ceremonies were held at the groups of rock engravings to increase the numbers of totemic animals and so ensure a plentiful food supply. Their main purpose, however, was to reveal to the youths being initiated, and to preserve in the minds of the initiated men, the creation of the world, the people and their customs and the fauna and flora by the great spiritual ancestors who form the dominating theme of this art.

Two main types of these heroes are shown, one posed from the front view, the other from the side and usually one-legged. They lived in the sky-world, the behaviour patterns of the people had their sanctions in them, they were the source of magical powers, and they visited the initiation grounds to take away the youths and return them as initiated men. They were all-powerful beings whose lives on earth, during the dreamtime before they created man, were dramatized in the ceremonies performed by the Aborigines at totem centres, at places where important mythological events happened, and where the heroes were depicted in the earth or on rocks in either engravings or paintings.

Art Phases

How far back in time these engravings were made is unknown. Recent studies by the author have shown that the outline naturalistic type of rock engraving belongs to the second or Outline phase in this art, being preceded by a simple style of abraded grooves, and followed by two phases, one of complex line design and one of fully-pecked intaglios. Radio-carbon datings obtained in South Australia indicate that the Outline phase of engraving can at present be traced back no more than 3,000 or 3,500 years. It is probable that it was practised in eastern New South Wales until, or almost until, the coming of the white man in 1788, as it was the only engraving technique known in this region. The later Design and Intaglio phases were employed in the interior and north-western parts of the continent. The earliest engravings may have weathered away, as the figures in the soft and medium kinds of sandstone appear to last only a few centuries, but those engraved in the hard ferruginous sandstone, and those re-grooved by succeeding generations, will last for thousands of years.

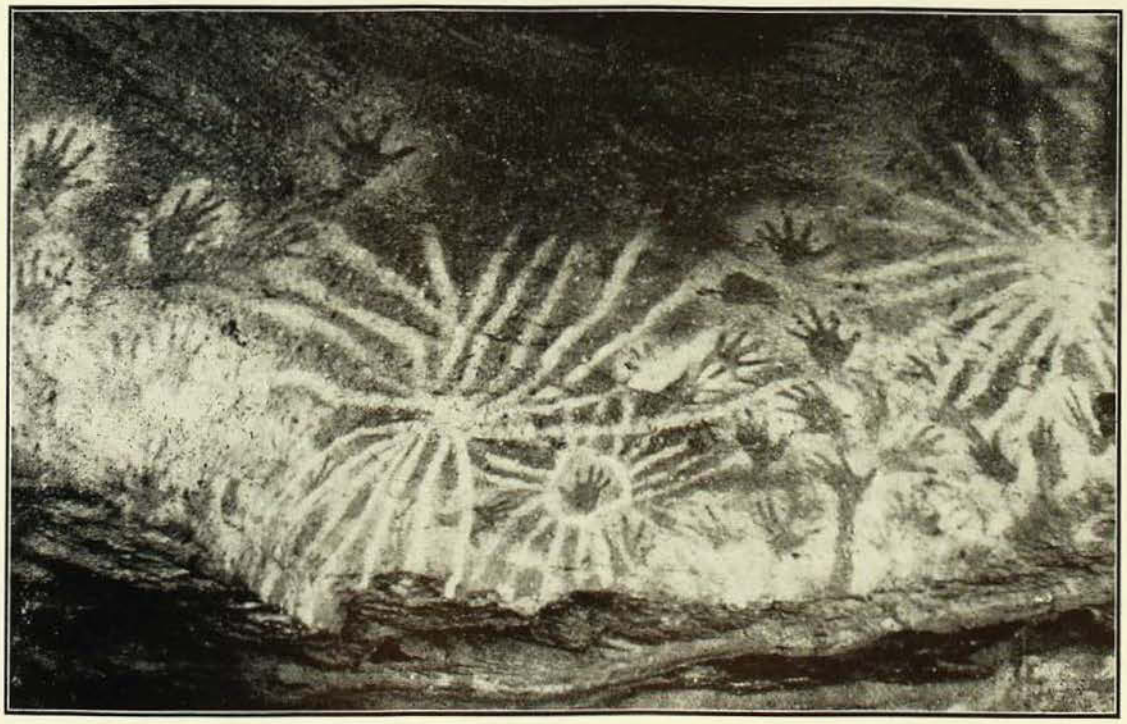
The innumerable rock shelters in the Hawkesbury sandstone formation not only provided excellent accommodation for the Aborigines, but also ample scope for drawing. Some 250 sites of cave drawings are now known, but many more exist and have yet to be found. Again, recent studies have revealed that the cave art of this area passed through a series of phases.

In the first or earliest phase were depicted stencils (mostly in white) of human hands and feet, emus' feet and other things, and impressions of human hands together with simple outlines and monochromes of animals and men. Friezes of up to 100 or more stencils in one cave are not uncommon. In the second phase the paintings were done in red, white, or red and white, in both outline and monochrome styles. In the third phase, the most prolific and interesting in subjects, the majority were in black, white, or black and white, drawn with charcoal and clay. At one site a fourth phase has been discovered in which red, yellow, white and black are used in a giant polychrome figure of a spiritual ancestor combined with a 40ft.-long ritual figure drawn in dry red pigment. The stencils were made also in the second, and possibly later, periods, and certainly until the stone axe was used, but it is not known whether the Aborigines living at the time of white settlement were familiar with them.

Unusual Motifs

Predominating among the subjects throughout the total period of cave drawing are such themes as the hunting of wallabies, kangaroos, emus and other animals, corroborees single figures and groups of human beings and animals. Weapons are also common. Unusual motifs, such as the split-open seed pods of the Hakea and Woody Pear trees, net and radiating sun-like designs, appear among them. Occasional large human figures are seen, but very few of the heroic type of spiritual ancestor so important among the engravings.

As the Aborigines lived in many of the shelters decorated with these drawings, it is obvious that the drawings were done, probably by the men, during wet weather and other free moments. Their purpose was to portray the totems of the artists' group, to record a successful hunting or fishing trip or an enjoyable corroboree, and, probably, to perform magic that would ensure success



White paintings of radiate figures, thought to represent the sun, in a rock-shelter in the parish of Tupa, near Singleton, New South Wales. They were painted over stencils of human hands.

After Enright.

A man spearing a kangaroo, with two fish or tadpoles below at left. All are in red, outlined with white. (Wollombi, N.S.W.).

in catching animals and fish. In one or two sites, shelters that have not been inhabited, is shown a spiritual ancestor with the weapons and other things that he introduced in the long-ago to the local Aborigines. It is difficult to say which caves were sacred, and the only criterion that we can use at present is whether a cave was occupied or not; some of the unoccupied caves were obviously sacred sites, but other small shelters and rock faces, bearing only a few black or red figures, would hardly come into this category.

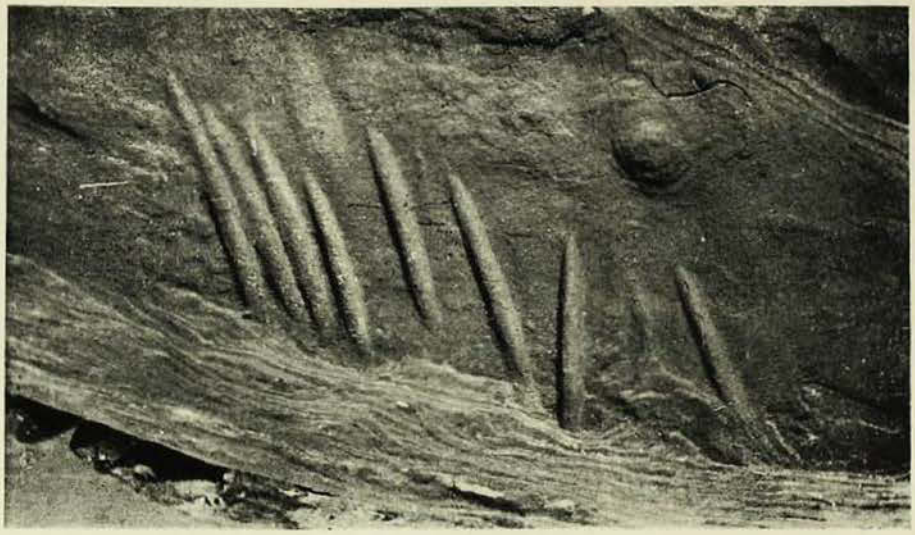
Destruction By Vandals

The artistic standards of the Aborigines of the sandstone region were not outstanding on the average, as the drawings and engravings tend to be stiff and not as well portrayed and finished as those done with a mixed paint elsewhere in Australia. But among them is to be seen some really beautifully controlled line work in the postures of some of the kangaroos and wallabies, particularly the rock wallabies and smaller species. Great strength and power are suggested in the giant human and animal figures, and many of the hunting and other compositions are exceedingly interesting to the student of the development of art.

Their antiquity is still a mystery. I believe that the first period of stencils, impressions and simple outlines goes back to the coming of the Aborigines to this part of Australia, and only archaeology will reveal the many thousands of years involved. The black and following phases appear to have been done right up to the time of the white man's occupation. On damp walls, where water is seeping through cracks, many fine series of drawings have crumbled away and are still doing so, but on the dry, well-protected walls and ceilings this art is affected very slowly by weathering agencies. The scribbling vandal is the worst enemy of this art today.

The stone arrangements are not as well known as the engravings and drawings. The majority of them are loose, irregular mounds of boulders (sometimes with a hollow from the top to one side) from a few feet to over 30 feet in length. They were thought by the bushmen who first stumbled across them to have been erected by surveyors, but it is now known that the latter were not responsible for them, because they erected neat cairns and recorded their exact location in their diaries. Another kind of stone arrangement is an oval or circle of boulders, believed to have been used in the special initiation of medicine-men, who sat and slept in them while they communed with the spiritual ancestors and received their magical crystals and powers from them. Only a dozen or more sites of stone mounds and circles have been found to date in the sandstone area, but many more will no doubt be discovered. They do not contain skeletons or burials, and should never be disturbed.

Trees have been reported in which the Aborigines cut foot grips to aid them in climbing, but such trees are rare nowadays. One of the popular entertainments in the early days of Sydney was a display of tree-climbing skill by the Aborigines.



Axe-grinding grooves at Castlereagh, on the Nepean River, N.S.W.

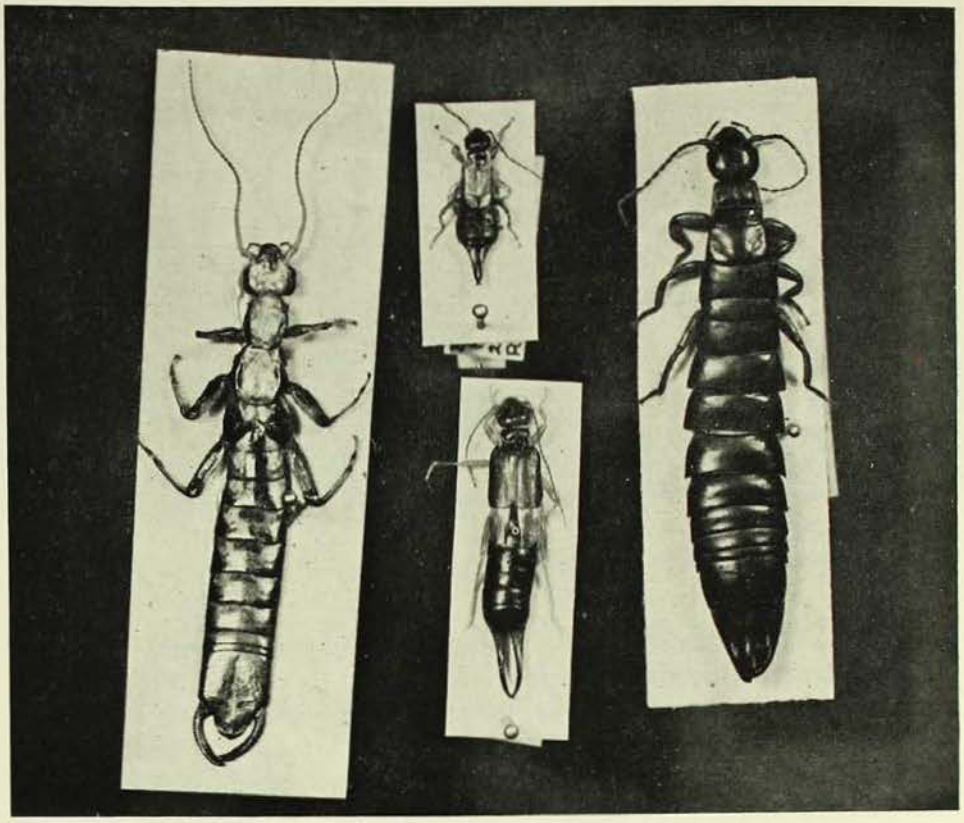
It is not uncommon to come across in the bush, in a creek bed or beside a pool intermittently filled with rain water, large smooth grooves a foot or less long and several inches wide and deep. From one to several dozen may be seen together, occasionally hundreds at one site; on the eastern bank of the Nepean River at Castlereagh thousands of these grooves are abraded in the soft sandstone rocks for half a mile along the river, which covers many of the rocks. These are the grooves in which the Aborigines ground and sharpened their axe blades. Grooves, several feet long, of this kind at the Nepean River site may have been used for smoothing club and spear shafts.

The remaining evidence of Aboriginal occupation is the shell and ashy soil deposits left at their camp sites along estuary and river banks and coastal dunes. One still under the esplanade at Bondi was the first local site at which a beautifully made spear point, known as the Bondi point, was collected and described in a scientific paper. Another one at Quibray Bay, George's River, has been obliterated by the suburban development of this locality. These middens contain implements and burials. Their scientific excavation by trained experts will reveal the story of the occupation of this part of Australia by the Aborigines, and for this reason they are worthy of protection until archaeology gains more impetus in this country.

In regard to antiquity, it might be mentioned that three prehistoric cultural periods have been established by the author in the sandstone country. One, the latest, is the Eloueran, in which ground-edge axes and knives were the main implement types associated with the Elouera adze flake, burin, fabricators and other flake tools; this was preceded by the Bondaian period, in which the Bondi point and geometrical microliths are associated with the Elouera, burin, fabricator and scrapers, and in which the ground-edge axe has only recently been found. The third and oldest period yet established is the Capertian, characterized by large cores and blocks and burins, and with nosed concave and convex scraper edges, and saw edges, on large primary flakes and blades. There is at present no definite link between these three prehistoric periods and the various phases of rock engravings and paintings in the sandstone area, but precise archaeological work in the future will no doubt establish this relationship.

One of the most difficult problems respecting these Aboriginal relics is their protection from vandals and constructing authorities. Many groups of engravings which were in comparatively inaccessible bushland a few years ago are now fringed by housing developments, the residents of which have chopped their initials all over the figures. Unless local councils and residents take steps to preserve these relics many of them will share the fate of those which have been obliterated in the inner suburbs.

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



These earwigs are: Left, a species of *Apachyus*, found under the bark of Snow Gums on the highest parts of the Northern Tablelands of New South Wales. Centre (top), *Forficula auricularia*, the common European earwig. Centre (bottom), *Labidura riparia*, a cosmopolitan species and probably the commonest Australian earwig. Right, *Titanolabis colossea*, found in N.S.W., the largest earwig known. (Natural sizes are about two-thirds of those in the photo).

Photo.—Howard Hughes.

Earwigs

By E. T. GILES

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EARWIGS seem to be better known to people living in Britain than to Australians. One species is very common all over the British Isles and often comes into houses in quite large numbers. It is, in fact, a rather serious pest in gardens and orchards. The Australian native earwigs are of very retiring habits and are seldom seen by day at all, but occasionally some species will fly to lights at night.

Earwigs are insects, usually reddish-brown in colour, rather flattened and long for their width. At the tail end are a pair of pincers, called forceps, which have a variety of uses, including capturing live food and fighting. When disturbed, earwigs open their forceps wide and arch them over their backs; this looks most threatening and is no doubt intended to scare off would-be attackers. Most earwigs have two pairs of wings. The forewings are leathery, very small and look like scales; the hind wings are quite large, membranous and kidney-shaped. While the earwig is not actually flying, the hindwings are folded up underneath the forewings in a most complex way. The forceps help with this rather difficult operation, which is not made any easier by the wings being behind the insect's back! Earwigs seem to eat almost anything in the way of plant and animal matter, but little is known of their exact diet requirements.

Origin Of Name

The earwigs form part of the group or order known scientifically as Dermaptera; this name is a combination of Greek words meaning that the wings are thin (like a skin). It seems that the common name "earwig" could have come from many sources. Some of the more likely are: a

corruption of "earwing", for the unfolded and expanded hindwings do show a slight resemblance to the human ear; a small beast or "wig" which gets into the ear; or, last, the forceps of the common European earwig are very similar to the pincers used to pierce human ears for the insertion of ear rings.

Earwigs are quite an ancient group, fossils having been discovered in Switzerland in rocks about 160 million years old. Others found in Colorado, U.S.A., in rocks only 30 million years old, are very like present-day forms.

For purposes of classification, the Dermaptera are divided into three suborders.

The first suborder comprises the true earwigs (Forficulina), of which about 1,000 species are known. These are a very uniform group anatomically and can all be recognised from the brief description given above. You could not mistake an earwig for any other insect, except perhaps for one of the beetles—the Rove or Devil's Coach-horse Beetle. This has a pair of processes on the end of the abdomen, but they do not come together like pincers, as the forceps of earwigs do. Earwigs are fairly common in tropical and semi-tropical countries, where they live under debris on the ground or under the bark of trees. In fact, you could expect to find them anywhere that is damp and where there are crevices they can crawl into. There must be narrow spaces for earwigs to live in, as they are happy only when their bodies are in contact with their surroundings on all sides. Undoubtedly, to a wandering earwig, the ear of anyone sleeping on the ground would be an ideal hiding place. The risk of this happening would be greatest in the tropics and among native people who are not too particular about their habitations. This habit has surely been important to these insects in acquiring their common name.

Two Species Live On Bats

The second suborder (Arixeniina) consists of but two species, both of which are closely associated with the Naked Bats of Malaya, the Indonesian Islands and the Philippines. Actually, they are not strictly true earwigs. They live either on the bats or in the bats' roosting places, and are very robust and hairy and almost blind. Both are wingless, and their forceps are quite weak and could not possibly be used as a true earwig uses them. The hairiness of these insects may be judged from the fact that one of them has been given the name *Arixenia esau*. Although closely-related bats to those found in Malaya and Indonesia are also present in New Guinea, this suborder of Dermaptera has not yet been found there. One wonders whether they have not been discovered or whether they are really not there.

The third suborder (Hemimerina) is made up of about 10 species, all of which live under the fur of the South African Sugar Rat. In most cases, a separate species of Dermapteran lives on each species of rat. They are well streamlined and very smooth, for moving through the rat's fur, and the feet are specially adapted for gripping the fur. In addition, all are blind and wingless.

Females of the last two suborders give birth to live young, which are able to move about very soon after they are born. This is a great advantage because eggs would have a very dangerous life in the bats' or the rats' fur. As far as is known, both groups feed on the outer layer of the host's skin and on debris found in the fur. However, in the bats' roosts *Arixenia* is notoriously cannibalistic and constant warfare seems to go on. Another small matter is that the bats' fleas are also found on *Arixenia*, where they apparently enjoy an occasional change of food.

Mating

In the true earwigs mating is preceded by a courtship involving a fairly long interplay with the forceps. Mating takes place at all times of the year; in the tropics the eggs are laid shortly afterwards, but in cooler climates at the hottest time of the year. The female tunnels into the soil or litter and lays the pale cream eggs, usually 30 to 50, in a large chamber, where she remains and broods over the clutch, constantly turning them and generally fussing about them. After about two weeks the eggs hatch and from each a tiny earwig

emerges, completely developed except for the wings. The female broods over these tiny creatures and also over the second growth stage, which results from the moulting and growth of the first stage. Shortly the youngsters must move off on their own, for mother soon becomes a cannibal. After three or four more moults the adult stage is reached.

Australian Earwigs

Only true earwigs are found in Australia, and some of the native species are very interesting indeed. The largest earwig known (*Titanolabis colossea*) is found in the northern coastal ranges and on the Northern Tablelands of New South Wales. It grows up to 2 ins. long and is very powerful. The strong forceps would be particularly formidable. Under the bark of Snow Gums on the highest parts of the Northern Tablelands is to be found *Apachyus australiae*. This handsome earwig is about 1½ ins. long, but paper-thin and perfectly adapted to life in the narrow spaces between the bark layers.

The common European earwig (*Forficula auricularia*) has been accidentally introduced into Australia, and in the cooler parts, where it is commonest, damages flower buds, fruit and vegetables. The N.S.W. Department of Agriculture has issued a leaflet (No. 82) in its Insect Pest Series giving methods of control.

In the apple-growing districts of Otago, New Zealand, this species is commonly found alive in the centres of apples, with no apparent entry hole. The answer really is simple, for the earwig crept into the apple when small via the calyx cup. Then, as the apple grew the cup closed, imprisoning the earwig which, however, has plenty of food on hand and gradually excavates its own home.

The lowly earwig, feared by many and despised by some, has many interesting features in its daily life and habits. As with all problems in biology, we have only scratched the surface in the study of the group and no doubt many new and more intriguing things will be learnt about it.

FLUORESCENT CORALS

Dr. Rene Catala, of the Aquarium of Noumea, New Caledonia, visited the Australian Museum in December and January while investigating the possibilities of exhibiting living fluorescent corals in Sydney. Dr. Catala and his associates at the Aquarium of Noumea are the discoverers of the fact that certain deeper-water species of corals fluoresce magnificently when irradiated by ultra-violet light. Normally, this strange and wonderful spectacle may be seen only by visting his aquarium, where living corals are featured, together with many of the rarer and beautiful animals associated with coral reefs.

COLLECTION OF GEMSTONES

Mr. O. le M. Knight has presented a choice and varied collection of 40 Australian gemstones to the Museum, of which he is an honorary correspondent. More than usual interest attaches to this gift because Mr. Knight personally collected the greater part of the material in the rough while on field trips, and also expertly cut and polished most of it. Thus, unlike many gemstone collections, the localities of the individual gems are known, which enhances the collection's scientific value. Aesthetically, too, the gift is striking. Many of the gemstones are quite large and are fine examples of the cutter's art. Notable are a large, perfectly cut citrine weighing 102 carats and a large topaz of 68 carats from Oban Creek, in the New England district of New South Wales. Zircons are outstanding, there being a number of stones, each weighing several carats, from Hanging Rock, N.S.W., and the Strangways Range, Central Australia. Also included are beryl, garnet and the rarities titanite and cassiterite. Altogether, the collection is a valuable acquisition and is one of the many examples of Mr. Knight's generosity to the Museum. It will be on public display.

NEW ZEALAND VISITOR

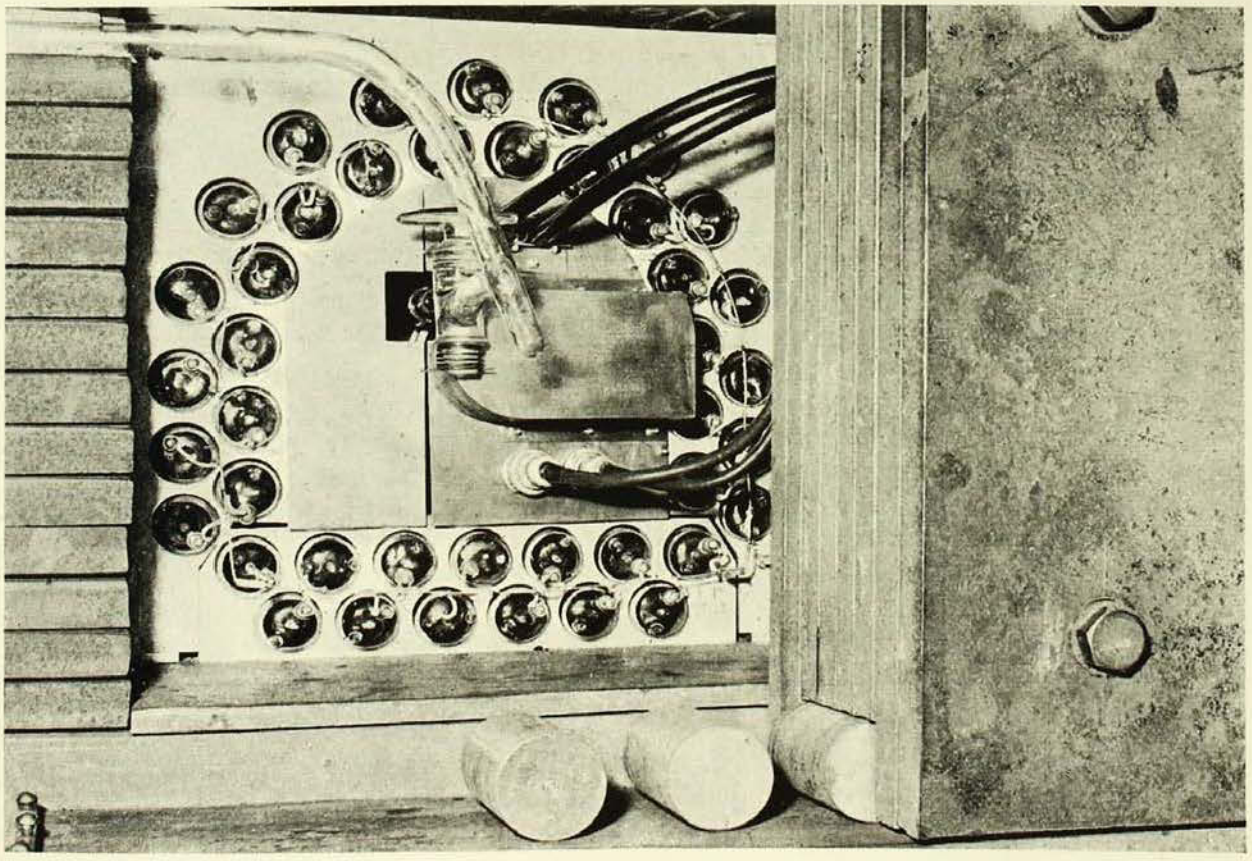
Dr. R. Duff, Director of the Canterbury Museum, Christchurch, New Zealand, visited the Australian Museum in January to examine the collection of Polynesian stone adzes, as part of a study of prehistoric relationships between Polynesia and South-east Asia. Dr. Duff has been granted a S.E.A.T.O. fellowship to visit the latter region.

THE RADIOCARBON DATING METHOD

By CHARLES FOCKEN
Director, Institute of Applied Science of Victoria, Melbourne

AMONG the many methods that have been used by geochronologists for dating ancient objects and long-past events, those dependent on radioactive techniques are the most scientific and reliable. Firstly, they depend on the immutable law of radioactive decay (Rutherford and Soddy), and secondly, they are objective as well as absolute methods. The scientists who analyse the samples that have been collected and supplied to them need know nothing of archaeology or prehistory. It is easy for them to be open-minded, with no preconceived opinions about the results. An estimate, admittedly sometimes rather rough, of the experimental and statistical errors of the results can be provided. These advantages do not absolve radioactive methods from the possibility of gross errors due to difficulties or lack of care in collecting the samples and to subjective influences in the interpretation and significance of the ages supplied by the determinations of the physicists and chemists.

Early in this century Rutherford pointed out that uranium and thorium were natural constant rate clocks, and attempts were made to use the suggestion for geological dating of the order of millions of years.



The iron door rolled back reveals the ends of a double ring of Geiger tubes. A glass tube and stopper admit gas to the counter tube.

Photo.—Institute of Applied Science, Victoria.

One of the earliest and most persistent geologists to exploit the methods was Arthur Holmes. He is still contributing and it is surprising, in view of its recent prominence, that he wrote a paper on the geological significance of the radioactivity of potassium in 1926.

Remarkable Developments

Within the past 20 years new and remarkable offshoots of the fruitful proposal were conceived and tested. Conditions were propitious because of our greatly extended knowledge of radioisotopes. Nier correctly inferred that the variations in the isotopic composition of common leads resulted from the final decay products of uranium and thorium contained in the lead ores. Included in the "radioactive family" of methods are two lusty infants—the potassium/argon method and the rubidium/strontium method —the value of which for geological dating has been established and which have a promising future.

The golden-haired wonder-child of the family is by general consent the radiocarbon method, now a most precocious youth not yet past the growing stage. It was no surprise when Professor Willard F. Libby was awarded the 1960 Nobel Prize in Chemistry for his discovery that the radioactive isotope carbon-14 could be used to date the past. The bright idea occurred to Libby about 20 years ago when he pondered over the suggestion that cosmic rays might be the source of radioactive isotopes in nature. His elegant reasoning, bold hypotheses and confirmatory experiments serve as a model. When laboratory experiments proved that neutrons of thermal velocity reacted with common nitrogen to produce carbon-14, Libby inferred that carbon in living material would most likely contain a definite small proportion of carbon-14. He proceeded to examine the intriguing consequences of this inference.

Carbon-14 is continuously produced in the upper atmosphere by the bombardment of nitrogen by neutrons from cosmic rays. It is oxidised to carbon dioxide and becomes mixed with the enormous volume of inactive carbon dioxide in the atmosphere. By respiration and similar processes all living plants exchange carbon dioxide with the atmosphere, and from plants animals incorporate the carbon, including a small proportion of carbon-14, in their bones and tissues. Libby showed that, so long as they live, plants and animals contain a constant ratio of carbon-14 to carbon-12, the latter being the much more abundant stable isotope. But when they die the life cycle ceases and the stock of carbon-14 atoms, no longer replenished, begins to diminish at a measurable rate through emission of beta particles. The half-life of carbon-14 is close to 5,600 years, so after this interval a piece of bone or charcoal will contain only half as much of the isotope as it did originally. After 11,200 years it will contain only a quarter as much, and so on.

Chicago Experiments

Another basic assumption of the method was justified by experiments at the Institute of Nuclear Studies, University of Chicago, by Libby and his colleagues, who demonstrated that the proportion of carbon-14 throughout the world-wide carbon exchange reservoir, consisting of oceans, biosphere and atmosphere, is substantially constant. The proportion was close to the inconceivably minute value they had predicted. In living material there is about one atom of active carbon to a million million atoms of stable carbon, and the proportion falls continuously when the host dies.

The idea had been brilliantly justified, some of the basic assumptions confirmed, and the potentialities had impressed all interested scientists. The practical application of the method necessitated the development and testing of a sensitive, reliable experimental technique for measuring, preferably on a routine basis, the extremely low levels of beta activity from carbon-14 found in ancient materials.

Working with Libby, the scientists at Chicago first devised the solid carbon method using a "screen-wall" Geiger counter. The device was ingenious and simple, and it has yielded many hundreds of reliable dates. The same method, with minor modifications, was used in nearly all the laboratories that soon started in United States and Europe.

From an early stage great care was taken to check the findings by testing a series of objects the ages of which up to about 10,000 years were accepted on the basis of other evidence, such as tree-ring chronology, archaeological and historical. Thus, wood samples from an Egyptian sarcophagus were known from historical researches to be about 4,600 years old. The weak radioactivity measured continuously over two days gave a mean value of 8.36 counts per minute per gram of carbon compared with 15.3 counts for modern wood. The age estimated from these figures agreed with the accepted age within 200 years, which was as close as expected from the estimated errors. This is typical of many satisfactory check-measurements that were made. Details of his method and the results are presented in Libby's book, "Radiocarbon Dating" (University of Chicago Press).

The original technique became insensitive at activities that correspond to an age of 20,000 years and was not suitable for small samples. It has been superseded principally because it could not be insulated against contaminations resulting from atomic explosions. Two more sophisticated techniques are now used. The liquid scintillation counter employs a photo-multiplier. The carbon of the sample must be prepared as a compound in liquid form and is mixed or incorporated with a liquid phosphor, usually maintained at low temperature to reduce the background. Larger samples are required than in other methods, and if there is sufficient sample the sensitivity can be raised enabling ages exceeding 60,000 years to be measured.

Successful Technique

The technique that has been proved most satisfactory, and is now used in over 40 laboratories the world over, is the gas proportional counter method. The carbon in the sample is burnt to carbon dioxide (and occasionally converted to acetylene or methane). After purification it is used to fill a proportional counter of a few litres capacity to a pressure of one or more atmospheres. The method has reached maturity after the dating of some thousands of samples. Many independent internal checks of reliability have been made by sending portions of the same sample to different laboratories for testing. The concordant results have been reassuring. Radiocarbon dates are now published annually in May in the "Radiocarbon Supplement of the American Journal of Science".

In Australia two laboratories for this work are nearing the stage of providing a routine service. One was started about two years ago at the University of New South Wales, and is in the charge of Associate Professor J. H. Green. The other, at the Institute (previously Museum) of Applied Science of Victoria, has slowly grown, because of limited resources, over five to six years. Three satisfactory age determinations were reported on samples of known age ("The Australian Journal of Science", Vol. 23, No. 4, Oct., 1960). The apparatus has since been improved and is now ready to supply a service for research workers in Australia and the South Pacific. Because of the lengthy and difficult analysis and the expensive apparatus (£10,000), a basic charge of £30 a sample has to be made.

Pitfalls Investigated

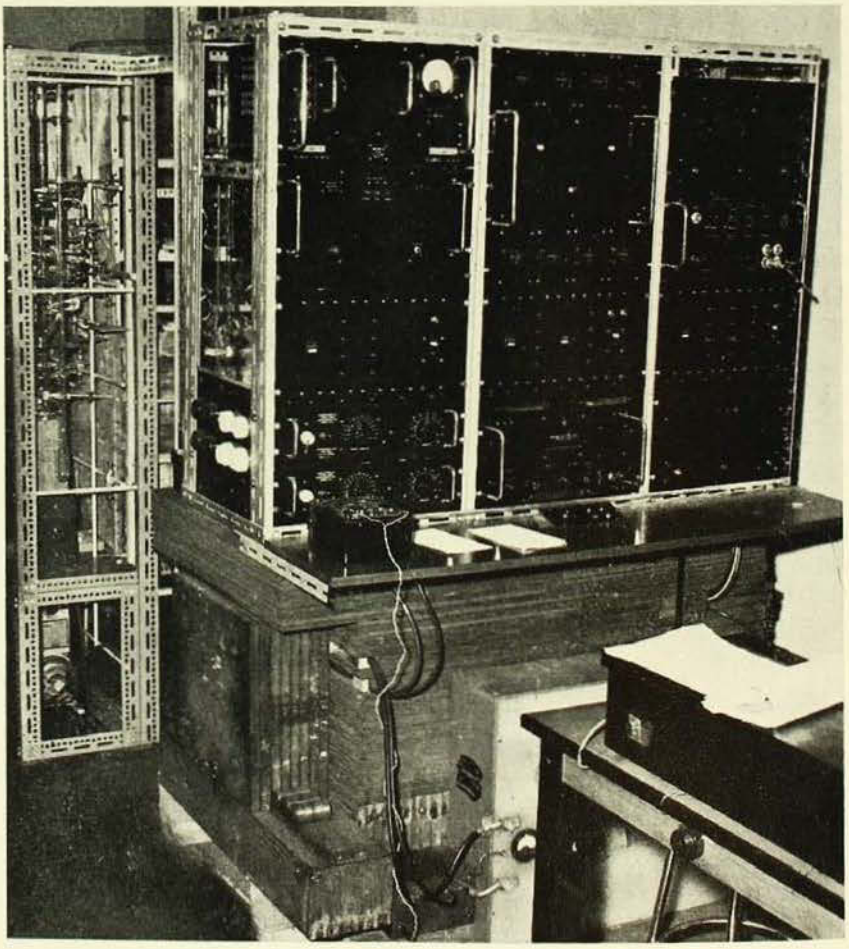
There are many pitfalls in this work, and at Melbourne we have been obliged to explore most of them. How to prepare gas samples of high purity and maintain them for weeks free of contamination? How to count the extremely low beta activity of the carbon-14 in the presence of a large and not always constant background? A typical set of rounded-off figures can illustrate this difficulty. Without any shielding the background from cosmic rays and all sources of radioactivity within the laboratory is about 2,000 c.p.m. Within an eight-inch thick iron shield it falls to 300 c.p.m. Cosmic ray mesons of great penetrating power are largely responsible for this residue. By an ingenious device called an anticoincidence shield, consisting of one or two rings of long Geiger tubes arranged around the counter, and the associated electronic circuits, it is possible to separate out the coincidences from the anticoincidences and count them separately. The coincidences are produced by penetrating mesons which pass through the proportional counter and cannot fail in doing so to pass also through one of the surrounding Geigers So each of these

produces two simultaneous pulses (a coincidence). They account for 283 c.p.m. The residue of 17 c.p.m. are the anti-coincidences or pulses that originate in the counter only. When an inner shield of mercury one inch thick, costing £460, was introduced this count fell to 15 c.p.m. This important figure is our present irreducible background.

A sample of carbon dioxide prepared from modern wood (recently felled) gives 18 c.p.m. above the background when at 1 atmosphere pressure, and this count is doubled at 2 atmospheres. For work at 1 atmosphere pressure all our count rates lie between the limits 15 and 33 c.p.m., at the upper limit for a modern sample of zero age and at the lower limit for an ancient specimen, such as coal, of age exceeding a million years. Since none of the figures remains constant, counts usually extend over 1,000 minutes, and statistical treatment is essential. To save time the counting runs are done overnight and a photographic recorder automatically notes the counts during each 50-minute interval on a film. This is rapidly developed when the staff returns in the morning. (See illustrations of equipment.)

Wood and charcoal are commonly used in dating work, but the most varied carbonaceous materials have been used, such as peat, bones, shells, rope and cloth, the remains of plants and the excreta of animals. The quantity required depends on several factors and should in general be sufficient to yield from 1 to 10 grams of carbon. The accuracy is less if only a small amount is available. Collectors are well advised to obtain several ounces of the sample material if possible, because only a small proportion may be carbon.

There remain a few cases where it has not been possible to reconcile radiocarbon chronology with other scientific evidence. For example, Professor Ernst Antevs dated the Valders glacial maximum at Milwaukee, U.S.A., at 18,500 years, but the inferred radiocarbon date, confirmed at several laboratories, is 10,700 years. Despite such rare riddles, the massive support for the radiocarbon method is impressive and very



Racks of electronic equipment stand on a massive iron shield surrounding a counter tube. Thick cables connect a high potential supply, and a photoraphic recorder is on the table.

Photo.—Institute of Applied Science, Victoria.

few doubt its basic soundness. So the last underlying assumption on which it is based must be substantially correct, namely, the average intensity of the cosmic rays has remained constant from year to year for the past 40,000 years.

Importance Of The Method

The method's supreme importance to the average person is that it is applicable to the prehistory era in which most people are interested. There are extensive actual and potential applications to history, archaeology, anthropology, geology and oceanography. According to R. Foster Flint, the radiocarbon method has contributed to geochronology in three principal ways:—

- It makes possible approximate measures of the rates of several geologic processes, e.g., advance and retreat of glaciers, rise of sea-level, sedimentation, and turnover of oceanic water.
- It facilitates the correlation of strata by establishing the contemporaneity of sediments at two or more localities, e.g., in Europe and North America.
- Dates of significant events in prehistory can be closely approximated.

PROTECTION OF RARE FAUNA

The Fauna Protection Act provides that any protected fauna may from time to time be proclaimed as rare fauna. Anyone taking or killing, or attempting to take or kill, any proclaimed rare fauna is liable to a fine of up to £50 or imprisonment for up to six months, or both.

The New South Wales Fauna Protection Panel states that it considers any animal proclaimed rare fauna requires special efforts for its conservation and, in consequence, has selected the following birds and mammals:—

Birds

Red-crowned Pigeon (*Ptilinopus regina*); Plains Wanderer (*Pedionomus torquatus*); Gould Petrel (*Pterodroma leucoptera*); Turquoise Parrot (*Neophema pulchellus*); Bourke Parrot (*Neophema bourkii*); Elegant Parrot (*Neophema elegans*); Scarlet-chested Parrot (*Neophema splendida*); Blue-winged Parrot (*Neophema chrysostoma*); Orange-bellied Parrot (*Neophema chrysogaster*); Jabiru (*Xenorhynchus asiaticus*); Topknot Pigeon (*Lopholaimus antarticus*); Wonga Pigeon (*Leucosarcia melanoleuca*); Australian Dotterel (*Peltohyas australis*); Painted Snipe (*Rostratula benghalensis*); Pied Goose (*Anseranas semipalmata*); Plum-headed Finch (*Aidemosyne modesta*); Squatter Pigeon (*Phaps scripta*); Brolga (*Grus rabicundus*); Spotted Bower-bird (*Chlamydera maculata*); Paradise Riflebird (*Ptiloris paradiseus*); Harlequin (Flock) Pigeon (*Phaps histrionica*); Superb Lyrebird (*Menura superba*); Prince Albert Lyrebird (*Menura alberti*); Lowan or Mallee Fowl (*Leipoa ocellata*); Brush Turkey (*Alectura lathami*); Bustard or Plain Turkey (*Eupodotis australia*); Wompoo Pigeon (*Megaloprepia magnifica*); Purple-crowned Pigeon (*Ptilinopus regina*); White-headed Pigeon (*Columba norfolciensis*); Swamp Parrot (*Pezaporus wallicus*); Paradise Parrot (*Psephotus pulcherrimus*).

Mammals

Marsupials

Native Cat (*Dasyurus quoll*); Yellow-bellied Glider (*Petaurus australis*); Long-nosed Rat-kangaroo (*Potoruos tridactylus*); Rufous Rat-kangaroo (*Aepyprymnus rufescens*); Bridled Nail-tail Wallaby (*Onychogales fraenata*); Brush-tailed Rock-wallaby (*Petrogale penicillata*); Yellow-footed Rock-wallaby (*Petrogale xanthopus*); Parma Wallaby (*Protemnodon parma*); Black-striped Wallaby (*Protemnodon dorsalis*); Pigmy Marsupial Mouse (*Antechinus maculatis*); Southern Planigale (*Planigale tenuirostris*); Eastern Jerboa-marsupial (*Antechinomys laniger*); Short-nosed Bandicoot (*Isoodon obesulus*); Pigmy Possum (*Cercaertus nanus*); Koala (*Phascolarctus cinereus*); Whiptail or Pretty-face Wallaby (*Protemnodon Parryi*).

Monotremes

Platypus (*Ornithorhynchus anatinus*); Spiny Ant-eater (*Tachyglossus aculeatus*).

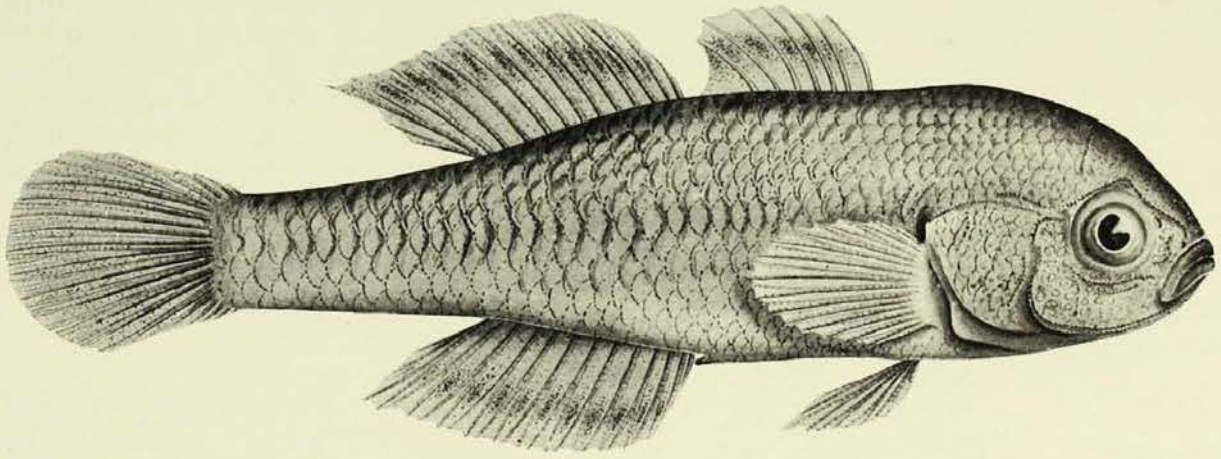
The Freshwater Gudgeons of Temperate Australia

By GILBERT P. WHITLEY

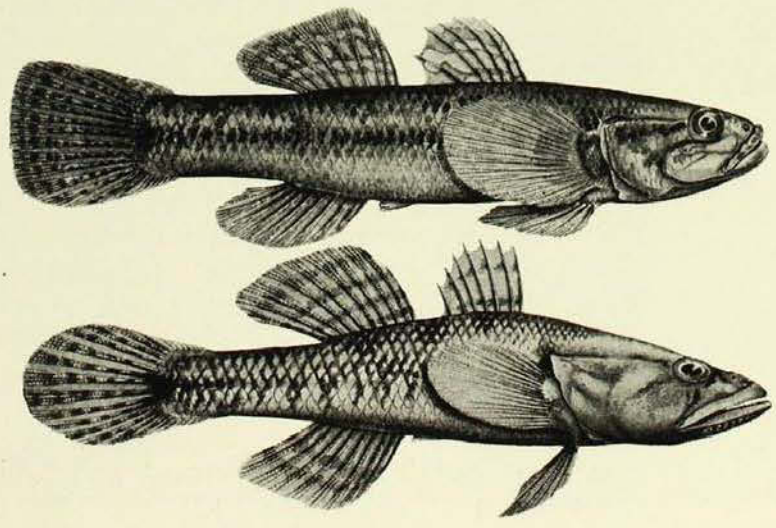
IN 1954 I contributed to "The Australian Museum Magazine" (Vol. XI, No. 5, pp. 150-155) an article on some freshwater gudgeons, mainly from tropical Australia. The temperate and cold-water species, with which this article deals, should be more familiar than the northern ones to aquarists who are becoming more interested in our local species than in the more spectacular foreign fishes.

Our temperate gudgeons may have originated from Asiatic ancestors very long ago, and, over periods of thousands of years, appear to have spread southward through flooded "channel country" or by "creeping" down our coastlines and entering and ascending coastal rivers.

Four genera concern us here, all of the family Gobiomoridae, and are distinguished as shown in the panel at the top of the next page.



A male Western Carp-Gudgeon (*Carassiops klunzingeri*) from the Cudgegong River, Rylstone, New South Wales.



Top: Female Cox's Gudgeon (*Gobiomorphus coxii*) from Menangle, N.S.W. Bottom: Male Big-headed Gudgeon (*Philypnodon grandiceps*), typical form, from the Hawkesbury River, N.S.W.

Genus	Cheeks and gill-covers	Spines in front dorsal fin	Transverse rows of scales between head and tail-fin	General form (see illustrations)
Philypnodon	naked	7	38 to 44	Big head, slender body
Mogurnda	scaly	7 to 9	30 to 35	Long and compressed
Gobiomorphus	scaly	6	37 to 40	Long and cylindrical
Carassiops	scaly	6 to 7	27 to 35	Short and slender

Only one Australian[1] species of *Philypnodon* is recognized, though it is variable in form and has been named several times, and only one, quite constant, species of *Gobiomorphus*[2]. However, two species of *Mogurnda*[3] and three of *Carassiops*[4] concern us in this review of temperate Australian kinds.

Flat-headed, Big-headed or Bull-headed Gudgeon; Collundera of the Yarra Aborigines, Victoria; *Philypnodon grandiceps* **(Krefft, 1864)**

The Flat-headed Gudgeon is found in fresh, brackish and coastal salt water from southern Queensland and the eastern watershed of New South Wales to Victoria and South Australia. It often travels long distances along pipes and drains, and one once came through a tap in the Australian Museum. Usually it lies amongst weeds stationary or almost so, awaiting small aquatic creatures upon which it feeds.

Two forms of this gudgeon are recognizable—the typical bull-headed one, with a broad space between the eyes and short ventral fins, and a kind called *angustifrons*, with a narrow interorbital region and head generally, and longer, slender ventral fins. It grows to 4½ ins. The colour is golden yellow or olive-greenish, with a more or less defined dark lateral stripe and sometimes (in the *angustifrons* form) some dark stripes below the pectoral fins. The latter have a dark basal stripe with a light yellow one above it. The first dorsal fin has two horizontal black bands and an orange margin; the second fin has four horizontal black bands, and its first ray is orange. The tail fin has brown cross-bands; other fins are translucent. The markings on the fins may be broken up into spots. The lips are sometimes orange or dark brownish (except in *angustifrons*, which is generally lighter and more variegated in tone, with no dark tip to the front dorsal fin).

Purple-Spotted or Purple-Striped Gudgeon, Chequered or "Trout" Gudgeon; "die australische Tupfelgrundel" of German aquarists; Koerin or Kurrin of Victorian Aborigines; *Mogurnda striata* **(Steindachner, 1866)**

This fish is russet or yellowish-brown in general colour, and the upper surface is suffused with purple. There are several large purple spots along the middle of the side and three or four oblique purplish bars down the sides of the head. The vertical fins are violet-grey with patches of dusky dots; the paired fins are spotless.

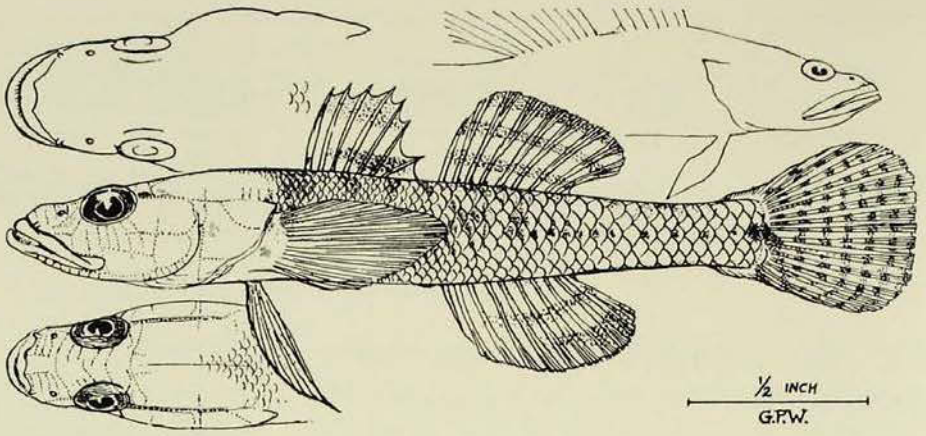
This gudgeon grows to 5 ins. and is known from Cape York, Queensland, down to New South Wales, Victoria and South Australia. In 1908 it was recorded as

1. There are two New Zealand species: *P. breviceps*, from the Kowai River, and the Blue-gilled Bully (*P. hubbsi*), from the Ashley, Canterbury and Westland Rivers.

2. Four species of *Gobiomorphus* are known from New Zealand, but so-called "*Gobiomorphus*" species from Hawaii, the Philippines, China and the Indian Ocean are properly referred to other genera.

3. Other speces of *Mogurnda* occur in tropical Australia, New Guinea, the Aru Islands, China and Japan.

4. *Carassiops*, known only from Australia, may be related to *Hypseleotris*, with allies in Indonesia, some Pacific Islands, and Ningpo, China.



Two forms of the Big-headed Gudgeon. Centre: The narrow-headed form (*Philypnodon grandiceps angustifrons*) from the Nepean River, N.S.W., and, below, the top of its head. Above: Top and side views of a typical *grandiceps* with broader head, long mouth and short ventral fins.

having fallen in a thunderstorm in Victoria Park, Brisbane. The species has long been known as an efficient destroyer of mosquito larvae and as an aquarium fish, and was transported to the United States in 1918 by fish fanciers.

The eggs are attached to flat rocks or the sides of an aquarium and hatch in nine days at 72° F. The male, which has larger fins than his spouse, fans the eggs with his fins to help in aerating them, but, in captivity, he is likely to eat the newly-hatched young. The earliest account of the breeding of this species (which is often called *Mogurnda adspersa* or *pallida* in literature) was given by Albert Gale in the "Australian Zoologist" in 1914, from which I condense:—

"The purple striped gudgeons in my aquarium are about five inches in length. They have become the parents of between one thousand and two thousand children during the breeding season of 1913-1914. They first bred in 1912, and were then three years old . . . . .

"Early in the breeding season (15th November, 1913) the female deposited her first batch of eggs on the glass side of the aquarium, and others again on the 18th and 27th December. She spawned on the 7th, 17th and 30th January, 1914, and now in March she has her tenth lot of eggs. Since last October the male has been tending the various batches of eggs for ninety days . . . . .

"On the 15th and 16th February, 1914, the male made preparations for the deposition of the ova by removing all confervoid growths and all foreign matter from the selected site . . . . Meanwhile the female lurked in the weeds on the far side of the aquarium. At 9 a.m. on the 16th she visited and inspected the site. Approving of it, she placed herself in a horizontal position by it, her abdomen lying at an angle of 45°, so the genital papilla had free play to eject the ova on to the glass. When his mate had settled herself, the male drew near and took up a position about one inch above her. His head pointed in the opposite direction to hers, and his abdomen lay at right angles to the prepared site: his genital papilla was immediately above that of the female.

"On the morning of February 17th the first ovum was emitted, and immediately afterwards two others followed. These were conjoined by a fine hair-like film, and were closely followed by a string of eight. She continued to eject strings of eggs until a circular patch of 2 by 2 inches was covered. All the chains of eggs were placed horizontally, no one crossing another . . . . . As the ova were being deposited the male hovered over the female, it being evident from the movements of his genital papilla that the spermatic fluid was being ejected, and fertilization taking place . . . . . .

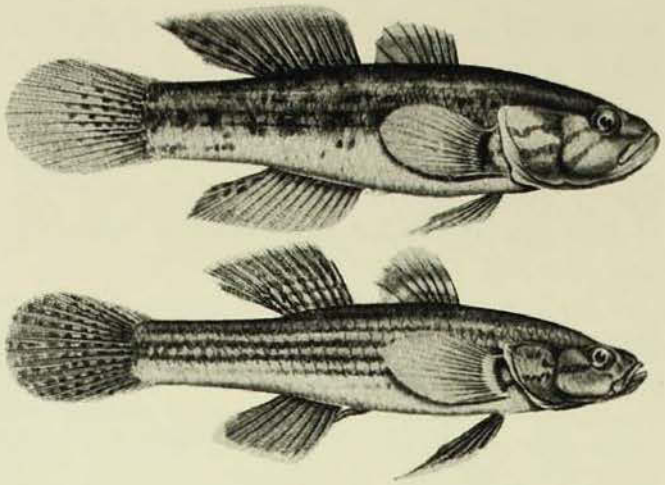
"On the morning of the 20th I noticed the first signs of eyes, and at 9 p.m. they were distinctly visible. On the 25th at 9 a.m. the fry were emerging from the eggs, nine days after the ova had been deposited.

"For a while they hung head downwards from the empty egg capsules by means of their tails, which were bent like the curve of a fish-hook. The motions of respiration and a tremulous movement of the pectoral fins were the first indication of life. At 8 p.m. the following day they had all dispersed among the weeds, where they were further guarded by the male for another twenty-four hours. The temperature of the water at this time was about 80 degrees."

C. F. Blewett ("South Australian Naturalist", x, 1929, p. 21) gave further remarks on the habits of the purple-striped gudgeon, noting:—

"The love-making was very pretty. The colour of the male deepened to a rich sky-blue, and as he swam around his mate he erected every fin to the fullest extent, and also expanded the gill-covers, reminding me of a peacock . . . . the female spawned on the stone . . . . The male continuously fanned the eggs . . . occasionally his fanning was so vigorous that I was afraid that he might cause the eggs to become detached from the stone . . . . . the young took 14 days to hatch and were weakly and died.

"It is significant and to me at least of great interest as exhibiting a natural tendency to protect the fry, that during the breeding season . . . *Mogurnda* . . . refused to eat mosquito larvae, which to some extent superficially resemble the young fishes."



Top: Male Purple-spotted Gudgeon (*Mogurnda striata*) from Bundaberg Lagoon, Queensland. Bottom: Male Striped Gudgeon (*Mogurnda australis*) from N.S.W.

Other accounts of the breeding of this species have been given by E. L. Hayes ("Australian Naturalist", vii, 1927, p. 26) and Hamlyn-Harris ("Australian Zoologist", vii, 1931, pp. 55-58).

Striped Gudgeon, *Mogurnda australis* **(Krefft, 1863)**

This species is very like others from Australia and New Guinea, but is distinguished by having nine rays in the second dorsal fin, a dark-striped body, and vertebrae numbering 29 instead of more than 30. It was first described as the "Australian Eleotris" in the "Sydney Morning Herald" of September 29, 1863. The male has a longer genital papilla and longer fin-rays than the female. The colour is olivaceous with dark grey marks along the sides forming stripes; some fin-rays are spotted, and there is some pink and bronze on the opercles. The eyes are blue. Rich brown, purple, green and gold tones are apparent in the nuptial dress, with chestnut spots on the fins. The anal fin is orange in the male, golden in the female with a broad lilac or grey margin.

The Striped Gudgeon grows to 7 ins. and is found in eastern rivers of Queensland and New South Wales. The Australian Museum has specimens which fell in rain at Mullumbimby, north-eastern New South Wales. (Whirlwinds sometimes lift small fishes from shallow pools and carry them alive for short distances, after which the fishes drop to the ground, often with rain). In the Sydney district these gudgeons deposit their spawn in April or May, after which they disappear, possibly hiding buried in mud or under stones or amongst snags, for the fish are not seen again until the first warm weather some months later.

Cox's Gudgeon or Mulgoa Gudgeon, *Gobiomorphus coxii* **(Krefft, 1864)**

Known only from eastern New South Wales, particularly coastal streams near Sydney and in the Nepean River, Cox's Gudgeon is sometimes seen climbing out of water, by means of the pectoral fins, and up the steep slopes of weirs and river-banks. It grows to $7\frac{1}{2}$ ins. in length and is brown above, yellow below, and marbled on back and sides with muddy, dark brown. Purple, blue and orange tones are sometimes present in both sexes. Fins are dotted or marbled, and the side of the head generally has two oblique dark bars.

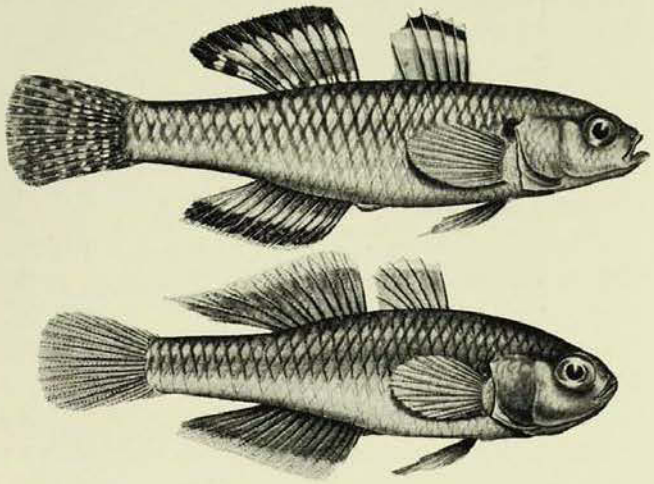
Cox's Gudgeon is related to the Bully or Toitoi (*Gobiomorphus gobioides* and some allied species) in New Zealand, where D. H. Graham found them to be expert destroyers of mosquito-larvae and noted that the Maori would not eat them, regarding them as tapu. In New Zealand, *Gobiomorphus* is preyed upon by trout. In Australia, their remains have been found in the stomach of bittern.

Empire Fish or Carp-Gudgeon, *Carassiops compressus* **(Krefft, 1864)**

The red, white and blue bands on the dorsal and anal fins of this pretty little fish are especially noticeable in the breeding season, when the red parts glow like live coals, and are responsible for the name Empire Fish. However, these fins are sometimes blue and black-banded in the male and yellow and violet in the female, or, in the young, pale terra cotta and white. The fish is variable in form and colouring, but is usually greenish-yellow; the second dorsal fin has 9 or 10 rays (other species have 11 to 14). Length, $4\frac{1}{8}$ ins.

This Carp-gudgeon is widely distributed in fresh water from north-western Australia, the Northern Territory and Queensland to New South Wales at least as far south as

Jervis Bay. It has been found in tap-water at Lismore, and examples are said to have fallen in rain in Queensland. The male often develops a swollen head, and is a glorious object in nuptial dress. The head may be red, the body green and the fins spotted. After a strong fresh in a Queensland river, a naturalist described the surface of the water as red with hundreds of these little fishes going upstream. They are unfortunately less resistant to cold and lack of oxygen than the introduced Gambusia, but they are good destroyers of mosquito-larvae and can be bred in a well planted pond or large aquarium. They pick at algae and take prepared fish food in captivity.



Top: Male Carp-gudgeon (*Carassiops compressus*) from a lagoon at Jervis Bay, N.S.W. Bottom: Male Firetail Gudgeon (*Carassiops galii*) from the Royal Botanic Gardens, Sydney.

Their manner of swimming rather resembles that of *Tanichthys* (the White Cloud Mountain Fish of China): a series of short runs, spreading the unpaired fins to their full extent as the fish slows down.

The remarkable Western Australian Blind Gudgeon, completely eyeless, may have evolved in underground waters from an ancestor like *Carassiops*, the Carp-gudgeon.

Firetail Gudgeon or Gale's Carp-gudgeon, *Carassiops galii* (Ogilby, 1898)

One of the early aquarists in Australia was Albert Gale, whom we have already met in connection with *Mogurnda striata* above. The frontispiece of his "Aquarian Nature Studies", published in 1915, shows him as a dignified old gentleman with a full white beard and moustache. In his honour, *Carassiops galii* was named by the distinguished ichthyologist J. D. Ogilby. As "Aquarian Nature Studies" has long been out of print, let us reprint here what Gale had to say about his own species, which he was the first to breed in captivity:—

"Gale's Carp-Gudgeon is a very handsome species, and a great addition to an aquarium when contrasted with its congeners. It is very shy when first captured, and runs to cover as soon as any movement is made near home. It is a small fish, being only about 2½ inches in length, and symmetrically deep . . . . .

"The male selects the site for the deposition of the ova always on the shady side of the aquarium . . . . All algae, confervae, and deleterious matter are carefully removed. While the site is in preparation the spawner is watching every movement as the work progresses, and coyly approaches the bridegroom elect, tremulously hovering to and fro until she settles herself, and receives further attentions from the milter. They are monogamous.

"There is method in the deposition of the ova, each egg being dropped singly and equidistant. The ova are placed on a perpendicular surface, the spawner reclining at a slight angle, and lying horizontally. The milter takes his place on the same site. He too lies horizontally, but in an opposite direction to that of the spawner. With slightly quivering fins he places himself upon the prepared site, somewhat above her. In about six hours the first act of nidification is completed. In another three days the little prisoners' eyes can be seen within the ova. The eggs are attached to the site by a gelatinous stem. After eyeing, the embryo fry matures rapidly; the baby inmate begins to oscillate; this vibration soon frees it from captivity. As the fry emerge from the ova they can be seen hanging on the capsules of the eggs, and soon they lead an independent life among the submerged foliage of the aquarium. On the site where they were cradled there is nothing to be seen but the empty capsules of the eggs."

The Firetail Gudgeon is pale olive-green, more or less clouded above with purplish-brown; the eyes are silvery. The fins are translucent, the dorsals and anal with broad coppery margins; the pectoral and tail fins are lemon, becoming dull to fiery reddish in adults. The ova can sometimes be seen through the sides of inch-long females. There is a high, transparent crest on the adult male's head, giving it a somewhat square form. This species grows to only 2½ ins. and its anal fin is inserted slightly farther forward than in *C. compressus*.

Its distribution is mysterious: it appears sporadically at long intervals in southern Queensland and in New South Wales. It

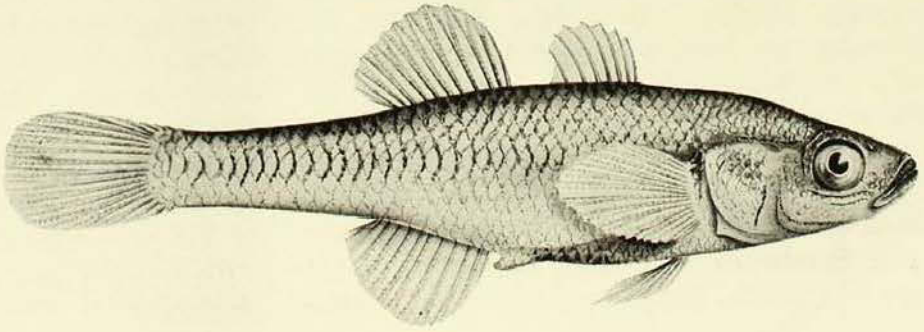
was discovered in 1898 in a pond in the Sydney Botanic Gardens, and for many years was known from no other place in the world. Messrs. E. R. Waite and Albert Gale bred it in their home aquaria. Eventually its real home was found to be in southern Queensland rivers. In 1951, "millions" of these fishes turned up in the Tamworth district. Fifty or more years ago some came down alive in a thunderstorm at Cooper's Plains, Queensland. Its absence over these years may be due to it burying in mud for long periods. The Firetail Gudgeon is an excellent destroyer of mosquito-larvae and feeds also on minute crustaceans, Vorticella, and some water weeds. It tends to school in out-of-the-way potholes of watercourses, in fairly deep and weedy water. The biologists of the Fisheries Branch of the Chief Secretary's Department, Sydney, recently bred this species. A hundred or so eggs were laid in a patch about 6 ins. long and 2 ins. wide. The male watched over them, fanning them with his fins, standing either head-up or head-down as he did so. The little fishes took 12 days to hatch at a water temperature of 74° F.

Western Carp-Gudgeon; Loetj of the Yarra Aborigines, Victoria; *Carassiops klunzingeri* **(Ogilby, 1898)**

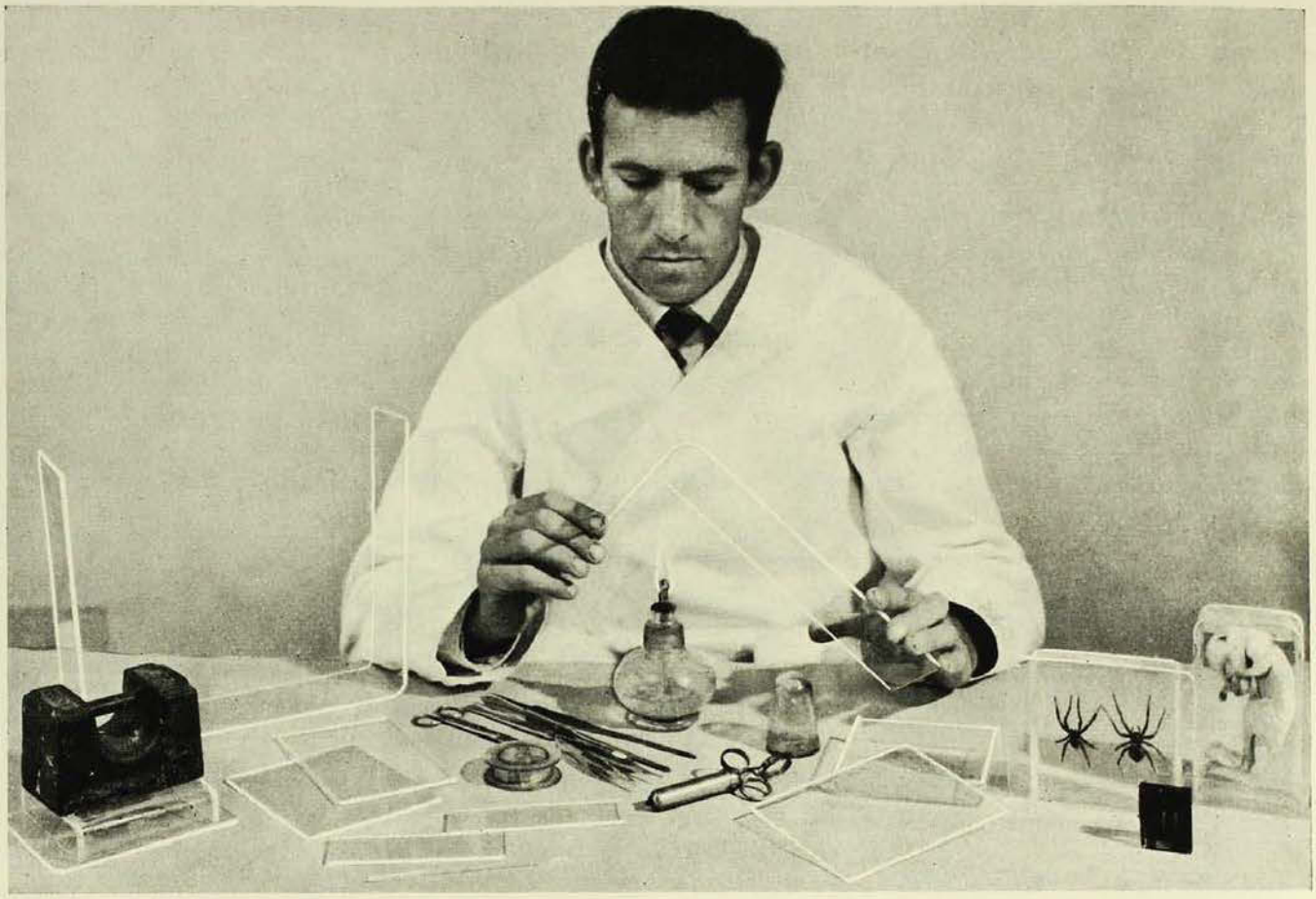
This is a slender species which is very like the Firetail Gudgeon but has a series of curved dark marks along the sides, each corresponding to a scale. The mouth does not reach below the eye. The adult male has the nape and occiput swollen, the last dorsal and anal fin-rays lengthened, and the butt of his tail shorter than in the female. The colour is greenish-brown to yellowish, the scales having darker margins. As already mentioned, the base of each scale along the middle of each side has a slightly curved, but almost vertical, dark bar. The dorsal and anal fins are dusky, with white margins in the male; in the female they are usually plain. The fish's length is 2½ ins. Specimens have been reported as falling in rain at Gulargambone. The natural range is the Murray-Darling river-system (i.e., mostly west of the Great Dividing Range in New South Wales to South Australia) and some rivers of south Queensland and Victoria; the fish is quite common. The species is often eaten by cormorants which, as a result, get the blame for eating "young Murray cod" and other fishes by those who cannot properly identify these little gudgeons.

C. F. Blewett, in the "South Australian Naturalist" (x, 1929, p. 28) gave particulars of the biology of the Western Carp-gudgeon, which, he said, "is almost always on the move, searching for food, while the males struggle for supremacy or skirmish for a secluded place, and endeavour to entice every passing female inside their selected nooks". In captivity the food consisted mainly of *Daphnia*, mosquito-larvae or small, chopped earthworms. The fishes vary in size, shape and colour, the mature males usually having pink dorsal and anal fins, which deepen to red towards the breeding season. Blewett observed the spawning in his aquarium, on its sides about 2 ins. from the water-surface. The eggs were like those of the Purple-striped Gudgeon, but only about half the size, and the male guarded and aerated the eggs in the same way as *Mogurnda*.

[*Illustrations in this article are by the late Allan R. McCulloch, except line-drawings of the Big-headed Gudgeon, which are by the author.*]



A female Western Carp-Gudgeon (*Carassiops klunzingeri*) from the Cudgegong River, Rylstone, N.S.W.



Many insects and other small, soft-bodied animals are now displayed at the Australian Museum in transparent plastic boxes filled with preservative, instead of in glass jars. This method of display can be used by amateur collectors, and several stages in the construction of a box are shown above. From left to right are pieces of plastic cut out, a piece being bent, a completed box ready to receive a specimen and two examples of boxes containing specimens.

Photo.—Howard Hughes.

New Museum Technique for Displaying Soft-bodied Animals

By ROY D. MACKAY

INSECTS, soft larvae, spiders, small fishes and many other small, soft-bodied animals have always presented a problem in museum display. In a few instances the difficulty has been overcome to some extent with models and casts, but the great majority remained a problem until recently. To show these soft-bodied animals in glass specimen-jars is incompatible with modern ideas of display, so two new methods have been developed to exhibit them to advantage. One is to embed the specimen in transparent, cold-setting plastic. The other is to mount it in a box of transparent plastic filled with a suitable preservative. The latter method is being used frequently in this Museum's displays, and it is the making of these boxes which is described in this article.

A few words about equipment and materials are needed to give a clear picture of the processes described:—

Perspex sheeting of $\frac{1}{8}$in. and 3/16ins. thickness.

A general-purpose woodworking lathe about 2 ft. between centres, with range of attachments to allow sawing, drilling, sanding and buffing.

A welding compound—to join the sections of the prefabricated boxes. This compound is made from small chips of perspex mixed with ethylene dichloride. (Five gms. perspex to 100mls. of ethylene dichloride produces a good consistency). A dispenser for this compound is made from $\frac{1}{4}$in. glass tubing about 6ins. long, narrowed at one end to a diameter of about 1/16in. At the other end is attached a rubber bulb to suck up the glue and dispense it along the edges of the joint. Bricks and half-bricks do quite well as weights, provided they are wrapped in paper.

A spirit lamp or bat's wing Bunsen flame —to bend the perspex.

Where several boxes are to be made to critical measurements, bending the perspex into smooth wooden forms is found best. Red chalk is used to mark the edges of the perspex where a bend is to be made. Polystyrene rod of $\frac{1}{8}$ in. diameter is used to make sealing plugs.

How The Boxes Are Made

So that the reader may see how we arrive at the finished product, as at the right of the illustration, a brief description of the process is as follows:—

The four sides, back and front of the box are drawn out roughly on a piece of paper and the measurements of each piece are calculated, remembering that allowance is made for an inch or so around the specimen and a little waste beyond the outline of the box to allow grinding back to the glued edges. The pieces are then cut out of the sheet perspex on a power saw. Where large areas are to be cut the thicker sheet is used.

If any pieces need bending the protective paper is removed and the perspex washed in warm water and then heated over the flame, keeping away from direct contact with the flame, as this causes blistering. The corners of these bent pieces need grinding back to the level of the edge.

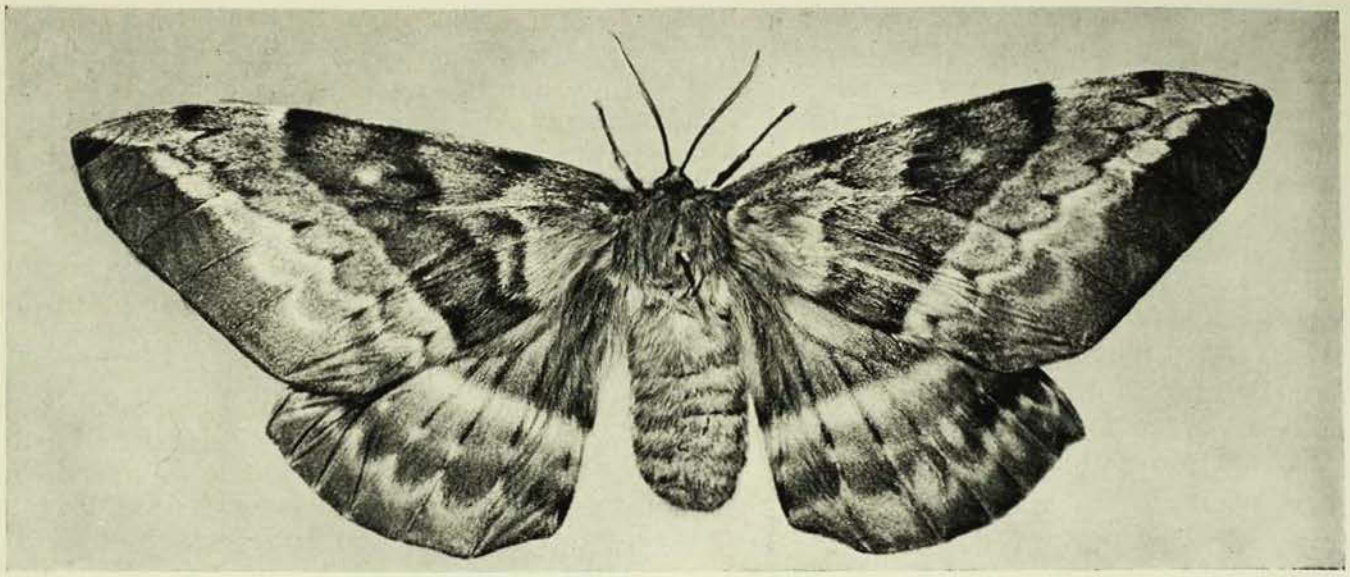
The pieces are glued together, except for the top or front. Small lugs are made with a small hole through them, and these are glued into predetermined positions where the specimen is to be sewn on with nylon line to hold it to the back of the box. With the specimen in position and a small hole $\frac{1}{8}$in. in diameter bored into the top of the box, the front or top is glued on. Weights are used on all glued parts for 20 minutes to an hour, depending on the area being glued.

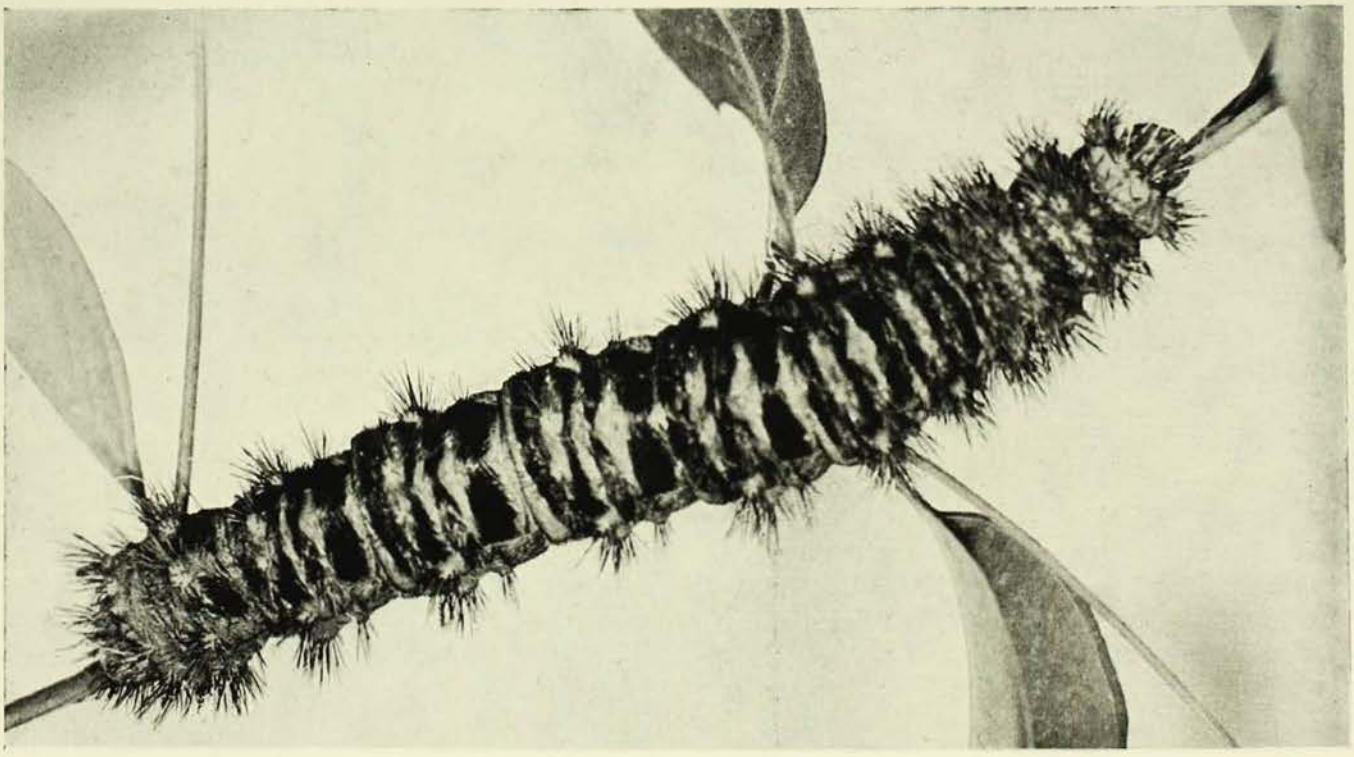
After the box is completed it is filled with a weak formalin solution and sealed with a plug made from the $\frac{1}{8}$in. diameter polystyrene rod.

This method of displaying specimens has several advantages: The boxes can be made to fit into a great variety of positions. A box may be hidden behind the background with only the specimen showing through an opening in the background. Lighting may be from the front or back, depending on which position throws the specimen up to advantage.

Even the rarest specimens may be shown in these boxes, as they can always be retrieved. The boxes are very strong, and so prove suitable for school demonstrations. They can be handled with safety, and dropping them has so far caused no damage.

THE WHITE-STEMMED GUM MOTH





The White-stemmed Gum Moth (*Chelepteryx collesi*) is one of the largest moths commonly occurring in New South Wales. The female moth (top) has a wing-span of six inches or more. The colouring consists of soft browns and greys in the female, but the slightly smaller male has darker and more strongly contrasted markings. The larva or caterpillar (below) of the White-stemmed Gum Moth measures up to four and a half inches long and bears tufts of sharp bristles which can easily penetrate the human skin. The body colour is brownish-white with dark-brown bands. The larva feeds on the leaves of Scribbly or White-stemmed Gum trees. When the larva spins its cocoon, in which it pupates, the bristles are pushed through the cocoon walls from the inside. The projecting bristles thus protect the cocoon in the same way as they protect the larva.