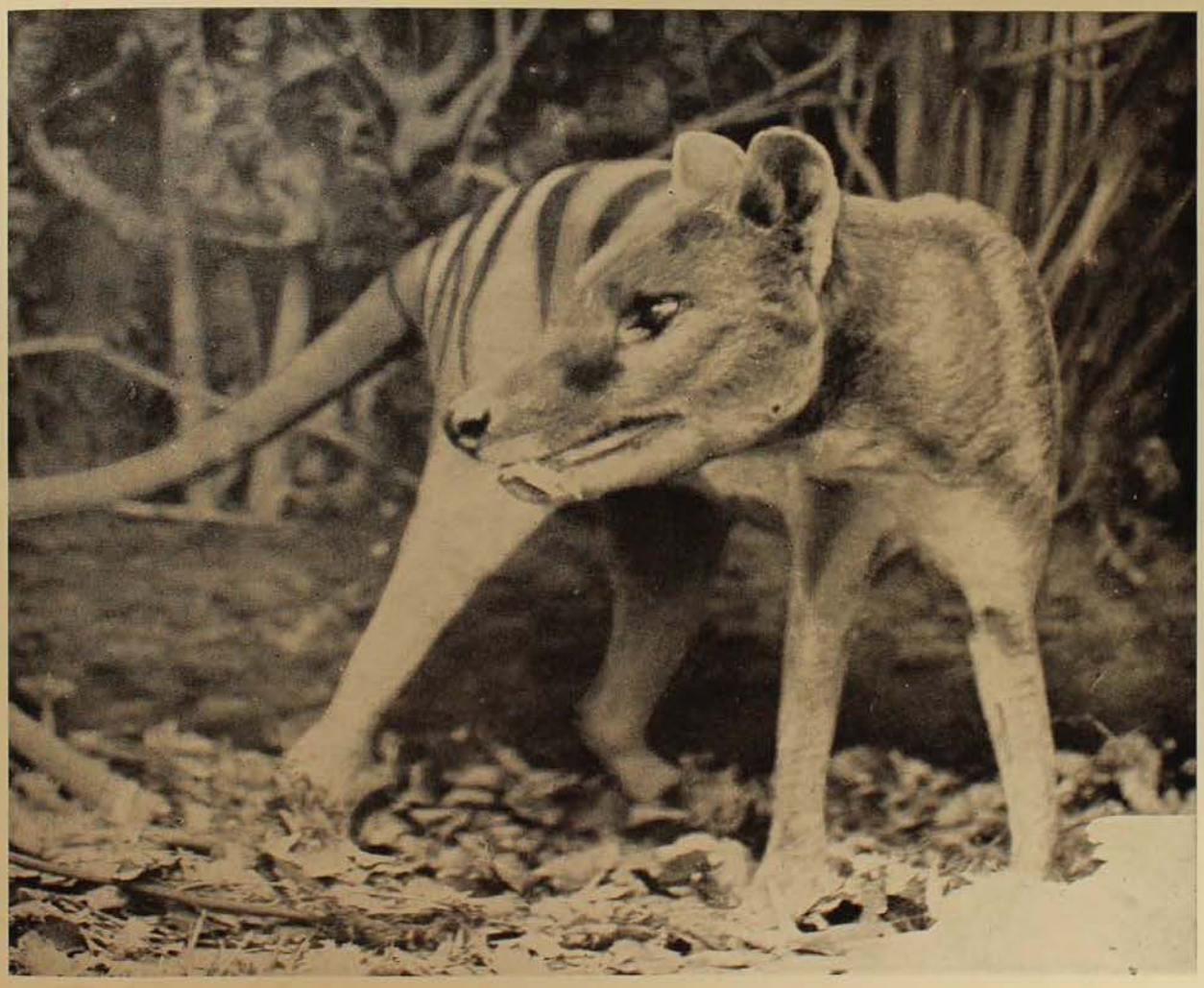
SEPTEMBER 15, 1958

The AUSTRALIAN MUSEUM MAGAZINE

VOL. XII, No. 11 Price—TWO SHILLINGS



THE THYLACINE, a marsupial, once roamed the Australian mainland but has been for so long confined to Tasmania that it is more commonly called the Tasmanian wolf, tiger or hyaena. **(See article Page 352.)**

Photo.—Australian Museum copyright.

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

THE AUSTRALIAN MUSEUM

HYDE PARK, SYDNEY

BOARD OF TRUSTEES

PRESIDENT :
H. B. MATHEWS, B.A.

CROWN TRUSTEE :
H. B. MATHEWS, B.A.

OFFICIAL TRUSTEES:
THE HON. THE CHIEF JUSTICE.
THE HON. THE PRESIDENT OF THE LEGISLATIVE COUNCIL.
THE HON. THE COLONIAL SECRETARY.
THE HON. THE ATTORNEY GENERAL.
THE HON. THE COLONIAL TREASURER.
THE HON. THE SECRETARY FOR PUBLIC WORKS.
THE HON. THE MINISTER OF EDUCATION.
THE AUDITOR-GENERAL.
THE PRESIDENT OF THE NEW SOUTH WALES MEDICAL BOARD.
THE SURVEYOR-GENERAL AND CHIEF SURVEYOR.
THE CROWN SOLICITOR.

ELECTIVE TRUSTEES :

FRANK B. SPENCER.
O. G. VICKERY, B.E., M.I.E. (Aust.).
WALLACE C. WURTH, C.M.G., LL.B.
PROF. A. P. ELKIN, M.A., Ph.D.
F. McDOWELL.
R. J. NOBLE, C.B.E., M.Sc., Ph.D.
E. J. KENNY, M.Aust. I.M.M.
F. L. S. BELL, M.A., F.R.A.I.
FRANK W. HILL.
G. A. JOHNSON.
PROF. P. D. F. MURRAY, M.A., D.Sc.
PROF. J. R. A. McMILLAN, M.S., D.Sc.Agr.

DIRECTOR :
J. W. EVANS, Sc.D.

DEPUTY DIRECTOR :
H. O. FLETCHER, M.Sc.

SCIENTIFIC STAFF :

Birds, Reptiles and Amphibians: J. A. KEAST, M.A., M.Sc., Ph.D., Curator.
Mammals: B. J. MARLOW, B.Sc., F.Z.S., Curator.
Fishes : G. P. WHITLEY, F.R.Z.S., Curator.
Insects and Arachnids: A. MUSGRAVE, F.R.Z.S., F.R.E.S., Curator; D. K. McALPINE, M.Sc., Assistant Curator.
Molluscs: D. F. McMICHAEL, M.A., Ph.D., Curator.
Crustacea and Coelenterates: F. A. McNEILL, Curator.
Worms and Echinoderms: ELIZABETH C. POPE, M.Sc., Curator.
Minerals and Rocks : R. O. CHALMERS, A.S.T.C., Curator.
Fossils: H. O. FLETCHER, M.Sc., Curator.
Anthropology: F. D. McCARTHY, Dip.Anthrop., Curator.

EDITORIAL ASSISTANT AND PUBLIC RELATIONS OFFICER:
MARGARET W. FRASER.

EDUCATION OFFICER :
PATRICIA M. McDONALD, B.Sc., Dip. Ed.

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

DEPARTMENT OF PREPARATION:
H. HUGHES, A.R.P.S.

DEPARTMENT OF ART & DESIGN:
F. J. BEEMAN.

HONORARY SCIENTIFIC STAFF :

Zoologists.

E. A. BRIGGS, D.Sc.
H. LEIGHTON KESTEVEN, D.Sc., M.D.
MELBOURNE WARD, F.R.Z.S., F.Z.S.
TOM IREDALE.
A. J. MARSHALL, D.Sc., D.Phil.
JOYCE ALLAN, F.R.Z.S.
S. J. COPLAND, M.Sc.

Ornithologist.

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

Philatelist.

FRANK W. HILL.

THE AUSTRALIAN MUSEUM MAGAZINE

OUR FRONT COVER: The Thylacine or Tasmanian tiger, stands about two feet high at the shoulder. Its tail is rigid and cannot be "wagged." It has some thirteen stripes on its rump, is a marsupial, has an outsize yawn, hunts by night and is thought to have poor vision.

Photo.—H. Burrell (Australian Museum copyright).

VOLUME XII, NUMBER 11 SEPTEMBER 15, 1958

THE AUSTRALIAN MUSEUM MAGAZINE

Published Quarterly by the Australian Museum - - College Street, Sydney

Editor: J. W. Evans, Sc.D. Annual Subscription, Post Free, 9/-

VOL. XII, No. 11 SEPTEMBER 15, 1958

Australian Geckoes

By HAROLD G. COGGER

AUSTRALIA boasts a large and varied lizard fauna; more than two hundred and forty species belonging to five families are currently recognised and of these approximately forty species belong to perhaps the most interesting and yet the most maligned of Australian reptiles, the geckoes or night-lizards (Family Gekkonidae).

Geckoes are nocturnal animals, as one of their popular names would imply. They are generally soft-bodied, flabby lizards with a thin scaly skin in which the individual scales lie alongside each other and do not overlap like those of many other lizards, or of snakes. In some forms these scales are modified to form tubercles, or hard spines, which give the gecko a very spiky appearance and which make it rough and sharp to touch. Sometimes the skin on the underside is so transparent that the internal organs are clearly visible.

Geckoes live in many different environments and each species is adapted to the particular habitat or "niche" in which it is found. Of the numerous features which show the results of this adaptation, the feet are perhaps the most remarkable. There are two basic types—feet with adhesive pads on the toes, and feet which lack pads but which have strong, bird-like claws.

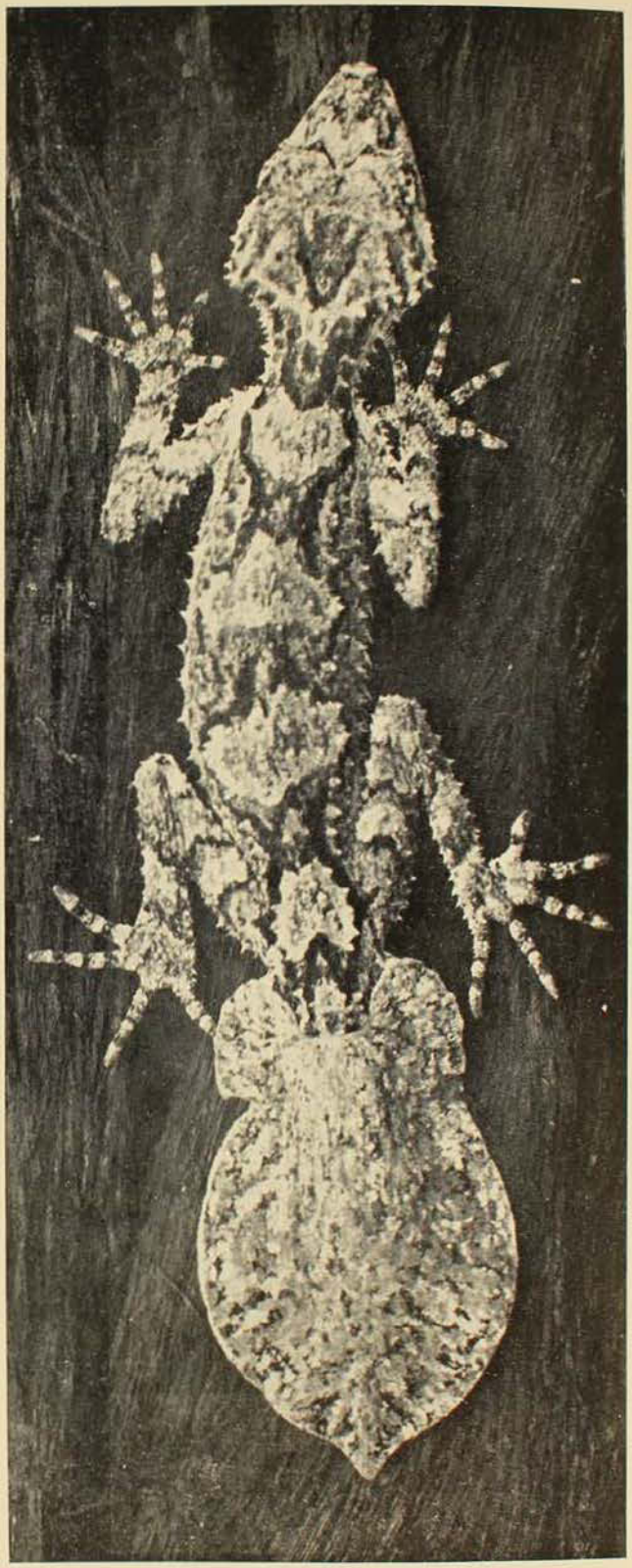
Adhesive pads characterise the climbing geckoes, of which the Dtella (*Gehyra variegata*) is a species found throughout Australia. It often frequents country homes where it may be seen in the evenings running across walls and ceilings in pursuit of moths and other insects which have been attracted by light. The Dtella has large, circular pads which are extremely efficient in climbing smooth surfaces, and which will even allow it to walk upside down across a smooth piece of glass. Members of the genera *Phyllodactylus*, *Oedura* and *Diplodactylus* also have pads, but ones which are smaller and less efficient than those of the Dtella, and some of these geckoes have discarded the climbing habit. Usually there is a small retractile claw associated with the pads and this can be withdrawn into a groove between them when it is not required. The claw is mostly used when the geckoes are climbing on rough surfaces.

The strongly clawed geckoes are a group consisting mainly of ground dwellers which do a minimum amount of climbing. Binoe's gecko (*Heteronota binoei*) is typical of this group and is found under rocks and logs throughout most parts of the Australian continent. The genera *Phyllurus*, *Gymnodactylus* and *Nephrurus* also possess a similar type of feet.

The eyes of geckoes are large and circular; they lack eyelids, and are covered by a large transparent scale like that of snakes. As there is no eyelid to keep this scale free from dust, etc., these lizards have a unique and effective mechanism to carry out this function. The tongue is slightly flattened, fleshy, and either smooth or covered with minute papillae, and it is frequently protruded so that it slowly wipes the lips and eventually the whole of the eye, cleaning this organ of any foreign matter. It does not appear to be concerned with the capture of food. In light of low intensity the pupil is almost circular in shape, but in daylight it is reduced to a narrow vertical slit. Geckoes appear to be unable to distinguish stationary objects, but are adept at sighting the slightest movement.

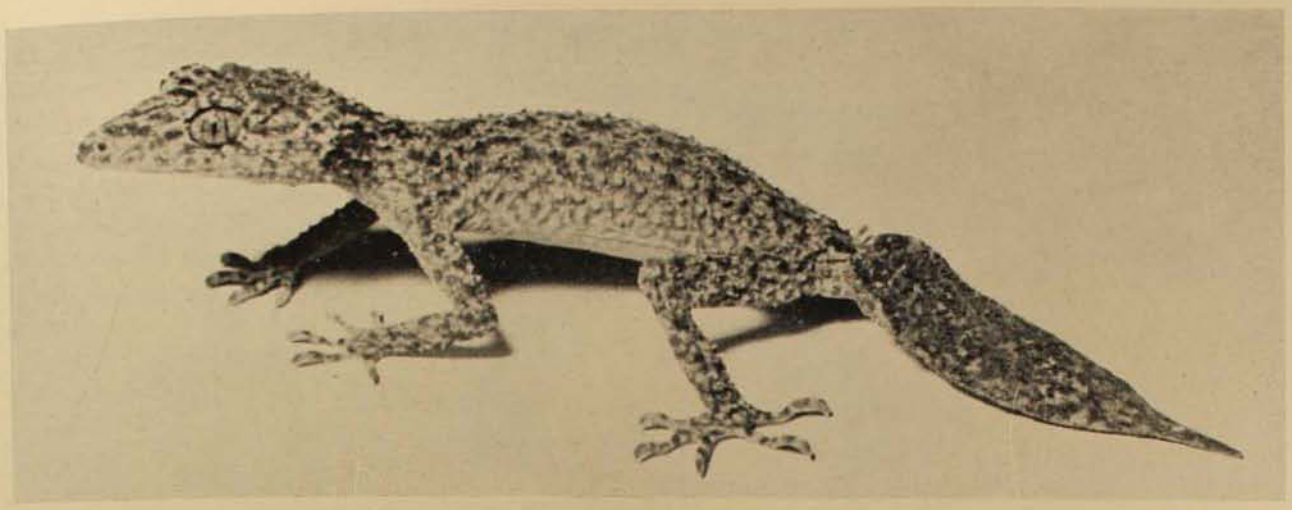
Geckoes are well known for their ability to reproduce lost tails. Although it is unusual in many species to find adults with their original tails, the oft-presented explanation that the animals have lost their tails in escapes from predators probably does not account for as large a number as previously believed. In captivity it is often found that all the males and a high proportion of the females kept together in a vivarium lose their tails during the breeding season due to fighting or coupling. It may take from four to eight months for a new tail to reach full size. There is no doubt, however, that many geckoes will readily part with their tails when attacked, and as the discarded tail will continue to wriggle vigorously for some time, the attacker's attention is often diverted from the escaping gecko.

Geckoes' tails occur in an amazing variety of shapes and sizes, from the broad, flattened extremity of the Leaf-tailed Gecko (*Phyllurus platurus*) to the absurdly disproportionate knob of the Knob-tailed Geckoes (*Nephrurus*). In many species the tail is used as a food reservoir; the fatty tissue laid down in this organ is used by the gecko during the winter, or in drought times, when it is unable to find or catch suitable food. In this manner some geckoes have been known to survive periods of more than twelve months in captivity without food, provided water was available to them during that time.



The northern Leaf-tailed Gecko (*Phyllurus cornutus*) is probably the largest Australian species. Its bright colour pattern blends with the lichen-covered bark on which it normally lives.

As might be expected, the colour and pattern of a particular gecko is intimately

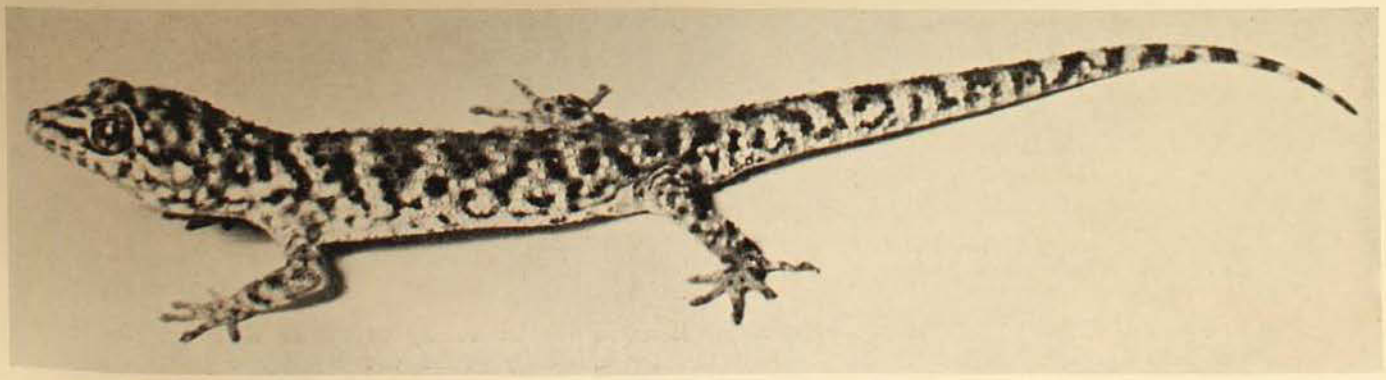


The southern Leaf-tailed Gecko (*Phyllurus platurus*) is a rock-dwelling species found commonly in the Sydney district.

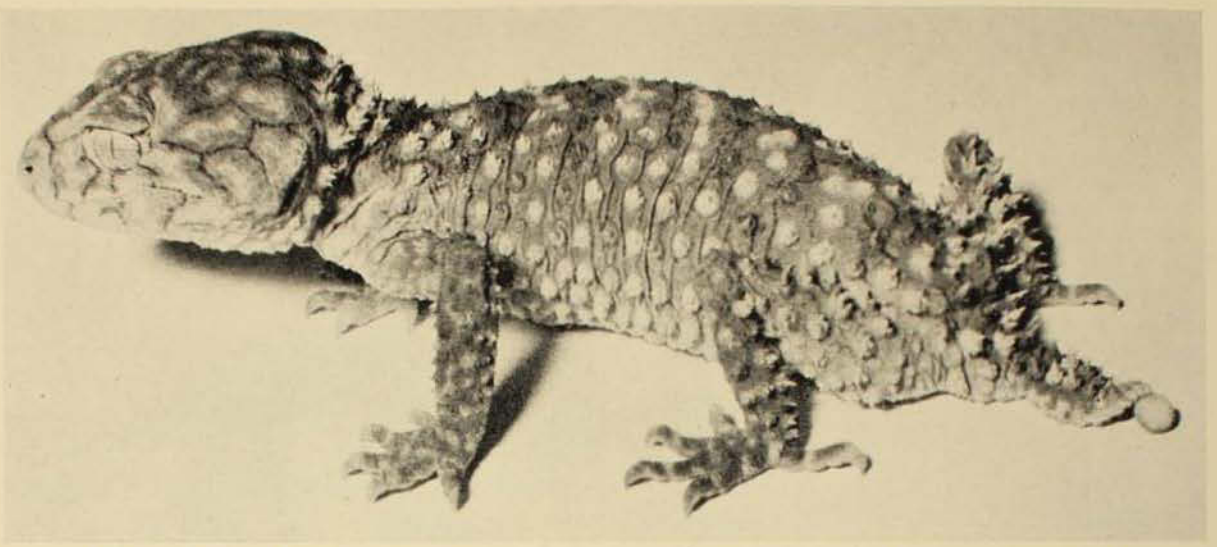
connected with the surroundings in which it lives. Ground-dwelling species usually resemble the colour of the soil in any particular area; species from the inland black soil plains are generally of a dark, drab colour, whilst those from the red sandy soils of the central arid regions are often brightly coloured with reds and yellows. However, in many species the individuals are able to undergo remarkable colour changes in a very short time when moved from one background to another, although this change is usually from a very light to a very dark form of a basic ground colour. The pattern may consist of a great variety of combinations of stripes, spots and bands, arranged so that the animals are perfectly camouflaged in their natural environment. Tree or rock-dwelling geckoes are usually brighter in colour than their cousins on the ground. Sometimes two unrelated geckoes living under identical conditions have similar colour patterns which make them difficult to distinguish when examined superficially. *Gehyra variegata* and *Phyllodactylus marmoratus* are two such geckoes, whilst *Diplodactylus michaelsoni* and *Ebenavia horni* cannot be separated on the basis of colour pattern alone.

To what size do geckoes grow? Although the majority reach adult length at between 3 and 6 inches, the giant of Australian species is probably the northern Queensland Leaf-tailed Gecko (*Phyllurus cornutus*), a rain forest form which grows to more than 12 inches in length.

Geckoes eat a variety of food, all of which needs to be alive and, as mentioned earlier, moving. Although insects and spiders are the principal sources of food, centipedes, scorpions, and even other lizards are also known to be taken. The food is generally crushed, but not chewed, and then swallowed whole. Often a gecko will



Binoe's Gecko (*Heteronota binoei*) is found throughout most parts of Australia. Its strongly clawed feet are typical of most ground-dwelling geckoes.

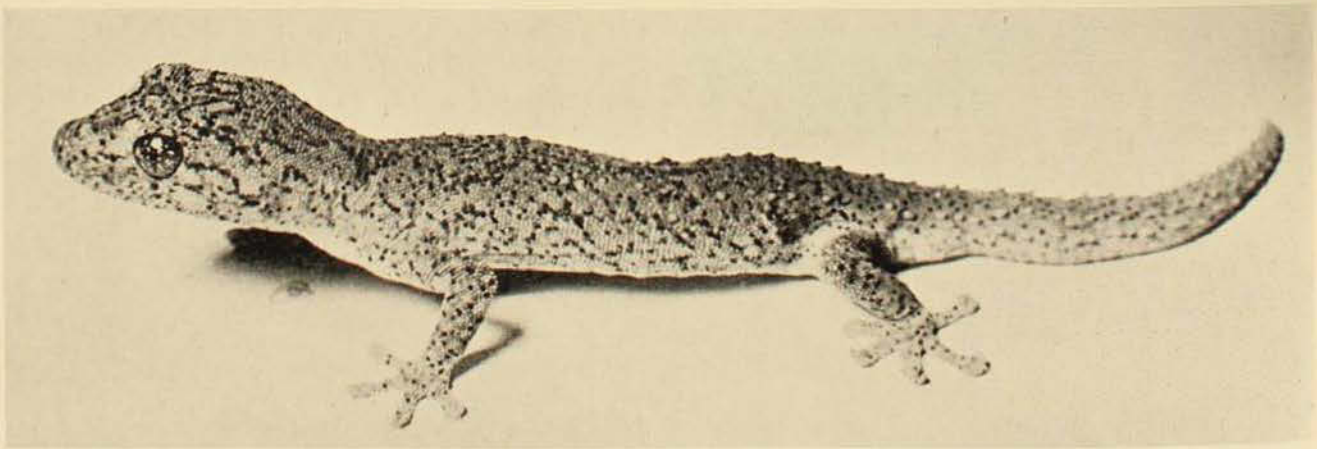


The Knob-tailed Gecko (*Nephrurus asper*) is a brightly coloured species from the dry inland areas.

grasp an insect between its jaws and then, thrashing its head from side to side, knock the struggling creature into insensibility against a rock or tree trunk. The noise from such operations can often be heard many yards away, particularly on a calm evening.

Unlike the majority of other reptiles, geckoes do not drink from an open body of water but obtain their water requirements by lapping from moist surfaces such as leaves and bark wet with rain or dew, or water-soaked rocks. Little is known about their ability to exist without water, but a three months' lack of it would appear to be the limit for most species.

Each female lays two eggs in a season, usually within a day or so of each other. In southern parts of the continent the breeding season generally extends from November to February, but in the tropical regions this period may be greatly prolonged, and it is even possible that there are two breeding seasons in each year. The eggs are laid under the bark of trees, or under logs and stones, and hatch in about six to eight weeks. The newly-hatched young are well able to fend for themselves, and immediately begin their search for food. The optimism and self-confidence of some of these young are boundless, for it is not an uncommon sight to see one of them, no more than an hour out of its egg, vigorously attacking and attempting to devour an insect or spider several times its own size.



The Spiny-tailed Gecko (*Diplodactylus strophurus*) is noted for its ability to exude a treacly fluid from the tubercles along its back. The feet of this tree-climbing gecko are equipped with small adhesive pads.

Photos.—Author.

Soon after hatching the little gecko sheds its skin, and this process is repeated at frequent intervals during its first few months of life. As the growth slows down with age, skin shedding occurs less often, so that the adult gecko rarely sheds more than two or three times a year. In the majority of species the young are identical with the parents, but in some forms the colour pattern in the young is very different from that of the adult.

Another popular name which is often applied to the geckoes is that of "barking lizards", a title derived from the ability of most forms to utter a short clicking or "yapping" noise when frightened or otherwise disturbed. This is the origin of their family name, for the word "gekko" is said to resemble the sound produced by certain foreign members of the group. However, some of our Australian geckoes, particularly the leaf-tailed *Phyllurus*, are able to make a prolonged high-pitched "wail", which in the case of *Phyllurus* is not unlike that of a crying baby. This noise production often accompanies the bluffing behaviour displayed by geckoes when confronted by an enemy, in which they raise themselves on all four legs, open wide their mouths, inflate their bodies with air, and move toward the adversary in short jumps.

This show can, at times, effectively bluff the largest enemy, humans not excepted, for many geckoes are greatly feared by the Aborigines and are often known to an enlightened white population by the name of "wood adders" or "stone adders". Such connotations imply that geckoes are highly venomous but this is quite erroneous; they are perfectly harmless, and a bite from even the largest would be unable to pierce human skin. Perhaps it should be mentioned that one species, the Spiny-tailed Gecko (*Diplodactylus strophurus*), can exude from the base of its spines and tubercles a viscous, treacly fluid with an unpleasant odour which can be very painful if it penetrates an opening in the skin or gets into one's eyes. This is the only species which is known to have such a mechanism.

Snakes and other lizards are probably the major enemies of geckoes, but birds, small mammals and even spiders and frogs have been known to eat them on occasions.

Geckoes are distributed fairly evenly throughout the Australian continent, being well represented even in the arid central regions. They are generally considered to be a very ancient group of lizards, and some of the Australian genera are thought to possess particularly primitive characteristics which would indicate their isolation in Australia over vast periods of time. Some New Guinea forms, however, have recently invaded Australia through the Torres Strait islands and Cape York, but these are largely tropical species which are restricted to denser rain forest areas in northern Queensland.

As one would expect in lizards which range throughout the country, they live in a wide variety of habitats—under the bark and in cracks of trees, under rocks and logs, in buildings or in burrows and fissures in the ground. From the dense rain forests of the eastern coast to the sandy central deserts, each species is adapted to fit into its particular niche.

Much remains to be learnt of this interesting group of reptiles. At present little is known about the distribution of all but a few common species, whilst practically nothing is known regarding their general biology and life histories. Although possible functions for their varied characteristics can be suggested, little positive information is yet available. For instance what is the real purpose of the knob of *Nephrurus* or the exudation of the Spiny-tailed Gecko? These and many other questions still remain to be answered.

Intertidal Barnacles

Miss Elizabeth Pope, Curator of Worms and Echinoderms, spent nearly a month in the field during May and June, working along the coast of Queensland between Caloundra and Yorkey's Knob, north of Cairns. She made extensive observations on the intertidal barnacles on rocky shores, wharf piles and mangroves, and brought back many specimens for the Museum collections.

Portion of a large dry-season flock of Magpie Geese (estimated at 30,000 birds) on swamps at the confluence of the East Alligator River and tributaries.

Photo.—H. J. Frith.

The Magpie Goose

By H. J. FRITH and S. J. DAVIES

Wildlife Survey Section, C.S.I.R.O., Canberra

IN 1954 experiments on the cultivation of rice on the subcoastal plains of the Northern Territory were begun by the Northern Territory Administration. Almost immediately these experimental crops were attacked by magpie geese and it was feared that the birds could become a major hazard to rice cultivation in this region. At the request of the N.T.A., the C.S.I.R.O. Wildlife Survey Section undertook a comprehensive study of the ecology and behaviour of the species in order to assess its place in the future development of the region. This article is based on some of the preliminary, unpublished results of this study.

Among the Australian waterfowl are several whose taxonomic position is not certain. The magpie goose *Anseranas semipalmata* is one of these. Taxonomically, in many respects, the birds resemble the true geese, but have many characters that, whilst contrasting very sharply with all other ducks and geese (Anatidae) resemble features of the screamers (Anhimidae). Some authors feel the species should form a separate family altogether but the most modern comprehensive work on waterfowl divides the family into two subfamilies; one (Anseranatinae) containing only the magpie goose and the other (Anserinae) containing all other ducks, swans, and geese in the world.

The magpie goose is a large goose-like bird with rather large wings and a high knob on the head. Its legs are long and feet half webbed. A normal male weighs about 6 pounds and has a wingspread of about 63 inches; females are smaller. Until this study began, its life history, habits, and behaviour had not been studied. It is probable that such a study, by enabling the habits and behaviour of the species in the field to be compared to other geese, would assist in finally deciding the bird's affinities and its place in the evolution of the world's waterfowl as we know them.

Distribution

Formerly the magpie goose ranged from the Kimberley region in Western Australia across the coastal regions of northern

Australia and down the east coast to Victoria. In New South Wales it was common inland as far as Moree, Booligal, and Echuca. It has, however, long been exterminated in even the sparsely settled part of its southern range and at present does not breed and is very rarely seen in New South Wales or Victoria. Today the geese are confined to northern Australia from the Kimberleys to the east coast of Queensland where it is not common south of Rockhampton. It is also found in the Merauke region of New Guinea.

Within its present range the birds are almost completely confined to a very narrow coastal strip and are seldom seen more than 40 miles from the coast. Occasionally, however, irruptions occur and odd birds turn up in the southern States.

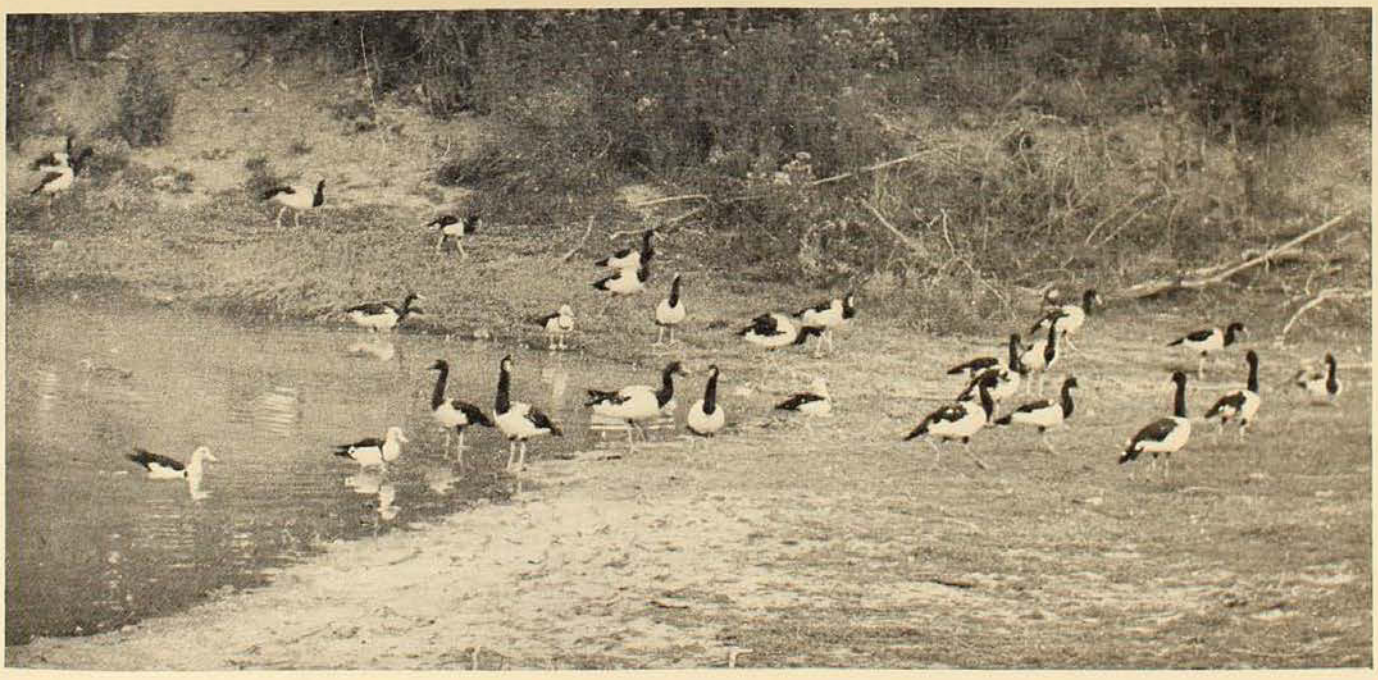
ENVIRONMENT

This study has been done on the subcoastal plains of the Northern Territory between Darwin and western Arnhem Land (Oenpelli). The area includes the Adelaide, Mary, Wildman, and the East, South, and West Alligator rivers. The climate is monsoonal with very pronounced wet and dry seasons. In the dry season which extends from April until October there is literally no rain, but in the wet season 60 inches fall. The wet usually begins with scattered storms in October or November and begins in earnest in December.

In this environment the plains vary from extensive wildrice-sedge (*Oryza-Eleocharis*) swamps in the wet season to dusty bare plains in the dry season. The water areas vary greatly in size. Frequently floods occur when the whole plain is covered with several feet of water, when these subside there are thousands of square miles of swamps which ultimately dry up and leave the only water as a few scattered lagoons of a few acres extent.

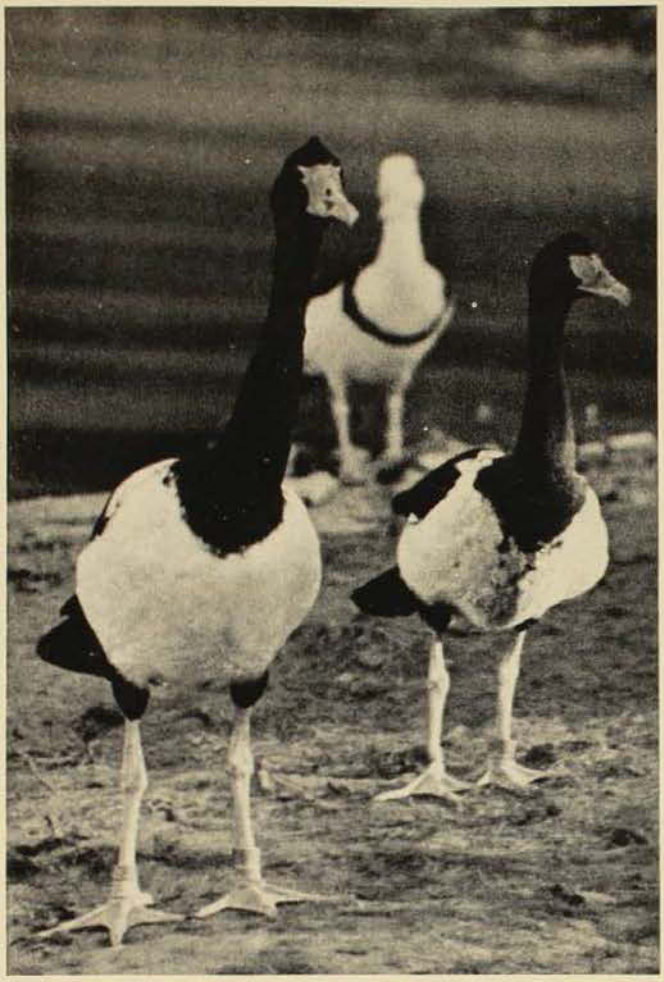
FOOD

The food habits of the birds were studied by the examination of large numbers of stomachs of birds shot for this purpose or killed during attempts by the rice growers to protect their crops. The birds usually feed in the early morning and in the late afternoon, but on some occasions, especially on moonlight nights, feed throughout the night. Food is secured by grazing, digging into the ground with the strong hooked bill, stripping the seeds of plants growing in or out of water and on some occasions by "tipping" in shallow water.



Magpie Geese feeding. (Two Burdekin ducks at left).

Photo.—H. J. Frith.



A male and a female goose (with Burdekin duck in the background).

Photo.—E. Slater.

In the early wet season, when the plains are flooded, the birds feed in the shallow water at the edges, on a wide variety of grass seeds, and as the various aquatic grasses and sedges grow in the newly formed swamps these form the main diet. A major event, however, is the ripening of the crop of wildrice which is the dominant plant over much of the Adelaide River valley, and the seeds of this plant are an important food in the latter part of the wet season.

As the swamps recede in level and the sedges mature the geese then begin to consume large quantities of the underground bulbs of these plants. They are secured by driving the bill and head deep into the soft mud at the edge of the drying swamps. It seems that this food whilst remaining plentiful becomes less available as the areas of soft mud decrease and disappear in the later dry season. Although many sedge bulbs are secured by digging into the hard, dried mud, the birds at this period also seek other food and large flocks graze on whatever herbage is available on the plains.

From this food study it is obvious that swamp grass and sedge are the mainstays of the diet of the birds and as these plants grow in those locations commonly chosen for cultivation the food of the geese must be severely reduced as development proceeds.

Flock Behaviour

The birds are gregarious and are found in groups of from two or three to several thousand birds. That a number of individuals of an animal species group themselves together implies some degree of social organisation within that group; that is, an ability on the part of an individual to anticipate the actions of other individuals.

When geese flight out from their roosts to their feeding ground, and at roosts, bathing places, etc., there is a strong tendency to land with the earlier arrivals. The flying birds appear to respond both to the sight and sound of other stationary geese. As a result of this simple reaction goose flocks build up automatically; one need not consider the individual goose as primarily a member of a flock, but rather as a member of a pair, or family party. During any activity the flock as originally constituted may break up, graze apart, or split into several smaller flocks and only during a situation of alarm is there any unity of action. When geese see something strange they call and take up an alert position which is quickly assumed by all geese within sight and the birds cluster into a tight bunch. Signals spread through the flock for one goose is stimulated to signal when it sees another signalling, even if it doesn't see the alarming stimulus itself, and the flock takes off together, as a flock, if the alarming stimulus remains. In the magpie goose the signals may be "marking time", "head shaking", or "wing flipping" and they serve to prepare the whole flock for the take-off.

The most interesting result of this instability of a goose flock is that there appears to be no peck-order or dominance

hierarchy within it such as is found in many social birds, *e.g.*, the domestic fowl or Cardueline finches. This feature is especially interesting as a dominance hierarchy appears to play a part in the reproductive activities of geese. However, selection would act against its development in the flocks whilst these act solely as a means of protecting the individual, and the pair or family group remains the stable unit, since the setting up of dominance relations every time a flock aggregates could give no advantage to any individual in an area where food, water, roosting sites, etc., generally cover an extensive area.

MOVEMENTS

The geese are nomadic and these movements are controlled by the amount of water available on the plains and probably the availability of food. The movement pattern of the birds has been determined mainly by regularly traversing the whole of the region in low-flying aircraft and recording the location of all goose flocks in the areas. In this manner it is possible to follow the movements of the birds very accurately. The results of the air surveys are confirmed by the return of bands from birds banded on the Adelaide River. They are trapped by means of a mortar-propelled net and each bird receives a numbered aluminium band and a coloured plastic one to enable quick recognition without shooting the bird.

At the end of the wet season large flocks of geese are scattered througout the region, each flock being confined to one of the large swamps. As these swamps dry the birds congregate on the more permanent ones and an exodus from most rivers begins. As the swamps nearer the coast are, on the whole, the more permanent this concentration leads to a movement of the birds towards the coast.

Each river differs hydrologically from the others and it was found that very large permanent swamps occur on the South Alligator and remain throughout the dry season. As the other river plains dry the numbers of geese on them decline and the numbers increase in these swamps. At the height of the dry season very great concentrations of geese occur on these permanent swamps.

With the first storms of the wet season the concentrations break and the geese move back to the other rivers and spread over the plains, ultimately becoming located on the newly formed swamps preparatory to breeding.

BREEDING

Breeding occurs at the end of the wet season in the deeper more heavily vegetated parts of the swamps. It seems that for nest building a critical water depth and vegetation density exist. The water may be too deep or too shallow, and similarly the vegetation may be too sparse or too dense for nest building. The various swamp plants used as nest materials also have rather specific water depth requirements. The exact requirements for nest building are the subject of a special study and are not yet fully understood. They do, however, limit the extent of breeding areas in the various swamps.

The nest is bulky and formed by trampling down the swamp vegetation, uprooting the plants in the vicinity and adding them to the heap. The number of eggs found in the nest varies from 4 to 14 but, as in many waterfowl, two females often lay in the one nest.

CONSERVATION

It is thought that on the whole the magpie goose will not be a serious problem to the expanding rice industry. It can and does eat the cultivated rice but the number of birds involved in attacks on the crops is relatively small even now when only a few hundred acres are under cultivation. It is probable that as the area devoted to rice increases, the number of geese will not increase and so the relative amount of damage done will rapidly decrease to negligible proportions.

On the other hand it is certain that, as cultivation increases in the region, the breeding and feeding habitat of the birds will be eliminated. The geese will become extinct in this, one of their last strongholds, unless suitable sanctuaries are provided. These studies have enabled us to determine what would be required in a sanctuary in order to preserve the species, and any move to protect the birds in this manner could be based on biological facts.

The Thylacine is primarily a blood feeder and eats only selected parts of its prey.

Photo.—H. Burrell. (Australian Museum copyright).

The Thylacine

By ERIC R. GUILER

Department of Zoology, University of Tasmania

NONE of the Tasmanian marsupials has captured such wide interest as the Thylacine, *Thylacinus cynocephalus* (Harris), for which the popular names of Tasmanian wolf, tiger and hyaena are used. It is not uncommon to hear Thylacines referred to as "bull-tigers" or "greyhound-tigers". Strictly speaking, the Thylacine is not related to either the wolf, the tiger or hyaena, and for this reason the word thylacine is preferable as a common name.

Characteristics

The Thylacine is a marsupial, carrying its young in a pouch, and the generic name *Thylacinus* refers to this habit. It is related to the native cat, the tiger cat and the Tasmanian Devil, all belonging to the Family Dasyuridae. The Thylacine is easily separable from any of these by its large size, as it stands about two feet high at the shoulder. Further distinguishing characteristics are the dog-like head (hence the specific name of *cynocephalus*) and the presence of about thirteen stripes on the rump, from which the animal obtained its name of tiger or hyaena. The Thylacine has a rigid tail and cannot wag it as a dog does.

The head of a male Thylacine is more wolf-like than that of a female, which is short and broad; thus males and females can be readily distinguished, apart from the presence or absence of a pouch. At one time the two sexes were believed to represent two different species.

One of its most striking features is the tremendous gape. I have seen a cinema film of a Thylacine yawning [1] and the gape can only be described as phenomenal. The lower jaws, when fully open give the impression of being disarticulated from the skull.

Distribution

Gill [2] has reviewed the evidence for the mainland distribution of the Thylacine as

[1] For a photograph of a Thylacine yawning, see Bourliere, F. 1956. Mammals of the World. Their life and habits. Harrap, London.

[2] Gill, E.D. 1953. Distribution of the Tasmanian Devil, the Tasmanian Wolf and the dingo in south-east Australia in Quarternary time. *Vict. Nat.* 70, 1953, 86-90.

found in cave deposits, and he found that in the Quaternary period Thylacines once roamed the Australian mainland. They have since become extinct on the continent but there is no evidence to show that man was in any way responsible for this. Reports are made from time to time of some large animal, which is supposed to look like a "tiger", frequenting dense bush country in Queensland. But no specimens have ever been produced. Tasmania became the Thylacine's last stronghold and early settlers found numbers of them roaming the plains areas and in the mountain country, though it should be borne in mind that this species, while numerous, was never as common as, for example, the possum or kangaroo.

Decline

When sheep were introduced to Tasmania, Thylacines started to kill them. They may have done so in periods of adverse weather or when other food was not available, but it is unlikely that they became sheep killers in general. Nevertheless, Thylacines were branded as killers and a war of extermination was waged against them. The Government offered £1 per head, though a carcase was worth more than this since graziers also would reward a trapper. As early as 1863, Gould [3] noted that the Thylacine faced extinction; by 1909, Smith [4] was very concerned about the future of the species. By 1920 live Thylacines were worth £20 each and by 1930 specimens were very rare and could not be procured for even £50.

It is probable that the killing campaign, combined with the clearing of land (with its consequential effect upon the habitat of the Thylacine) were the principal factors in the decline of the species. However, the late Mr. Fred Burbury of Parattah (pers. comm.) has put forward the interesting view that a disease "like distemper" swept through the Dasyures about 1910 and thereafter Devils, native cats, and tiger cats, together with Thylacines, became very scarce. While it is unlikely that this statement can ever be confirmed by scientific evidence, it is important that it should be placed on record. Fur trappers used to kill Thylacines from time to time, to keep them from eating snared game, but this was only a minor factor in hastening the decline of the population. The possibility that the decline in numbers was due to some long-term population cycle about which nothing is known must not be overlooked. The Thylacine was placed on the "wholly protected" list in 1938 but this may have been too late to be of any use.

Footprints

Thus we have an animal which once ranged Tasmania, to quote Gould, "from sea level to the tops of mountains". Is it extinct? The last Thylacine produced was shot and killed at Mawbanna, on the north-west coast of the island, in 1930. Since then several expeditions have searched for it, the last one in 1945. These expeditions have all concentrated upon the rugged western parts of the State but none has ever brought back a photograph or a specimen, although various footprints of the animal have been found. The best description of these is that of Pocock [5]. It is clear from his figures that, under all but soft conditions, only four claws appear on the impression of each foot but that five will occur on the forefoot in soft mud. An examination of the feet of stuffed specimens confirms this statement. The hind foot under ideal conditions may show a long (six inches or so) tarso-metatarsal pad, but this is rarely found. The last expedition brought back prints from the Jane River area near the west coast and recently footprints have been collected near Hobart [6].

From footprints collected by the expeditions and from other prints collected in 1957, we can assume with some degree of certainty that the Thylacine is not yet extinct. In fact, unconfirmed reports of its presence are becoming more frequent

[3] Gould, J. 1863. The mammals of Australia. Vol.I. Francis & Taylor. London.

[4] Smith, G. 1909. A Naturalist in Tasmania. Clarendon Press. Oxford.

[5] Pocock. 1926. The external characters of *Thylacinus*, *Sarcophilus* and some related marsupials. *Proc. Zool. Soc.* London. 1926, 1037-1084.

[6] Guiler, E. R. & Meldrum, G. K. 1958. Suspected sheep killing by the Thylacine, *Thylacinus cynocephalus*. *Aust. J. Sci.* 20, 7, 1958, 214-15.

but caution must be exercised in interpreting these since the great publicity obtained by such Press reports may have something to do with their frequency.

HABITS

Very little authentic knowledge is available as to the habits of the Thylacine. We know that it eats kangaroo, wallaby and probably the smaller marsupials. It will eat chickens when available and also sheep, but these only when hard pressed for food. It eats only selected parts of its prey and is primarily a blood feeder, sucking blood from the severed jugular vein of its kill. It is known to eat also the vascular nasal tissues, as well as the liver and the kidney fat. It may occasionally eat the meat.

It is known that the Thylacine hunts usually as a solitary animal though sometimes a male and female have been seen together. Apparently, at times the young join the parents in hunts and family units of up to four individuals have been reported. The Thylacine is not a rapid runner but relies on a steady jogging pace to wear down its prey, which it catches in a final spurt of speed and then kills.

While it hunts by night some movement may take place during the day and the animal often moves about at dusk. It has been stated that its vision by day is poor. In spite of this some Thylacines, including those observed by Renshaw[7], who noted this anomaly, bask in the sunlight and other nocturnal marsupials, such as kangaroo and the potoroo, also do this.

During the breeding season in December the Thylacine retires to a den in either a cave or a hollow log and there three or four young are reared at a time.

The noises made by Thylacines are varied. When hunting these animals make a coughing, barking noise, a low growl when irritated (probably as a warning), and a whining noise like that made by a puppy. This latter sound is perhaps used as a method of communication between individuals.

Many improbable stories have been written about the Thylacine. Thus the animal is credited with bipedal locomotion, an inability to swim, tremendous jumping power and great ferocity. The fact that these stories gain credence is additional evidence of the intense, if imaginative, interest in it. Recent discoveries and field work are throwing some light upon the ecology of this interesting species and it is hoped that more useful information about it will be gathered in the future.

[7] Renshaw, G. 1938. The Thylacine. *J. Roy. Soc. Preserv. Fauna Emp.* 35, 1938, 47-9.

Answers to
"TEST YOUR KNOWLEDGE"
(Page 374).

No. 1: Thirteen-inch-high wooden face mask from Sepik River, New Guinea. Features are painted black on yellow; the border between the large outside points is white. Melanesian masks of varying shapes and expressions are used as disguises by adult men and youths in public pageants and sacred ceremonies. They are the work of professional craftsmen who exploit traditional techniques to gain their artistic effects.

No. 2: Some species of Long-horned Grasshoppers frequent gumtrees and will lay flattened scale-like eggs, as pictured, on the edge of a leaf or along a twig.

No. 3: Portrait of Leichhardt, the explorer, believed to have been drawn by Charles Rodius (or Rhodius), an accomplished artist and lithographer who came to Sydney about 1823. The picture in the Museum library is not an original; it could be one of the lithographic reproductions sold in Sydney after Leichhardt's triumphal return from the north in 1846.

No. 4: This beautifully incised paddle blade from Mangaia (Hervey Islands) illustrates the skill of Polynesian carvers. Paddles of this kind are used by men of high status on ceremonial occasions. The paddle is almost 3 feet long, the blade 14 x 8 inches. The shaft bears similar intricate carving on all sides; around the butt is a series of human faces. In the "old days" such carving was done with sharks' teeth. The paddle illustrated is one of the Cook Relics, purchased by the N.S.W. Government in 1893 and now in the Australian Museum.

No. 5: This yellow House Centipede (*Allothereua maculata*), also called "Hairy Nanny" and "Forty Legs", is native to Australia. The first pair of legs beneath a centipede's head is modified to form poison-claws or foot-jaws, which are weapons of offence and defence. Rarely is a human being bitten by a centipede and no fatal cases are known. Centipedes live under stones, logs, amongst rubbish and leaves, usually in damp situations.

Observing Ants in Artificial Nests

By JOHN FREELAND

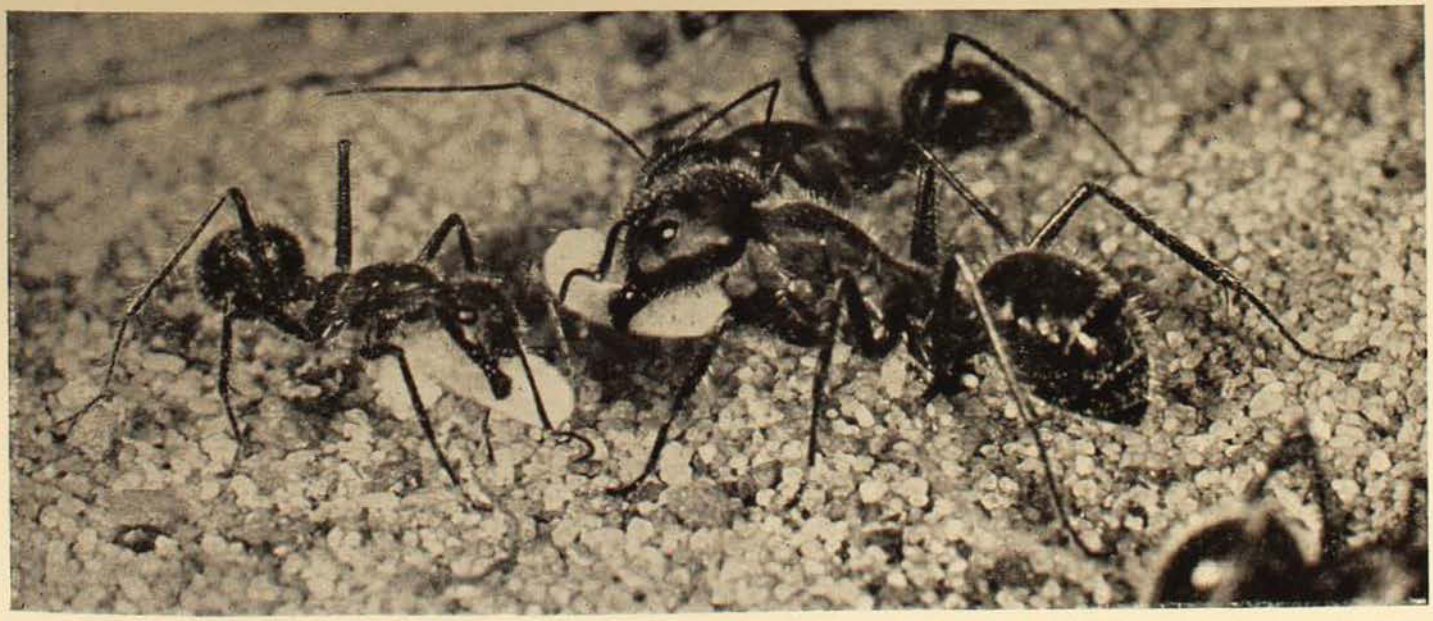
WHEN Solomon instructed the sluggard to gain wisdom by studying the ant, he doubtless visualised the bustling activity and industry of the insect as seen outside its nest. Many of the most interesting features of the social life of ants, however, can be seen only if they are studied in artifical nests. This provides a most rewarding field for the amateur or professional naturalist and one which is ideal for nature study in schools.

Ants constitute the family Formicidae, of the order Hymenoptera, which also includes the bees and wasps and their relatives. So-called "white ants" (termites) are not related but have evolved a social structure in some ways similiar to that of the ants.

Many Australian ants are not yet named and it is not known how many species exist. The smallest estimate is over eight hundred Australian species, so the scope is wide indeed.

Like many other insects the stages of growth in ants consist of egg, larva, pupa and adult. The larvae and pupae are often erroneously called "ant's eggs", but the eggs are very small, in most cases much smaller than a pin's head, and usually escape notice. The larvae are helpless and resemble fly maggots, but are cleaner-looking. When these are fully grown they pupate. In many species they first spin cocoons, aided by workers, which bank earth on the spinning grub thus helping to mould the shape of the envelope. Upon attaining their adult form, the young ants are called "callows" and for a time remain pale in colour. In most of the cocoon-spinning species the callows have to be assisted to "hatch" from the envelope by adults.

A colony normally consists of one or more true females, or "queens", a good many workers, which are under-developed females, and the brood (eggs, larvae and pupae). At certain times of the year,



The sugar ant *Camponotus bellicosus* is more amenable to captivity than the more common *C. consobrinus*. Around Sydney it is more often found in bush than in domestic surroundings. Here workers and a soldier are seen with larvae in an artificial nest. A worker (left) is about five-eighths of an inch long.

Photo.—D. Trengove.

varying with different species, winged males and young queens (also winged) may be found in the nests.

Once or twice a year, again according to the species, generally when there are thunderstorms about, the young queens and males leave the nests and the nuptial flight takes place, several males sometimes and in some species, mating with each queen. Later, the wasp-like males die of starvation, or fall a prey to other animals. The young queens discard their wings and dig or select a small burrow which they seal off from the inside and then begin laying eggs.

When the eggs hatch the queen feeds the larvae with a salivary secretion derived from the fat body stored in her abdomen and from the degenerating wing muscles. She may thus overwinter, taking up to ten months to rear her first few workers, in the meantime not eating unless consuming some of her own eggs or larvae.

Upon maturing, the young workers set about enlarging the nest and foraging, so that the queen may confine herself to egg-laying and occasional licking of the brood.

Workers are typically only able to lay unfertilised eggs. These are nevertheless able to develop, in most cases resulting in males, though in some species, worker-laid unfertilised eggs have produced workers, and even queens. Most of the queen's eggs are fertilised as they are laid, by spermatozoa stored alive in a special sac in her abdomen, but a proportion emerge unfertilised. These develop as males. Workers and queens both appear to grow from the same type of fertilised egg, but relatively few of the larvae receive the diet necessary for full queen development. The majority, instead, are partly castrated by malnutrition and as a result can only become workers or soldiers (large-headed workers).

Queens and males, however, are not produced until a colony has attained a sufficient numerical size and this may take several years. Thereafter the young sexuals are produced regularly while the colonly continues intact. As in captivity, workers have been known to live up to seven years and queens up to fifteen, the life of a colony may be considerable. Furthermore in some species a colony may replace an old queen with a young one by taking one back into the nest after a nuptial flight, but for most ants little is known of such details. With some species, such as the infamous Argentine Ant, there are normally a number of active queens in the one colony.

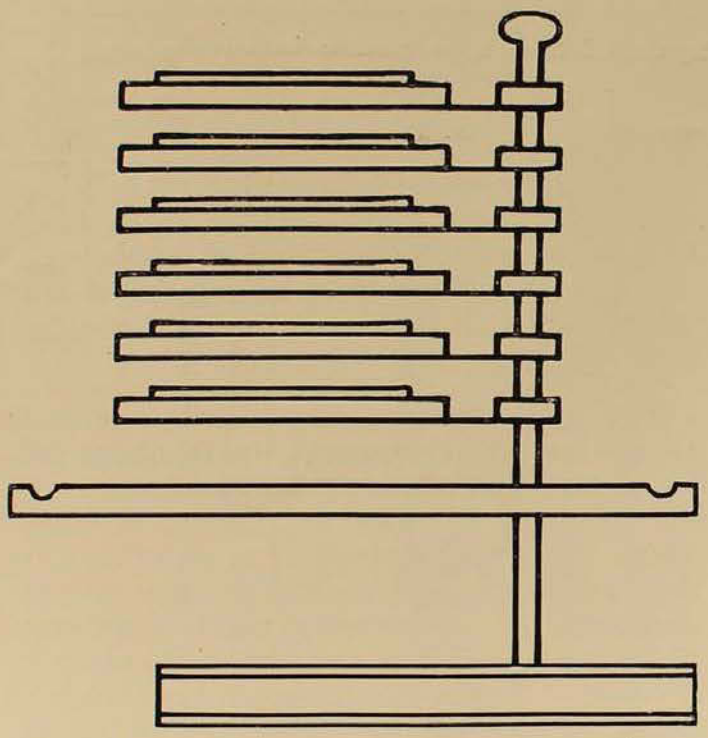
Of particular interest are the various forms of behaviour between individuals within a nest. Ants groom one another and the queen and the brood, carry the young to various parts of the nest, seeking the desirable degree of moisture or warmth and transfer food from one to the other by regurgitation of the contents of the crop or "social stomach". Many ants, however, lack this last habit. It may be observed, for instance, in the "sugar" ants, but not in the "greenheads". The latter appear to feed their brood entirely on insects or other small animals. In fact the above general description of the social structures of ant colonies has more exceptions and variations than can be mentioned here, and in most cases they are unknown in detail. This is one of the reasons why the observation of ants in artificial nests can be so absorbing.

Nest Designs

An intending observer may choose from a number of nest-designs, ranging from those that can be improvised in a few minutes to elaborate ones needed for special experiments. Perhaps the first to use an artificial nest was Swammerdam, who placed some earth in a flat dish and surrounded this with a moat (a strip of wax) hollowed out and filled with water. He described this in his "Biblia Naturae" in 1737.

Glass nests such as were originally used by Huber (1810) may be constructed with a thin rectangular wooden frame from six to twelve inches long, and of similar width. The strips of wood comprising the frame should be up to half-an-inch thick and half-an-inch wide. The frame separates two panes of glass, forming a cavity, in which the ants are to nest. Fine nails, or waterproof glue, hold the frame together, and the panes of glass are, in turn, cemented, to this. A gap of an inch should be

left in the frame near a corner, so that ants and food may be introduced into the nest. The aperture is then plugged with cotton wool wrapped in a piece of nylon stocking. This permits a certain amount of air to enter the nest, the nylon preventing the ants from teasing the wool. Earth or sand can be placed in the cavity if desired. This should be scattered thinly, so that the ants are unable to burrow in it and hide.



This nest has a centre pole fixed to a base. The six nests on their platforms can be swivelled round the pole. The square platform of wood beneath the nests is surrounded by a "moat" of water.

After Lubbock.

Alternatively, if the observer wishes to see these burrows constructed, the wooden strips should be of a thickness consistent with the diameter of the burrows typical of the kind of ant studied, so that no layer of soil adheres to the top pane of glass. An opaque cover of blotting paper, plywood or similiar material, cut to the size of the glass, darkens the nest to simulate underground conditions. This is removed for observations.

Occasionally a few drops of water should be introduced into the nest with an eye-dropper, as the ants require slightly moist conditions. With this kind of nest the ants are not able to emerge to forage, unless the stopper is removed, and the nests placed within the confines of a moat, as was done by Sir John Lubbock.

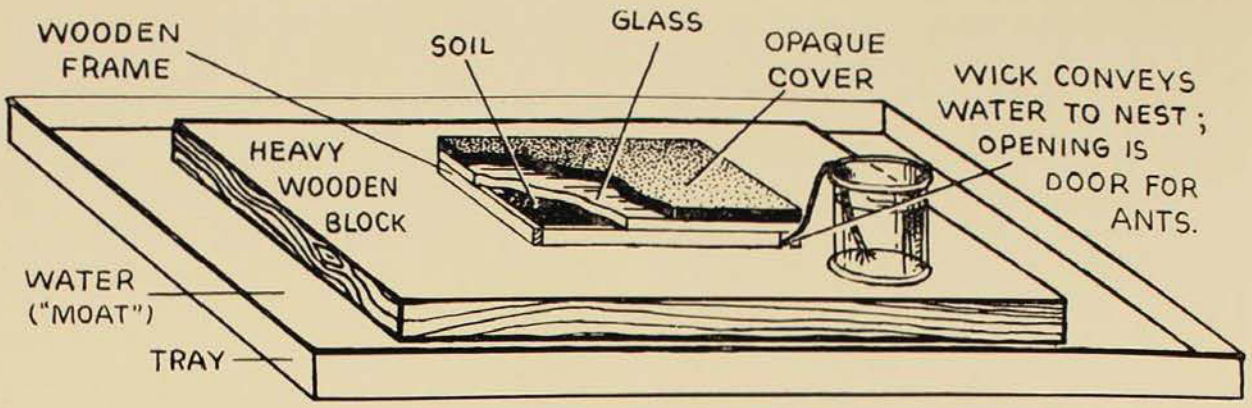
This famous English myrmecologist (as an ant specialist is called) in his book *Ants, Bees and Wasps* (1894) described many interesting observations of ants made by the aid of what has become known as the "Lubbock nest". This consisted of a wooden base, with a vertical pole several feet high supporting a number of platforms, somewhat like the display stands used in cake-shops. The glass nests of Huber rested on the platforms, the ants being permitted to wander all over the stand, but prevented from escaping by a moat hollowed out of the wood near the edge of the base. A good coating of paint prevented the water from penetrating the wood. If well made a nest of this sort does not look amiss indoors.

Instead of a moat some observers have used strips of inverted fur as a fence or formed a barrier with a trench filled with repellent powder. The present author has used a gauze cage attached to a vertical glass and wood cavity nest, like a Huber nest on end, to house the severely stinging "bulldog" ants.

Another successful type of nest was devised by Janet (1897) and made from plaster of Paris. This was moulded with disc-like hollows, joined by passageways, panes of glass being placed over the top of the plaster block. No soil was placed in these nests but the interior was moistened by water seeping through from a separate trough in the plaster. The underneath and exterior of the nest were painted or varnished to prevent seepage from escaping and soiling the table on which the nest was placed. As with Huber nests an opaque cover prevented the admittance of light. Food was introduced by sliding the glass away from a chamber not at the moment containing ants. This part of the nest had no opaque cover and served as a foraging area.

Various nest designs may be found in Wheeler's comprehensive book, "Ants, their Structure, Development and Behaviour" (1910) to which the reader is referred for general information on ants.

More easily improvised nests are found sufficient for some Australian ants and



A nest for "sugar" ants. If "greenheads" are being studied there is no need to include the moat and heavy wooden block as workers and queens cannot climb clean vertical glass.

the beginner is advised to experiment first with these. The choice of nest depends largely upon the kind of ant to be studied.

For some ants, such as the common "greenhead" (*Rhytidoponera metallica*, until recently known as *Chalcoponera metallica*) and its relatives, no moat is needed. This is due to a peculiarity of the feet of the workers and queens. Only the males of these ants can climb clean, vertical glass. Consequently a fence of glass or plastic will retain the workers quite easily, and the workers will prevent the males from leaving in most cases. A large glass or smooth plastic tray or dish, with vertical sides, will do for a formicary. A smaller pane of glass, raised slightly from the floor of the tray by wood strips, covers a thin layer of soil wherein the ants may nest. An opaque cover, the same size as the glass, completes the nest.

Sugar ants (*Camponotus consobrinus* and their relatives) can climb these fences, however, and it is necessary to form an island with a piece of heavy wood upon which is fixed a glass pane as for "greenheads". This improvised moat will do quite well.

Hints for Beginners

Greenheads and sugar ants, which abound in most parts of Australia, are among the most easily studied ants for the beginner. The greenhead is about a quarter to three-eighths of an inch long and has a pitted irridescent body surface which varies from green to purple according to the age of the ant and the way the light is reflected. It is very beautiful when viewed in good light through a hand lens. This is the ant usually responsible for the stings one experiences when sitting on a lawn. It may be quite safely picked up between the fingertips, however, as can most ants other than bull-ants and one or two other large forms.

The most common sugar ants are those orange and black insects up to about five-eighths of an inch long which wander into the kitchen, in ones and twos, at night. These are quite devoid of a sting and, as they are large and do not forage in large numbers, do not usually make a nuisance of themselves. They probably help clean up a house. There are many other kinds of sugar ants, varying considerably in size and colour.

Collecting

The requirements for collecting are quite simple:

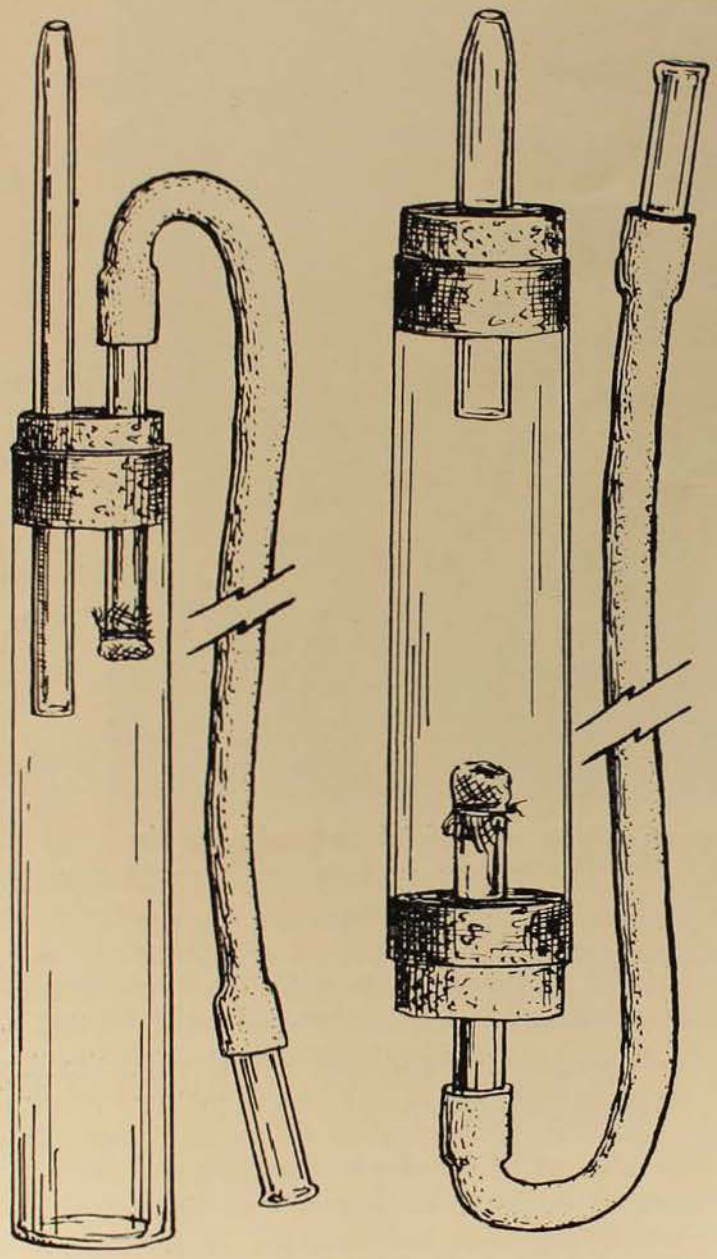
A trowel or broad chisel, for digging up the nest.

A pair of lightly sprung forceps for collecting ants.

A spoon for picking up brood.

Empty soft-drink bottles for holding the ants; the narrow necks make it difficult for them to escape whilst others are being added. A stopper or piece of cotton wool is placed in the top.

Nests may be located almost anywhere but some sites provide easier excavating than others. Loose soil is generally the best. The turning over of surface stones often yields ants without much digging. Soil, ants and brood may be taken quickly with the trowel and tipped straight into a



Small ants may be collected with a home-made "vacuum sucker."

bottle, though this method seldom nets the queen. A queenless colony is generally interesting enough and enables the beginner to get some initial experience. More patient digging is usually required to obtain the queen, unless one is lucky enough to see her immediately after turning over a stone, but in some species she differs in appearance so little from the workers that she is easily overlooked. This applies to the greenheads but greenhead workers can fully assume the queen functions. In the sugar ants she is larger than the workers or soldiers and has an enlarged abdomen and thicker thorax.

The "Kitchen Midden"

As many brood as possible should be collected as these are not only potential ants but also because without them the adults are not nearly so interesting. One should also look for the "kitchen midden" particularly in the case of the greenheads. This consists of a refuse heap of the parts of insects and harbours the "ant guests" and parasites. These are a medley of tiny beetles, silverfish, roaches and the like which feed on the leavings of the ants. In some instances they are tended by the ants, being groomed and fed, in others they are merely tolerated and in others, again, are hunted and rely on agility to escape. As not a great deal is known about their relationships with Australian ants the collector should shovel up the kitchen midden as well as the ants.

Naturally experience helps and a few attempts may be necessary before a sizeable population of ants is collected. Collecting is easier in winter when the ants are less active. Small ants may be collected by means of a home-made "vacuum sucker" (see illustration) and discharged directly from this into the artificial nest.

Introducing Ants to the Nest

The collected ants, with brood, and any soil taken with them, may be tipped into the prepared foraging area, perhaps on the opaque cover which hides the actual nest. The ants will seek a dark, slightly moist place for the brood and the only such place is the nest cavity provided. The loose unwanted soil may be gradually removed from the area as the ants disappear into the nest. The process of settling down is speeded up by leaving a pre-formed chamber in the nest-soil. This induces the ants to begin storing brood at once.

A small but continuous supply of moisture is needed in the nest. This may be introduced daily, with a pipette, but the wick system is better. A tape or string extends from a small jar in the foraging area conveying water into the nest proper. If the soil is unevenly dampened so much the better as this permits the ants to select the most satisfactory place for their brood.

A greenhead worker ant moving a cocoon across soil in an artificial nest. In life the total body length of this ant (*Rhytidoponera metallica*) would be about a quarter of an inch.

Photo.—D. Trengove.

The observer should experiment with a variety of foodstuffs. Greenheads will occasionally take diluted honey and grass seeds but they seem to subsist mainly on insects. Other kinds of ants, or insects such as house-flies, should be killed and then placed in a dish for the workers to find. Greenheads do not forage in columns and appear to have poor eyesight and perhaps even a limited sense of smell. They appear to have to blunder into food before finding it, but these are the very things about which more information is needed for most kinds of ants. Sugar ants are more adaptable and will eat almost anything. Experimentation in these and other matters is very desirable.

Observations

Observations upon ants in the field should be combined with those made with the artificial nest, which should not be placed in direct sunlight. Notes should be made, including the date and time of day of an observation and as much background information as possible. For instance, ants behave differently in different weather and these weather conditions should be noted.

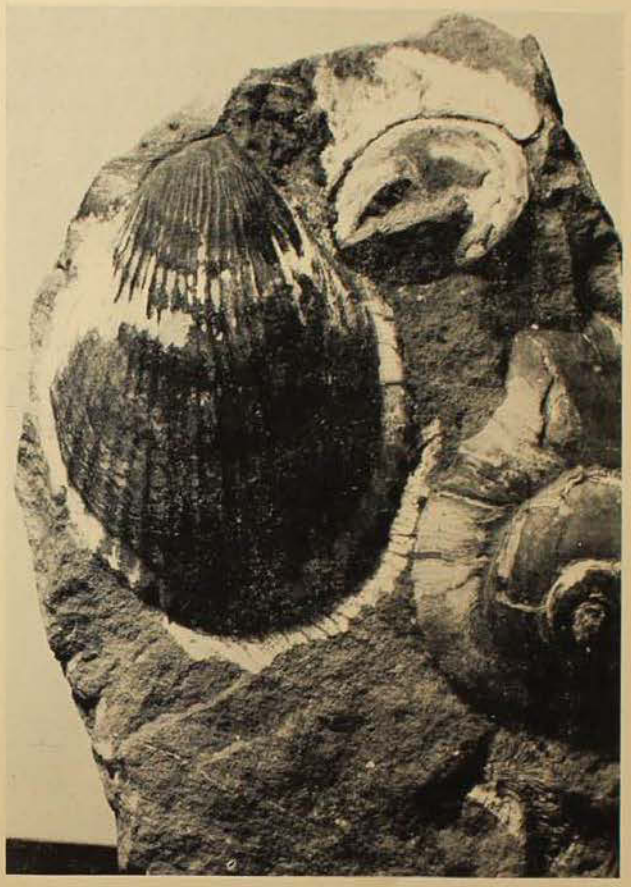
When reporting information to the Australian Museum or any other research centre it is desirable to submit specimens of the ants studied, preferably from the actual colony, so that there is no doubt as to the species concerned. This is because the classification of ants is a task for the expert and many superficially similiar kinds belong to different genera or even subfamilies.

Here is an opportunity for the layman to contribute to scientific knowledge. All that is needed is a capacity for accurate observation and reporting. Avoid extravagant explanations. Simply tell what you see and a useful hobby will be the result.

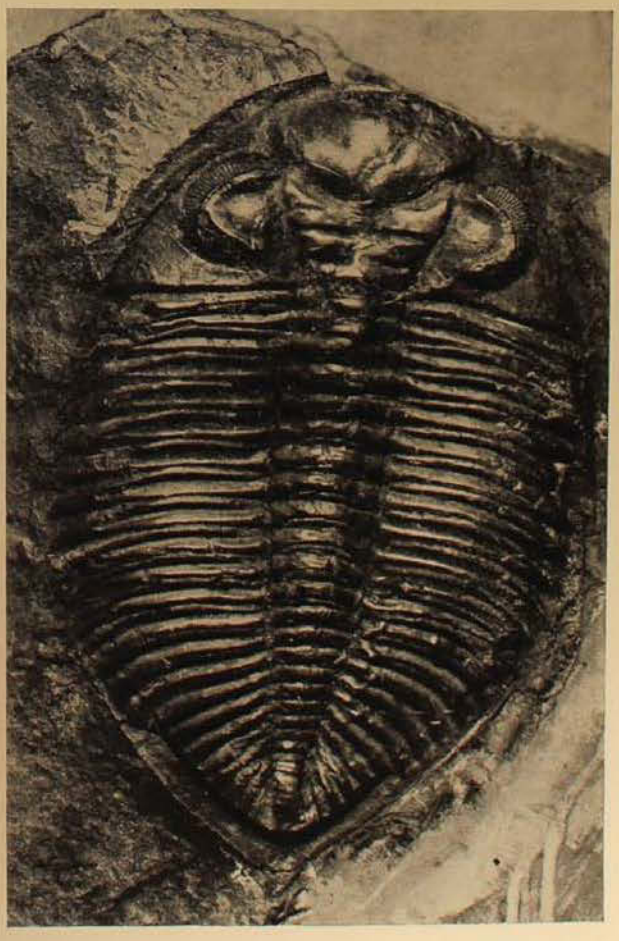
John Freeland is a professional musician (2nd flautist in the Sydney Symphony Orchestra) who is also a devoted myrmecologist. He describes himself as a "naturalist by temperament," has studied ants for about six years, is particularly interested in animal behaviour and has recently had a paper published in *The Australian Journal of Zoology* on "Biological and social patterns in Australian Bulldog Ants." He has an open mind on whether he will continue his observations of ants or change to another group, but thinks his studies may lead him eventually to a concentration on comparative psychology.

Top.—A fossil bivalve shell (*Aviculopecten*) and two univalves (*Keeneia*) from the famous fossil horizon at Harper's Hill in the Hunter River Valley. These shells are restricted to rocks of Permian age.

Bottom.—A trilobite, *Odontochile loomesi* (Mitchell), from rocks of Upper Silurian age near Bowning, N.S.W. The many lenses of the eyes are well preserved.



Photos.—H. Hughes.



Fossils and their Value in Stratigraphy

By H. O. FLETCHER

THE exposed rocks on the earth's surface consist of igneous, metamorphic and sedimentary rocks. The latter group is the most important to the stratigrapher as it is from the fossil life assemblages found preserved in these sediments that the geological ages of rocks are determined. Sedimentary rocks are mainly stratified and are derived from pre-existing rocks. Their origin and structure are due mostly to the mechanical action of water. The great limestone formations of the world have been largely built up by the gradual accumulation of invertebrate animal remains and although unstratified are recognised as sedimentary rocks. They are in most cases richly fossiliferous.

Traces of fossil life would naturally not be found in igneous rocks which solidify from molten material and originate in the depths of the earth. These rocks include volcanic rocks which are formed when molten material is forced to the surface and escapes through volcanic vents as lava.

When a volcano is in eruption a great deal of rock material is thrown out and deposits of considerable extent and thickness are formed. The larger fragments become consolidated to form breccias while the finer particles, which travel much further, are deposited as tuffs. Any plant or

animal entombed in a fluid lava is immediately destroyed and assimilated, whereas animals and plants are frequently preserved in breccia and ash or tuff deposits. Volcanic ash may be deposited in lakes or in the sea and it is then subjected to the action of water before consolidation and is not only stratified but contains the remains of organisms killed by the polluting of the water.

Tuffaceous deposits are not uncommon to the geological succession in all parts of the world. One of many examples in New South Wales is found in the Permian rocks of the Hunter River Valley, where the Allandale Formation, at Allandale, consists of 460 feet of strata, including andesitic tuff and tuffaceous sandstone. These tuffs contain a rich and varied fossil fauna with most of the specimens beautifully preserved and revealing even the most delicate structures and ornamentation. This is a feature of most tuffaceous rocks as in every instance the animal life has been quickly and effectively buried under considerable thicknesses of volcanic ash.

Metamorphic rocks are both igneous and sedimentary rocks which have been altered by heat or pressure. All degrees of alteration are found and in extreme cases the original character of the rock and any contained fossils are destroyed. The geological age of the unfossiliferous igneous and metamorphic rocks is in most cases readily determined by their field relationship and association with fossiliferous sedimentary strata of a known age.

Sediments of marine origin and of different geological ages occur over extensive parts of Australia and other continents. These exposures, which at times cover very large areas, represent ancient sea-floors and prove that continental masses in the past have not always been stable, but at different times in their geological history have been covered or partly covered by the sea.

Most sediments were originally deposited on approximately horizontal planes in former lakes, on the bottom of the ocean, or even as terrestrial accumulations. If deposited on a slowly sinking sea-floor considerable thicknesses of sediments can be built up until such time as earth movements of great magnitude raise them high above sea-level to form new continental masses or adjuncts of older ones. When examined to-day many sedimentary strata are found to be tilted or dipping steeply at different angles, clearly proving that since deposition and hardening into solid rock they have been subjected to vast pressure by earth movements. Earth movements of world-wide influence and importance have usually marked the closing of past geological ages.

The continents of the earth as we know them to-day bear little resemblance to their size, height and outline in past geological ages. Since the world was formed more than 3,000 million years ago, their appearance has been ever-changing. Forces of erosion have been actively and unceasingly at work denuding the continents and lowering the high lands to peneplain surfaces. The weathered material or detritus, which to-day is being derived from 60 million square miles of land surface, is transported, mainly by rivers, out to sea, where it is spread over large areas. The sea itself has been constantly breaking down the coastline and enroaching on the continents.

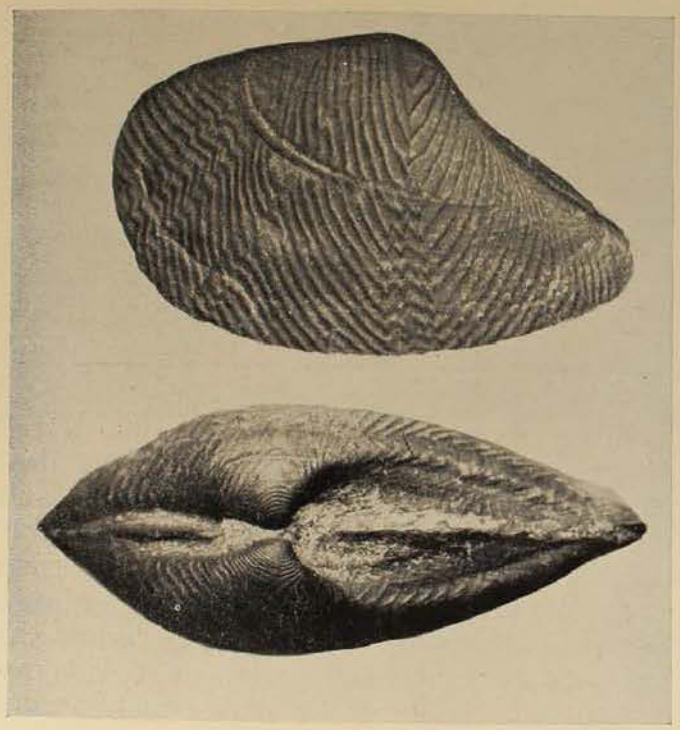
Large rivers, with vast drainage areas, each year carry millions of cubic feet of detritus from the continents to the surrounding seas. This weathered material is sorted, as the impelling force of the river decreases, into layers of large pebbles, then small pebbles, followed by sand and mud. These layers are later consolidated to form consecutively varying types of conglomerates, sandstones, silts and shales.

This relentless process of denudation, deposition, hardening of sediments, their uplift to form new land surfaces, and the sinking of denuded land below the sea, has been a feature in all parts of the world throughout geological history.

Sedimentary rocks of all geological ages are exposed at different places on most of the continents of today, and their age may be determined by the fossil life enclosed in them while being deposited as offshore sediments.

Fossils are the remains or traces of animals and plants which lived in the past and for the most part are now extinct.

The oldest known fossils of use in stratigraphy are found in sediments originally deposited in seas of the Cambrian geological period about 500 million years ago. Obscure traces of life have been recorded from the younger Pre-Cambrian rocks, 825 million years ago, but it is not until Lower Cambrian times that an amazing abundance and variety of invertebrate life are found. These forms possess such a complexity of structure that it is obvious they were derived from earlier ancestral



A beautifully ornamented fossil shell of the genus *Glyptoleda*, from Permian rocks in Queensland. The genus is also known from rocks of the same age in Western Australia.

Photo.—H. Hughes.

stocks. Most Pre-Cambrian sedimentary rocks, however, have been metamorphosed (altered) by heat and pressure to such an extent that any contained fossils have been entirely destroyed or are unrecognisable.

Most of the great invertebrate groups (animals without backbones) are represented in Cambrian rocks, including primitive corals, lamp-shells, worms, sponges, univalve shells, crinoids, cephalopods and trilobites.

A study of the complete fossil record found in geological history proves without doubt that modern living animals have been derived from more primitive ancestors. The fauna of the oldest rocks is represented by animals without backbones, then as we proceed progressively into the younger rocks we encounter the fossil remains of fishes, amphibians, reptiles, birds, mammals and finally man himself. By studying fossil life it is possible to trace the gradual evolution of complexity in body structures, from primitive early types to highly specialised descendants which appeared millions of years later. By such study it has been shown that all stages or periods of geological time are characterised by distinctive assemblages of animals and plants. The easily recognised and interesting group of trilobites is an excellent example of how fossils are of value in determining the age of the rocks in which they are found and in the correlation of local, continental and intercontinental rocks.

Trilobites are an extinct group of exclusively Palaeozoic arthropods and thus any rock in which they are found must have been deposited during Palaeozoic times. Trilobites first appeared in Cambrian seas and, during the 70 million years time of that period, increased in numbers and spread to such an extent that they became the most dominant organisms in the seas in all parts of the world. Forms increased in number, gradually became specialised and radiated into a variety of habitats where still further changes took place in their structure and appearance. The trilobites persisted into the succeeding Ordovician and Silurian periods with only a slight dimunition in numbers and types, but they rapidly declined in Devonian and Carboniferous times. The last lingering survivors became extinct in early Permian times, just before the close of the Palaeozoic Era.

During the life history of the trilobites many genera and species which could not withstand environmental changes, or which became over-specialised, became extinct. Their fossil remains are therefore found only in the zone of sediments laid down during their time of life in any particular geological age. These are "index" or "marker" fossils and the rocks (usually with no great

vertical extent) in which they occur in any part of the world can be correlated and are obviously of the same geological age.

It can be seen that by observing the order of superposition of the sedimentary rocks, and studying the contained fossil life, geologists have been able to establish a time sequence of the past. The sequence, although never complete in any one area, is everywhere the same in its general order of succession.

The time sequence is divided into four large divisions or eras known as the Pre-Cambrian, Palaeozoic, Mesozoic and the Cainozoic, the last named embracing the younger rocks and those of the present-day. These eras, which represent a total time duration of 3,000 million years, are divided into Periods, Groups, Formations and Zones, each of which contains a diminishing vertical extent of rock strata. Zones are usually characterised by a particular "index" fossil.

The Cambrian system of rocks outcropping over a very large area of north-west Queensland and the eastern part of the Northern Territory, has been found to contain a great variety of trilobites. When these were correctly identified they were found to be very similiar to others recorded from America and Europe. Correlations have been made and it has been proved that the Australian sequence ranges from near the top of the Lower Cambrian to the Upper Cambrian, and that a large part of the Lower Cambrian strata is missing.

It must be remembered that the trilobites have been used only as an example of the value of fossils in stratigraphy. The same value applies to almost every group of animals found in the fossil record. Fossils associated with the trilobites in the Cambrian rocks of north-west Queensland and the Northern Territory include an abundance of echinoderms, brachiopods, sponges, gastropods and cephalopods.

In most places only exposed outcrops of rocks can be examined and the hundreds of millions of fossils which obviously must be entombed in the underlying strata remain undisturbed as we have little or no access to them. When a sequence of rocks is horizontal in position fossils can be collected from successive strata exposed in deeply eroded valleys. A most striking example is the Grand Canyon in the United States of America, where the Colorado River has cut a cross-section through the earth's surface, 65 miles long and in places a mile deep. In most cases, however, a search for fossils is restricted to rail and road cuttings, quarries and, of course, surface exposures.

Bore-cores from diamond drilling have frequently brought fossils to the surface from depths up to 6,000 feet and more. Some years ago a bore was sunk in the middle of the Sydney Basin at Kulnura, west of Gosford, New South Wales. It reached a depth of 6,279 feet, passing through successive sediments of the Triassic and Permian periods. At a depth of about 6,000 feet fragments of a distinctive type of brachiopod shell were found in the core which enabled the age of the sediments at that depth to be determined.

When rock strata have been subjected to great earth movements a great deal of displacement and tilting results and under these circumstances it is possible to have exposed on the surface a succession of steeply dipping strata. By determining the direction of the dip one can follow the succession and obtain series of fossils representing a time-span of millions of years.

The first essential in any search for fossils is to select rocks which are stratified or are a limestone. When this is established a search should be made for signs or traces of fossil life on the exposed and weathered surface. If present, well preserved and complete specimens may be found when the rock is broken open or split with a geological hammer. If an outcrop shows no sign of fossil life on the weathered surface or freshly broken faces, then it is possibly unfossiliferous and a search should be made elsewhere.

How Fossils are Preserved

In order to be fossilised an animal or plant must be buried at the time of death or very soon afterwards, since otherwise it will suffer damage or may disintegrate and be completely destroyed. Animals

Searching for vertebrate fossil remains in an excavation at Cuddie Springs, New South Wales. At a depth of eight feet the remains of extinct marsupials and a large bird were collected. The extinct bird, *Genyornis*, was about twice as large as an emu.

Photo.—G. C. Clulton.

with hard parts such as shells, the skeletons of mammals, and the hard protective covering of crustaceans, have better chances of fossilisation than soft-bodied creatures. Nevertheless, even in some of the most ancient rocks impressions of jelly-fish and other soft bodied creatures have been preserved in considerable detail.

Rapid burial of marine and freshwater organisms is accomplished when, after death, they fall into constantly shifting soft sand or mud which is always accumulating on sea, lake or river beds.

When an organism is quickly entombed the soft mud or sand fills any cavities in the animal and becomes tightly packed. The pressure of the surrounding material at the same time causes it to adhere closely to the exterior of the animal. Thus, in time, as the soft sediments harden to form rock, two parts are formed, a cast or "kernel" and a mould or impression. The cast reveals internal structures such as the muscle scars and hinge features of bivalve shells, while the mould shows ornamentation and other external characters.

In some cases the original shell or hard parts of an animal, particularly if preserved in a porous rock, may be completely dissolved by solutions or replaced by a mineral substance. Replacement is so gradual that even the most minute characters are preserved and thin sections when cut for examination under a microscope then show even the smallest structures.

It is not unusual to find the remains of plants and terrestrial animals associated with marine and freshwater fossils. Thus, in Cretaceous rocks in Queensland a large log has been found completely riddled with holes made by the "Shipworm" and, still containing the fossilised small valves of its shells; proof that the log, swept by floods from a nearby land area, was floating for a long time before it became waterlogged and sank into the mud of the sea-floor where it was preserved together with the marine life of that time.

Mixed assemblages of fossils are frequently found in shale deposits originally laid down as silt on ancient lake beds. Shale quarried from brick-pits of the Sydney district represents material which was accumulating on lake beds in Triassic times about 180 million years ago. The life of that time, entombed during deposition of the silt, is now found fossilised during quarrying operations.

At Beacon Hill quarry, near Brookvale, Sydney, an abundance and variety of freshwater fishes have been collected which are of great interest. Other fossil life in the same exposure includes crustaceans, freshwater bivalves, plants, insects and the remains of primitive amphibians known as labyrinthodonts.

In exceptional instances organisms may be preserved as fossils with very little or no change. Many types of insects which lived in early Oligocene times, about 38 million years ago, have been found in the fossil state embedded in amber collected along the Baltic coast. Drips of gummy resin dropped from the Oligocene coniferous forests of that area frequently trapped a variety of small insects. The resin, in time, became hard amber and the entombed creatures are so well preserved that on some spiders even the minute hairs on the legs and silken threads leading back to the spinning tubes, are easily seen.

Fossil carcases of extinct mammoths and mastodons exposed by the gradual thawing of the frozen gravels of Siberia have also been preserved with no change. These fossils, preserved in a natural "deep freeze" are still covered with hair and in some cases wolves have eaten some of the flesh before news of the fossils' occurrence was brought to the attention of scientific institutions. It is recorded that at least one scientist ate several steaks from a fossil carcase and suffered no ill effects.

Impressions of footprints, tracks and trails, are recognised as fossils even though the animals which made them are unknown. Usually they are found on the shores of lakes and seas and include the trails of marine-worms, crabs and similar organisms. Trails made by the extinct group of trilobites, 500 million years ago, are found preserved on the flat surfaces of Cambrian rocks in the Northern Territory and other parts of the world.

The footprints of birds, mammals and reptiles are not uncommon and much information has been obtained from them concerning the stride of various creatures. In the Pre-Cambrian rocks of the Northern Territory and Western Australia, fossil raindrops indicating a shower of rain and ripple marks left by a retreating tide, are found perfectly preserved and indicate events which took place at least 1,000 million years ago.

It is most interesting and not difficult to visualise the conditions in the past which made possible the geological events explained in this article. We are living today in part of a geological period and it is possible to observe the same agencies of erosion at work just as they have been during past geological eras. The same cycle of events continues unceasingly and the pattern is always essentially the same. Continents are lowered by erosion, the weathered material is transported offshore by various means where it accumulates to form great thicknesses of sediments, later to form parts of new land surfaces. When circumstances permit the dying fauna and flora is buried, to become in time the fossils of the future.

THE HALLSTROM THEATRE

Sir Edward Hallstrom has most generously met the cost of remodelling the Australian Museum lecture theatre. Those attending lectures and classes in the hall will shortly have the benefits of better acoustics and lighting and generally more up-to-date and comfortable surroundings.

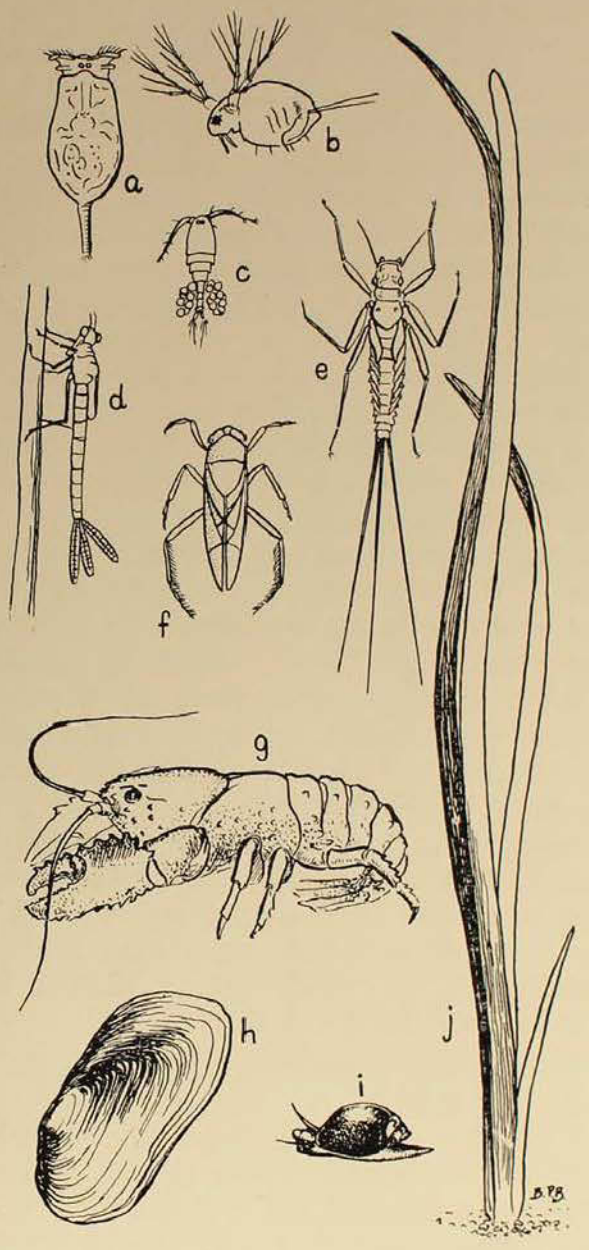
In recognition of Sir Edward Hallstrom's practical interest in the Museum the Trustees have named the theatre after him and a plaque will commemorate this and the date of the opening function.

The Freshwater Aquarium

By DONALD F. McMICHAEL

ANYONE interested in nature study can learn a great deal and get much pleasure as well, from a simple indoor aquarium, which is one of the easiest ways of bringing nature indoors. There is a large variety of freshwater plants and animals everywhere, even in the waterholes and temporary pools of the drier parts of our continent, which can be kept alive with, as a rule, very little trouble. An aquarium is especially useful for learning something of the ecology of freshwater animals—how the various animals and plants reach a balance of numbers; how they breed and develop; what they feed on and where they live.

To start with, take a watertight container, preferably of glass or clear plastic so that one can look through it and see just what is happening below the surface. Large fruit preserving jars will do, and one scientist I know uses plastic dishes made for keeping vegetables in the refrigerator ("crispers") which have a loose fitting lid, are shallow but fairly large, and comparatively unbreakable. Better still, buy a proper aquarium with clear glass sides set in a metal frame. It is important that there should be a fairly large surface area of water (compared to the depth) which will allow the maximum amount of oxygen to dissolve in the water. All the animals will require oxygen and unless an aerator is used the supply will have to be maintained by the green plants which absorb carbon dioxide and give off oxygen, and by diffusion of dissolved oxygen from the water surface. However, an aerator is much more efficient and several kinds of small, electrically operated airpumps can be bought for a few pounds. To achieve efficient aeration, a stream of very small bubbles is best, and this can be produced by attaching a piece of pumice, or sponge



a. Rotifer. *b*. Water Flea.

c. Copepod. *d*. Damsel Fly larva.

e. May Fly larva. *f*. Backswimmer.

g. Crayfish. *h*. Freshwater Mussel.

i. Pond Snail.

j. Eel-grass (*Vallisneria*) is a useful aquatic plant in an aquarium.

rubber, or even a plug of cotton wool to the air-supply tube, but be sure to keep this clean.

Having got the equipment together, let's think about the contents. Sand and water are needed first. A little sand in the bottom of the tank is necessary for burrowing animals and for rooting aquatic plants; a few small hard stones or rocks (sandstone is very good) are useful as they provide shelter for many of the smaller animals which like to hide away during the day. Used washed river sand and stones obtained from a creek if possible; seashore sand should never be used unless it is thoroughly washed. A few inches in the bottom should be sufficient. The source of the water used can be very important. If it is too acid, some animals, especially pond snails, will not survive, while others cannot tolerate alkaline conditions. If possible use clean pond water, which is usually slightly alkaline, and filter it through coarse cloth before using, to remove the larger particles of debris. Swamp water tends to be slightly acid but will do if a swamp is the main source of your plants and animals. Tank water is satisfactory, but be careful in using tap water from a town supply as it may have been heavily chlorinated, in which case it should be left to stand for a few days.

Next obtain some aquatic plants, especially the common water weed *Elodea* or *Philotria*, or the Eel-Grass *Vallisneria*, complete with roots which can be pushed firmly into the sand and will quickly establish themselves. Other aquatic plants will do just as well, but be careful of the water lilies and the small floating fern *Azolla*, both of which will cover the water surface and to a large extent cut off the supply of oxygen. Now the aquarium is ready for the addition of some animals.

The smaller animals (the microfauna) will soon become established, living in the slime which will develop on the leaves of plants, on the sides of the tank and on the rocks and stones. Algae will also appear quickly, especially the unicellular diatoms and desmids and the filamentous greens. Do not let the aquarium become too densely coated with algae, for they will obscure the glass and soon take over the whole tank. Scrapings of the algal slime will usually repay study under the microscope, as there will probably be various kinds of protozoa, nematode worms, rotifers and other small creatures.

When adding the larger animals, aim towards establishing a balanced aquarium which will keep itself going without the addition of artificial foods and without one species becoming too numerous. Thus it is wise to simulate the conditions of the pond or pool from which the animals come. Make sure plenty of herbivorous animals are added, such as the larvae of mayflies and stoneflies, snails, tadpoles, small crustaceans like the copepods and *Daphnia* (water fleas), not forgetting a freshwater mussel or two, or else some of the smaller freshwater bivalves (*Corbiculina* and *Sphaerium*). Herbivores tend to be numerous, and small in size, thus providing food for the larger carnivores. The bivalve molluscs will filter the water and help to keep it clean.

Next add the carnivores, like dragon-fly larvae, crayfish, freshwater shrimps, and some of the water bugs and beetles. If there are too many carnivores, they will eat all the herbivores, so keep their numbers low and provide hiding places for the herbivores (like the undersides of flat rocks). It is best not to introduce fishes into an aquarium if the other animals are to be studied, for fishes will soon consume all the small insects and need a constant fresh food supply. If fishes are kept, then a supply of mosquito larvae, *Daphnia*, and mayfly larvae must be maintained and a few larvae added each day. Remember that larval insects eventually turn into adults and will fly away, and that tadpoles turn into frogs. To enable these animals to metamorphose to adults, it is a good idea to have a stick or twig in the aquarium which projects above the water surface, so that the larvae can climb to the surface prior to emerging as adults.

Once the aquarium is established one can start to study the animals living in it, watching them eating and moving about, and noting the times at which they are most active. If eggs of freshwater animals are found try and breed them right

through to the adult stage, keeping careful notes on their development and preserving samples of the various life stages. In this way an observer may contribute something to our knowledge of the life cycle of many freshwater animals. If the animals are insects, some sort of net or cage must be placed around the aquarium when the adults are about to emerge. By careful observation of the larvae and pupae, the appropriate time of emergence can be anticipated.

As a final reminder, let me stress the importance of keeping the aquarium clean. Some animals live best in dirty, polluted water, but the great majority require clean, fresh, water and will die if the tank becomes foul with algae or decaying animals. Watch out for the larger dead animals and remove them quickly. The smaller animals will be attacked by bacteria when they die, and will cause no harm. Clean waste matter from the tank at least once a week if it is accumulating, and replace the water now and then. Do not use copper pipes or instruments in an aquarium as copper compounds are poisonous to some animals. Keep dirty hands and food scraps out of the tank, too. Finally, avoid placing the aquarium in direct sunlight, for this will cause the filamentous algae to develop very quickly and they will soon take over the whole tank. Choose a cool, shaded place where there is adequate but not excessive light, and your aquarium will become an easy-to-keep attraction which will give a great deal of pleasure and teach you much about the fascinating plants and animals which live in our ponds and streams.

Nesting Seasons of Australian Birds

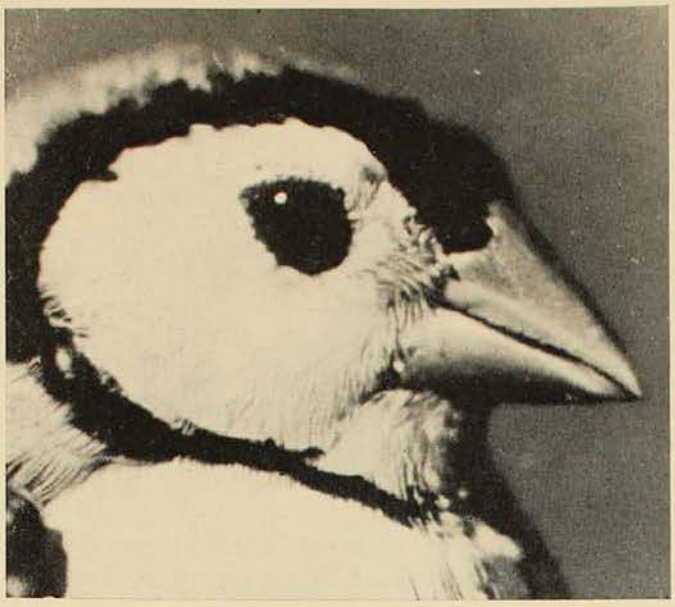
By ALLEN KEAST

BIRDS have a somewhat stereotyped annual cycle of behaviour that includes a period of reproduction (typically in the spring), a post-breeding moult, outward migration in the autumn (in those species that are migrants), gregariousness in winter (in many species), return migration and, in some species, a prenuptial moult.

Breeding in itself involves a very regular chain of events that starts off with the spring song of the males, selection and defence of a future nesting territory, pair formation, chosing of the actual nest-site, nest-building, incubation of the eggs, and feeding of the young. Breeding takes a couple of months or more, and it is sometimes followed, later in spring, by a second or possibly even a third, brood.

It is only in the last couple of decades, as our knowledge of birds has increased, that we have come to appreciate the full import of these aspects of bird behaviour. Breeding in the spring is no accident for that is the time when the weather is warming up and there is a maximum amount of food available. Autumn is the ideal time for the moult (which, in that it involves the replacement of all feathers, must be a great physiological strain), for the weather is yet warm, the birds are freed from the duties of reproduction, and a warm coat is assured before winter. Migration serves to take the population away from a place of deteriorating climate or food supplies to one where these are assured. The prenuptial moult produces, in various species, the temporary gaudy plumes used in courtship.

The significant feature of the annual cycle of birds is that all members of the group behave in the same way at the same time. Their behaviour is instinctive: they act under a sort of compulsion. This is in contrast, of course, to the relative freedom



The Black-rumped Double-bar of the north-west (*Steganopleura bichenovii annulosa*) nests when seed is abundant, frequently in autumn.

of action enjoyed by ourselves. But how, biologists asked, does the individual bird know when to commence each of these varied activities at the appropriate time. And, above all, how does it come about that all members of the group are similarly affected, obvious though it may be that this is very desirable?

The answer came, at least in part, in 1929 as a result of the brilliant work of William Rowan, who proved that breeding and migration could be induced by artificially altering the day-length of captive birds to one corresponding to the time of year when these functions normally occurred. Subsequent research confirmed the link between changing day-length and successive stages in the bird's annual cycle and left little doubt that the mechanism is as follows. In spring, the days are growing steadily longer. Somewhere along the line day-lengths are reached that register in a bird's brain—tripping the switch, so to speak, that causes the pituitary gland to secrete the hormones that lead to the development of the reproductive organs and the inititation of the whole string of events that lead to the successful rearing of young. This may seem a cold scientific explanation. It is, none the less, a true assessment of what really happens in nature; a benevolent environment "triggers" different kinds of behaviour and it does so in all members of the group at once. Later experiments have shown that migration and moulting have similar controls. One should not, however, oversimplify as there are many things interacting at once and the processes are much more complicated than the early experimenters appreciated.

Breeding, next to eating and protection, is obviously the most important aspect of a bird's life. It is essential that a success be made of it or the species will become extinct. Not always is the spring a time of luxuriant growth and abundant food. Large sections of the world are desert, or of uncertain rainfall. If birds tried to breed in the spring in these places tragedy would almost certainly result. Hence, rainfall, not day-length must initiate breeding in such areas. The day-length hypothesis cannot, as was thought, have universal application and John R. Baker pointed this out in 1938. It was not until the end of the last war that this matter could be thoroughly studied. Recent work in Africa and particularly Australia, has now completely altered our thought on factors controlling the annual cycle of birds. There is currently a great upsurge of interest in the problem and a whole range of interesting information is coming to light. It reveals that birds have evolved, in Australia,

The Plumed Tree Duck (*Dendrocygna eytoni*) is a nomad; it enters "the Centre" in good seasons and breeds when water is plentiful and herbage lush.

Photos.—Author.

many remarkable ways of adjusting themselves to an environment that is fundamentally different from the classic climate of Europe and North America.

Australia is unique in that it has a fertile periphery and a large, arid centre. As one travels inland from the fertile east coast the 25-inch line of average annual rainfall is reached after a mere 100 to 150 miles, the 15-inch line at about 350 miles, and the 10-inch line (whence conditions can be described as arid) at about 500 miles. Accompanying this is a rapid falling off in the reliability of the rainfall. Reliability (or variability as it is also called) is calculated for each district from the rainfall figures over a fixed period (say 10 years). First of all the average is obtained, then the deviation of each year's figures from this average is calculated. The mean of these deviations, expressed as a percentage of the average rainfall figure, gives "reliability". The higher the figure the more unreliable the rainfall. Thus, at Sydney the rainfall is relatively regular (reliability of 20 per cent.), but it is less so at Bourke (35 per cent.), and is only 50 per cent. reliable at Birdsville. In these latter areas it is virtually a "toss-up" as to whether the spring will be fertile or barren. The spring of 1957 came into the latter category and a field trip by the writer and Mr. R. Mackay, an Australian Museum preparator, showed that only a couple of bird species that normally breed at the end of winter had been able to breed in the spring. Notwithstanding that it was early November, when all the insectivorous birds should have had young on the wing, none had nested. Discretion had been the better part of valour. In some way not understood (but presumably occasioned by food shortages) the harsh conditions had cancelled out nest-building instincts, for any young hatched would certainly have died.

One can best generalize about the breeding seasons of Australian birds by dividing the continent into a series of zones:

(*a*) *East and south-east*: Here there is normally a good winter fall of rain and another fall in late summer. Accordingly, conditions are normally quite fertile. In this section of the continent birds nest in the spring, the bulk of them between August and December. Members of migratory species return to the same areas to breed every spring. Only one or two birds nest other than in spring. Thus the Lyrebird and a couple of the hawks, for example, are winter nesters. Peewees sometimes nest in autumn, when there is plenty of mud after the summer rain, and some of the finches have broods in conjunction with the seeding of grasses. The Mistletoe Bird and Painted Honeyeater nest in February and March, when the mistletoe berries are ripening.

The drought spring of 1957 provided an excellent opportunity for studying the effect of somewhat bad conditions on the birds in this section. Results are still coming to hand and they show that the drought imposed a real restriction on many species. The start of the season was delayed for most species by perhaps a fortnight. Most did, however, then nest and successfully rear their young. As spring progressed conditions became progressively drier and birds that normally do not start nesting until late October or early November suffered greatly. Amongst these were the returning migrants of the open forest, the White-throated Warbler and the Rufous Whistler, some individuals of which never laid eggs, though they started to build, and others lost young in the nest due to dryness and heat. Up to mid-January the Cicada Bird, that normally lays early in November, had not even started to nest. Apart from nesting the heat of late spring had a decidedly depressant effect on bird song, and species that would normally have reared a second brood showed no desire to do so.

(b) *South-western Australia*: The south-western corner has a winter rainfall. Spring breeding is the rule.

(*c*) *The desert*: In the central regions breeding is highly unpredictable and irregular and is completely associated with rainfall. During an Australian Museum field trip in 1952, to central and north-western Australia, a good opportunity offered for investigating this phenomenon for, at Alexandria on the Barklay Tableland, a record drought was raging, but at

Camooweal a couple of hundred miles further east in the same latitude, a chance downpour had produced an inch of rain. The behaviour of birds in the two places was strikingly different. At Alexandria those species that remained (most birds forsake drought-stricken areas) showed no apparent intention of breeding. At Camooweal, however, notwithstanding that it was July, the air resounded with territorial song. Individual birds of various kinds were examined and in many cases the reproductive organs were found to be enlarged and the birds were ready to breed.

(*d*) *The "intermediate" zones*: Much of western New South Wales comes into this category. The birds of this section can be regarded as spring breeders—if they get a chance! The further west one goes the less regular is spring nesting and the more inclined are the birds to utilize food resulting from unexpected rain to raise a family. As noted previously, studies last year have shown that breeding did not occur (with only one or two exceptions) in the Bourke area. It was, moreover, much depressed at Coonabarabran where there had been (up to mid-November) no rain since the middle of winter. At Bingara, by contrast, four inches of rain in mid-October initiated much nest-building.

At Cunnamulla, in south-western Queensland, where Mr. M. Schrader very kindly gathers field data for the Museum, the abundant summer rains of 1954-55 caused almost all species in the area to nest in the autumn and breeding proceeded right through the winter into the following spring!

(*e*) *Northern and north-western Australia*: Across this section of the continent there is a summer monsoon that provides good conditions for some months. The rest of the year is dry. Though a few species nest in spring the majority does so at the time of the rains, or immediately following them.

Current scientific work is revealing a whole range of interesting adaptations in birds to the dry environment that makes up almost two-thirds of the Australian continent. It has long been known that most are nomads, not migrants. That is to say they wander in any direction, to wherever conditions are temporarily good and they breed when they can. In good years they have an increased number of young to make up for the losses of drought years. In some areas they even moult, not at a regular time but, apparently, as the opportunity offers. The evidence shows that the desert birds do not perform any of their major behavioural functions at regular seasons. And, it would seem, they have never even heard that birds are supposed to nest at the time of year when days are getting longer.

Notes and News

Archaeology of the Far West

Mr. F. D. McCarthy, Curator of Anthropology, Australian Museum, spent five weeks in the far west of New South Wales during April and May, advancing his study of the archaeology of this region. Surveys were made of the art motifs at the extensive sites of pecked rock engravings at Mootwingee and Sturt's Meadows and here Professor N. W. G. Macintosh, University of Sydney, recorded some interesting engravings of dingoes and their tracks, associated with other motifs. Mr. McCarthy also collected knapped stone implements on twenty-five camp-sites used by the Aborigines prior to the coming of the white man, north of the Darling River and between the Warrego River and Menindee. Mr. O. le M. Knight gave valuable assistance in this part of the field-work, which formed a survey of the types of implements and their distribution between the Darling River and the Queensland and South Australian borders.

Mr. McCarthy spent July and August studying the remarkable series of rock engravings at Port Hedland, Western Australia, a project made possible by a grant of funds from the Wenner-Gren Foundation for Anthropological Research, New York.

Insect Collecting

During May, the Assistant Curator of Insects, Mr. David McAlpine spent two weeks collecting insects at Cairns and Kuranda in North Queensland. The aim of the visit was not to collect the large and brightly coloured butterflies, moths, and beetles which are brought back by most collectors visiting these areas and are therefore well represented in the Museum Collections. Instead attention was given to the smaller insects, particularly to small flies. From this viewpoint the

trip was most successful. Although the several thousand specimens collected have not yet been critically examined it is predicted that many of the species are new to science and others are not previously known from Australia. The most interesting collecting was inside the tropical rain forest or jungle but in many places this was so dense that entry could only be made where narrow tracks had been cut. No observant collector in this district could fail to be impressed by the size, brilliance and abundance of the butterflies. These ranged from the huge Cairns Birdwing (*Papilio priamus euphorion*) of which the female measures seven inches across the fully expanded wings, to the small but colourful Rovena Jewel (*Hypochrysops polycletus rovena*), with marking on the wings suggestive of inlaid rubies. The peculiar Stalk-eyed Flies (*Achias*) were not encountered but a local collector, Mr. E. J. Harris, presented a specimen to the Museum on hearing that they were needed. This is the first Australian specimen of its kind in the Museum Collections.

Fossil occurrence in Cobar district

Interesting fossil remains of ancient armoured fishes and of sharks were recently collected by Mr. H. O. Fletcher, Curator of Fossils at the Australian Museum, and Mr. E. O. Rayner of the Geological Survey of New South Wales. The fossil occurrence was discovered last year by Mr. J. Spence (Frome-Broken Hill Co. Pty. Ltd.), while carrying out geological investigations in the ranges near Wuttagoona, in the Cobar district.

The fish fauna consists of new genera and types closely allied to European species. The specimens are beautifully ornamented plates of the armoured fishes and spines of a primitive shark. These fishes, now extinct, lived in Upper Devonian times about 313 million years ago.

Other fossil material collected on this field-trip included marine shells from Hermitage Plains, between Hermidale and Nymagee.

Americans re-visit "the Centre"

Professor R. A. Stirton and Mr. Richard Tedford, of the Department of Palaeontology, University of California, visited the Australian Museum recently on their way to central Australia. They are continuing their previous investigations of vertebrate fossil deposits in the country east of Lake Eyre. While working in this area last year Mr. Tedford discovered a most interesting sequence of three distinct horizons, each of which contained a characteristic assemblage of vertebrate fossil remains. It is thought that the oldest horizon may prove to be of middle Tertiary age.

Professor Stirton and Mr. Tedford are working in association with the South Australian Museum and will be accompanied on their expedition by Mr. Paul Lawson of that institution. They propose to be in the field for three months.

Shark Repellents

Mr. G. P. Whitley, Curator of Fishes at the Australian Museum, attended a Symposium on Shark Repellents at New Orleans last April, held under the auspices of the American Institute of Biological Sciences. He also studied specimens of fishes in museums and universities in Miami, Washington, Boston, California and Hawaii.

Book Review

AN INTRODUCTION TO SOCIAL ANTHROPOLOGY. By Ralph Piddington, Professor of Anthropology, Auckland University College, University of New Zealand. Vol. II, pp. 443-813. Oliver and Boyd, Edinburgh, 1957.

The second volume of this textbook of anthropology deals with some important themes for the museum and field worker in this science. The ten chapters are headed: Place, work and folk; People and things; Methods of field work; Culture and personality; Culture contact (agencies of change, trends of policies, the examples of Hehe and Malaita); Study of more complex societies. Appendices and bibliography complete the volume.

The extremely wide range of topics is discussed in a vigorous but easily read and understood style, so that the work as a whole forms both an introduction for the layman, to social anthropology, in which research throughout the world has been pursued very actively during the past few decades, and a text book for the anthropologist. It contains a very useful outline of the problems, and how they may be studied, arising from the contact between backward and advanced groups of people.

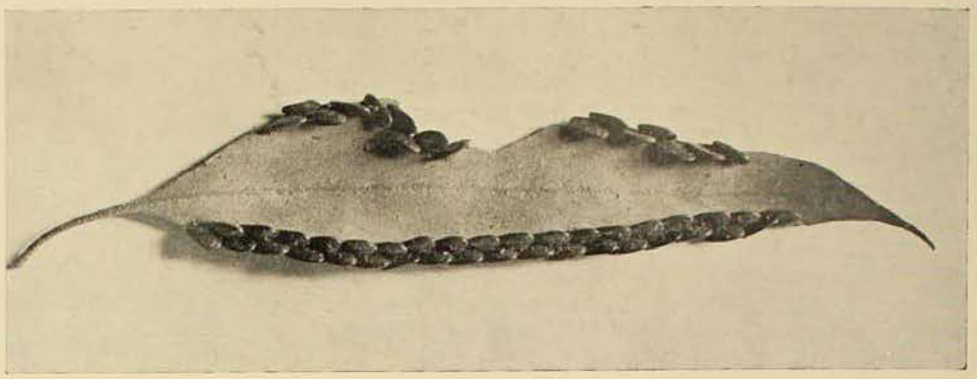
In a note on museums the author stresses the important part they can play in promoting understanding of non-European cultures. The two general methods of display, comparative and geographical, are discussed, and a useful list is given of the exhibit headings, arranged on the former plan by the Horniman Museum, London, which has specialized in this method of arrangement. The principle is stated that, to achieve the maximum educational effect, specimens should be regarded as the least important part of the display, which should emphasize the imparting of information to visitors with labels, diagrams and other visual means. For this reason the great value of school services in museums is stressed.

The four main functions performed by anthropological museums are stated to be: (1) they can make a substantial contribution to the improvement of race relations; (2) they can help to give a concrete background to the study of the more abstract principles of anthropology; (3) museum displays, and particularly comparative series, can do much to offset the impression that primitive peoples are somehow of a different order of humanity from ourselves; (4) museums help in clarifying the relations between the different anthropological sciences. F.D.McC.

Test Your Knowledge!

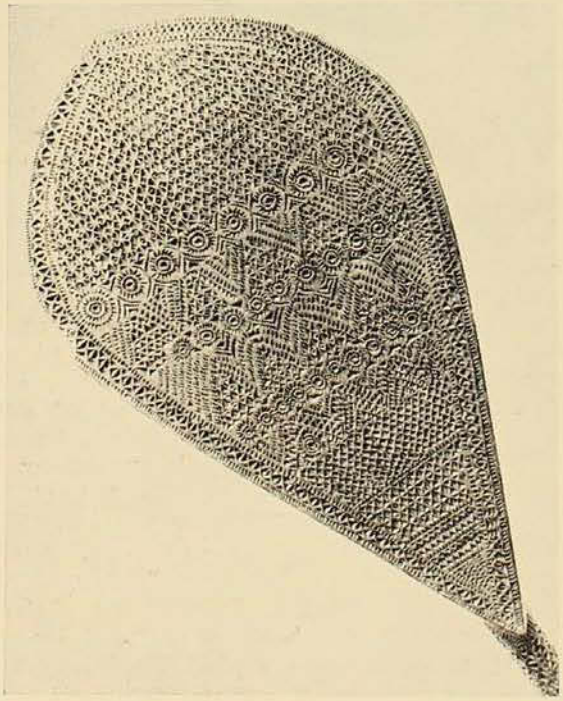
(ANSWERS ON PAGE 354.)

No. 1: Wipe out ideas of Hallow'een and circus clowns; this doesn't tie in with either. Ancient or modern?

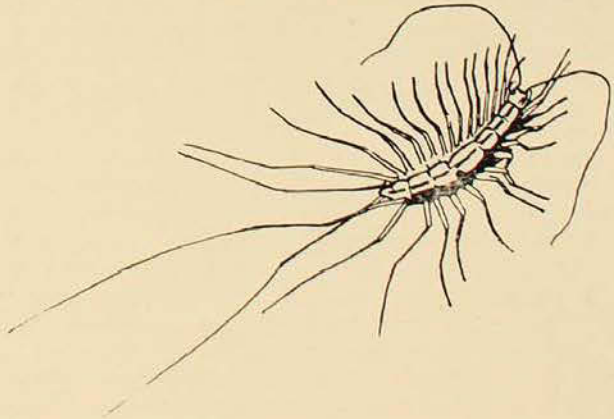


No. 2: Obviously a gum leaf, but what are the other objects?

No. 3: This "likeness" hangs in the Australian Museum library. The man? And the artist?



No. 4: Made of carved wood? Plaited fibre? Is it a fly-swat or a native ornament?



No. 5: If this appeared in your laundry or bathroom would you know its name? It could bite you but so far as is known you wouldn't die!