

# AUSTRALIAN NATURAL HISTORY

JUNE, 1968

VOL. 16 No 2

PUBLISHED BY THE AUSTRALIAN MUSEUM, SYDNEY

30c



REGISTERED AT THE GENERAL POST OFFICE, SYDNEY, FOR TRANSMISSION BY POST AS A PERIODICAL

# AUSTRALIAN NATURAL HISTORY

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

Editor: F. H. TALBOT, Ph.D., F.L.S.

Annual Subscription, \$1.40 posted

---

VOL. 16, NO. 2

JUNE 15, 1968

---

## CONTENTS

	PAGE
AUSTRALIAN DRAGONFLIES— <i>J. A. L. Watson</i> .. .. .	33
THE SEA-LIONS OF DANGEROUS REEF— <i>B. J. Marlow</i> .. .. .	39
FISHES BENEATH ANTARCTIC ICE— <i>Donald E. Wohlschlag</i> .. .. .	45
DISTRIBUTION AND ADAPTIVE DIVERSITY OF TRAPDOOR SPIDERS— <i>Barbara York Main</i>	49
THE LITTLE BENT-WINGED BAT—EVOLUTION IN PROGRESS— <i>P. D. Dwyer</i> .. .. .	55
ECOLOGICAL ASPECTS OF SERPULID FOULING— <i>Dale Straughan</i> .. .. .	59
BOOK REVIEWS.. .. .	48, 54, 58, 64

---

● **FRONT COVER:** A large burrowing frog, *Cyclorana australis*, from central Queensland. This species grows to nearly 5 inches in length, and is found in many parts of Queensland, the Northern Territory, and Western Australia. During the dry season it burrows up to several feet underground, where it aestivates in a special cavity until, with the coming of rain, it comes to the surface to feed and breed. (Photo: Howard Hughes). **BACK COVER:** A desert gecko, *Lucasium damaeum*, from a mallee-spinifex community in central-western New South Wales. This gecko, which grows to about 4 inches in length, is found commonly in the arid spinifex or porcupine grass (*Triodia* species) areas in all mainland States. Like most geckos it is insectivorous, but is especially partial to termites. The female normally lays two parchment-shelled eggs. (Photo: C. V. Turner).

---



Front view of the dragonfly *Rhyothemis graphiptera* (Rambur) in a typical perching position. The wingspan is approximately 6 cm (about 2½ inches). The abdomen is hidden behind the thorax.

## ***AUSTRALIAN DRAGONFLIES***

By J. A. L. WATSON

Curator of Odonata, Division of Entomology, CSIRO, Canberra, A.C.T.

**B**EING very conspicuous insects, dragonflies are familiar to most of us. Their large size, powerful flight, rapacious habits and bright colours all command attention. They have common names in many languages; the Japanese have long accorded them a prominent place in art; they were obvious models for the early designers of flying machines; and the sustained interest of collectors has provided us with a better knowledge of the world fauna than exists for most other insects. The attention of laymen has also been attracted by the larvae of the

larger dragonflies, as food and bait for fish; what Australian trout fisherman has not heard of mud-eyes?

In point of fact, the Odonata, the order of insects to which the dragonflies belong, constitute less than 0.5 per cent of the known species of insects. The order contains two main suborders, the Anisoptera or dragonflies proper, large, sturdy insects which generally rest with the wings spread, and the Zygoptera or damselflies, slim insects generally resting with the wings closed above the body. Nowadays the name dragonfly is loosely

applied to both suborders, although its older usage, dating back some four centuries, applied only to the larger species now recognized as Anisoptera.

All dragonflies are active predators. The adults are highly specialized for catching and consuming other insects in flight, and flies, wasps, moths, and even smaller dragonflies commonly fall victim to them. The larvae, which are almost always aquatic, use their uniquely modified labium to catch food. When suitable prey comes within range, the labium is shot forward, and the unfortunate animal is trapped between the apposed teeth and spines of the two lateral lobes. Neither larva nor adult is harmful to man, despite the name horse-stinger which is commonly applied to the adult; rather the reverse, for the diet of both larvae and adults often includes flies and mosquitoes.

#### More than 4,000 species in world

The Australian dragonflies are few in number, the total number of species being probably less than 300, compared with the world fauna of something over 4,000 species. On the other hand, the Australian fauna includes a great number of ancient or problematical forms. There are dragonflies closely allied to the species of Jurassic times, 150 million years ago, in the age of reptiles; species whose only known relatives live in Chile; species whose nearest counterparts are fossils from the Permian period, approximately 250 million years ago; and, at the other extreme, there is *Pantala flavescens* (Fabricius), a species known from temperate and tropical zones all around the world.

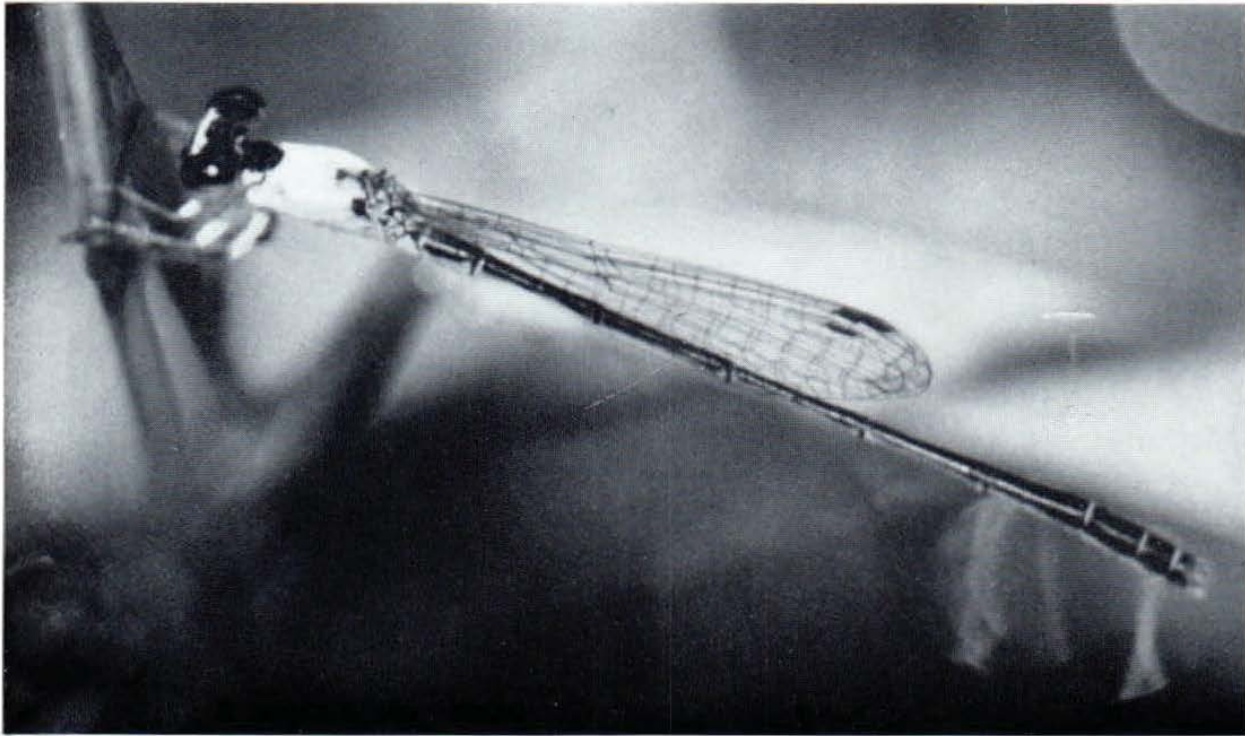
Predominant among the ancient groups is the family Petaluridae, a family abundant among the dragonflies of the Jurassic, and now reduced to nine living species. Four of these live in Australia, one in New Zealand, one in Chile, two in North America, and one in Japan. The four Australian species all belong to the genus *Petalura*, which is confined to Australia; two occur in north Queensland, one ranges from south Queensland to central New South Wales, and the fourth is confined to southwestern Australia. All are huge dragonflies, and *Petalura ingentissima* Tillyard from north Queensland, with a wing-span of up to 16.5 cm, is the largest living dragonfly. The larvae are

also bulky, rugged creatures, and, unlike other dragonflies, live in burrows in wet mud. Their diet is correspondingly different and includes earthworms, terrestrial beetles, and other small animals of the bogs.

Another primitive group is the subfamily Neopetaliinae, two species of which occur in southeastern Australia, the remainder living in South America. The family Aeshnidae, to which the neopetaliines belong, also includes many common and widespread dragonflies, mostly large. The two Australian neopetaliines are *Austropetalia patricia* (Tillyard) from the Blue Mountains (New South Wales) and Victoria, and *Archipetalia auriculata* Tillyard from the mountains of Tasmania, the most primitive living aeshnid known. Both species, in common with other members of the subfamily, have a row of reddish spots along the leading edge of each wing.

Two unrelated Australian damselflies, *Hemiphlebia mirabilis* Selys and *Chorismagrion risi* Morton, are unique in showing venational characteristics otherwise known only in fossils from the Permian period. It is possible that the venational characteristics are secondary, in which case the arguments for affinity with the fossils would founder; yet such characteristics would be striking cases of parallel evolution, especially in *Hemiphlebia*. Both species have a genus to themselves, and occur only over a limited range; *Hemiphlebia mirabilis* apparently occupies only a short stretch of the Goulburn River in Victoria, and *Chorismagrion risi* is confined to the rainforests of northern Queensland.

The known larvae of the more primitive Odonata breed in permanent water, generally in streams. They commonly take more than a year, sometimes up to 6 or 7 years, to reach the adult stage, so it seems that the larvae of ancient dragonflies first colonized permanent waters, where temperature and oxygen content were fairly even. But how can we be sure that dragonfly larvae were originally terrestrial? The petalurids give us a clue, but the respiratory systems of larval dragonflies provide more convincing evidence. Terrestrial insects breathe air through segmentally arranged apertures, the spiracles; aquatic insects generally breathe by means of gills of various types. Dragonfly larvae have gills, at least four distinct and



The damselfly *Agriocnemis dobsoni* Fraser, photographed in a swamp near Innisfail, Queensland. The tiny *Agriocnemis*, all only 2 to 3 cm long, have a distribution similar to that of *Pseudagrion*.

independent types being represented, some on the outside of the abdomen and others in the rectum. In addition, however, relics of abdominal spiracles are common to all. We can be sure that they were once terrestrial, presumably in the moist atmospheres of the mid-Palaeozoic era.

One of the striking features of "modern" dragonflies, together with a few of the older forms, is that they have forsaken the permanent streams and can now breed in ephemeral and often shallow and warm waters. The species that have overcome the problem of breeding in temporary waters have done so in one of two ways. Firstly, the larvae of several unrelated dragonflies, mostly species that breed in boggy places, have developed the capacity to withstand drying. Although some can survive only if the mud around them remains damp, others tolerate long periods in dry sand. However, none of these Australian species have spread widely, and the resistance to drying may be a relic of the necessity to tide over the period of maximal aridity in Australia some 5,000 years ago. Thus *Synthemis leachi* Selys and *S. eustalacta* (Burmeister) are now confined to the areas of higher rainfall in southwestern

and southeastern Australia respectively; *Argiolestes pusillus* Tillyard occurs only in southwestern Australia; and *Austrocordulia refracta* Tillyard is confined to eastern Australia, in the coastal region from southern New South Wales to northern Queensland.

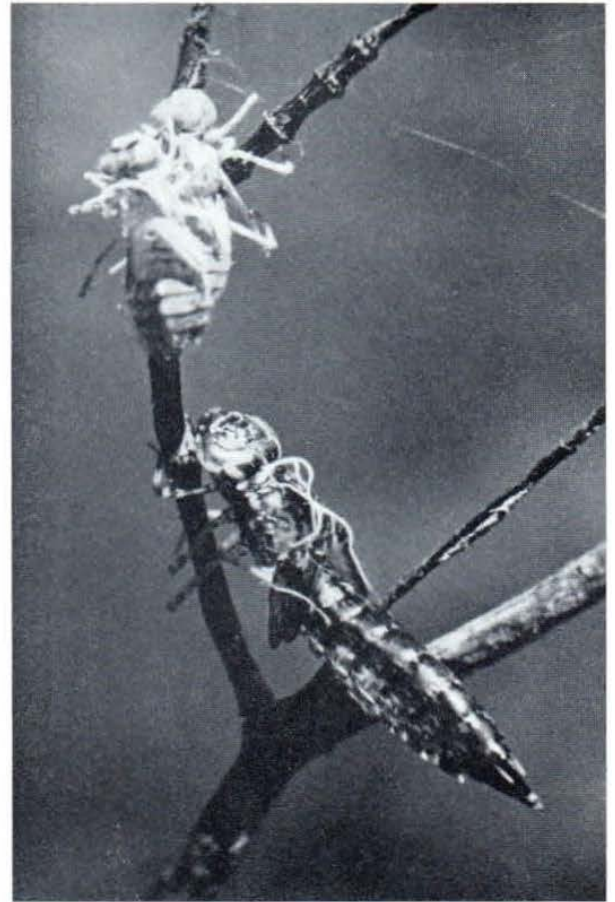
#### "Opportunists"

Secondly, we find species that have shortened their larval life to a period compatible with the duration of temporary ponds. Such species are opportunists, laying eggs when water is available, and flying far to find it. Thus the adults are widespread throughout Australia, and are better known than those of other species. Perhaps the most interesting point is that, like the species that have developed resistance to drying, these opportunists have evolved independently from a series of unrelated groups—lestid and coenagrionid damselflies and aeshnid, corduliid and libellulid dragonflies—including some characteristically Australian genera. *Hemicordulia tau* Selys, perhaps the most ubiquitous species, will lay eggs in the water lying in sheep troughs or trapped in small tins after rain. All species apparently share a tolerance of the high temperatures and

low oxygen tensions that are common in shallow ponds, and grow rapidly in such conditions. Newly hatched larvae of *Diplacodes*, *Hemicordulia* and the aeshnid *Hemianax papuensis* (Burmeister) can reach the adult stage in 2 to 3 months at 29° C. Yet even this rapid growth is often an insufficient insurance, and many larvae die when their pond dries out before they can emerge.

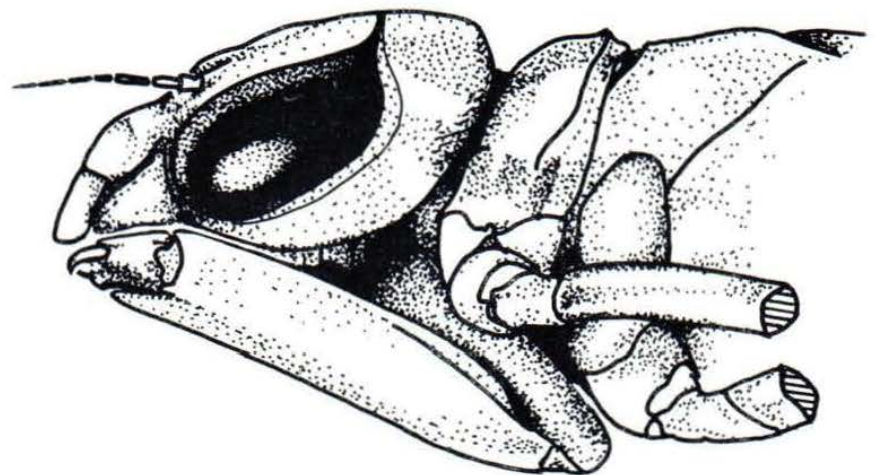
The tendency for the more primitive dragonflies to live in cool, permanent waters affects their distribution in Australia. As an example we can take the Synthemidae, a family of dragonflies confined to Australia and surrounding islands. The family is an ancient one, connecting the aeshnoid group of families to the libelluloid group. Recent unpublished studies by E. F. Riek in Canberra show that larvae, almost certainly synthemids, are present in Victorian deposits from Cretaceous lakes, which are only slightly younger than the Jurassic deposits in which petalurids predominate. The present Australian synthemids occupy a broad crescent in eastern Australia, with its centre in Victoria and New South Wales, and a smaller crescent in the extreme southwest of Australia. In Queensland the family is virtually confined to the higher rainfall of the coastal and montane regions, and the rain-forests.

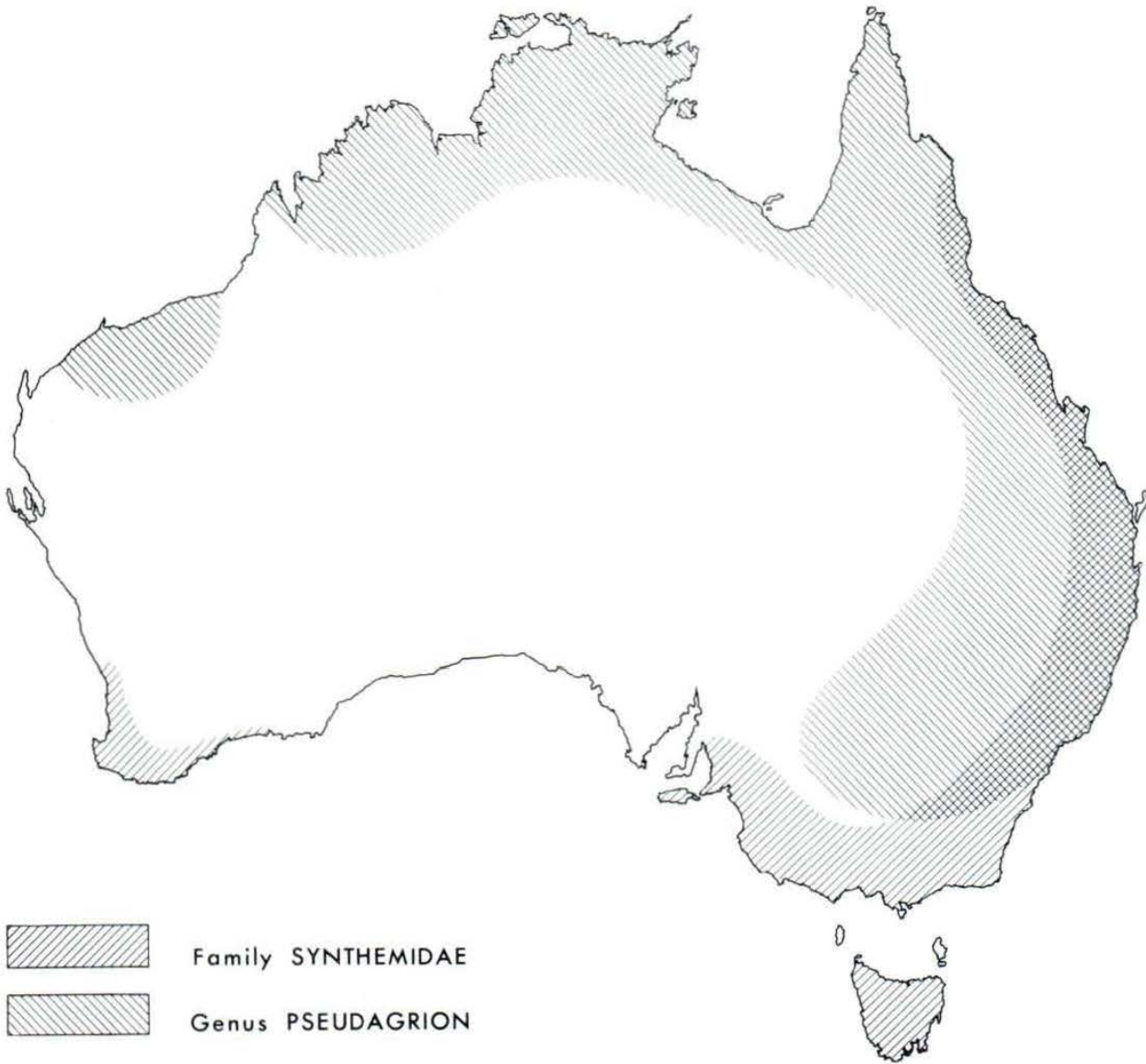
In the north, however, this southern element is joined by a tropical fauna, consisting of relatively new arrivals from the islands north of Australia. As an example of this second element, we can take the genus *Pseudagrion*, widespread in the tropics and



Two larval skins of *Hemicordulia tau* Selys (above) and one of *Hemianax papuensis* (Burmeister) (below), from which the adults have emerged. The skins were photographed beside a shallow pool in the Murchison River, in the drier part of Western Australia, a typical habitat of these wide-ranging opportunists.

Side view of the head and part of the thorax of a larval *Hemianax papuensis* (Burmeister). The huge labium lies folded beneath the head, and the left lateral lobe shows the large hook at its tip





The approximate distributions of the family Synthemidae and the genus *Pseudagrion* in Australia. The synthemids exemplify the southern element of the fauna, and the *Pseudagrion* the northern element.

and warm temperate regions of the old world. Four species are known from Australia, and their range is shown in the accompanying map. Two species are confined to Australia; a third occurs also in New Guinea; the fourth, *Pseudagrion microcephalum* (Rambur), was originally described from India, and includes a wide range of forms of uncertain status, spread across an enormous area of southern Asia and the Pacific. Unlike many of the northern elements, two species of *Pseudagrion* have penetrated far south of the Tropic of Capricorn, and one even into the cold, montane areas of southeastern Australia.

#### Brilliant coloration

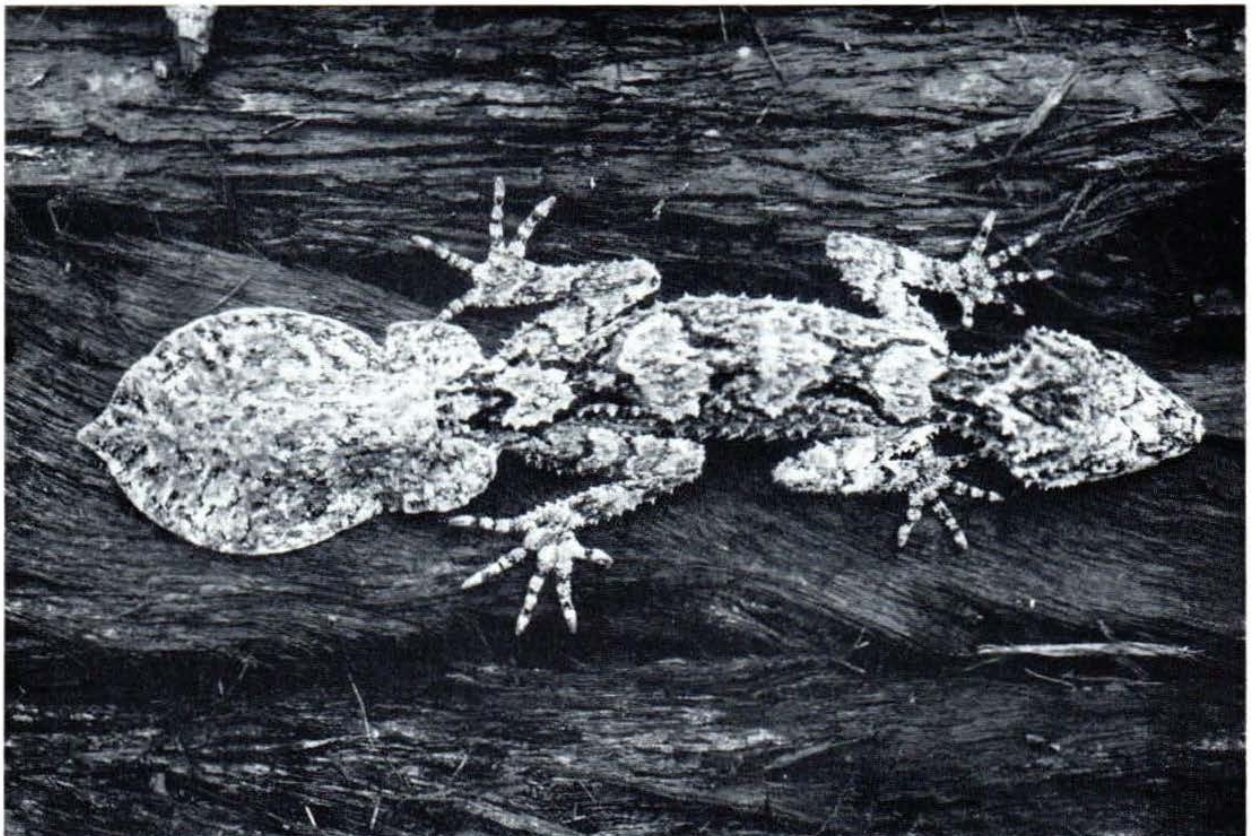
The tropical species include some of our most brilliantly coloured dragonflies, particularly forms with tinted wings. The libellulid genus *Rhyothemis* includes five Australian species, one with clear amber wings mottled with dark brown ciphers, others with wings patterned in black, and one in which the male has the basal half of the wing tinted a vivid metallic blue. The ranges of all except one of these five *Rhyothemis* extend beyond Australia, some far into Indonesia and the Pacific, and other species occur in southern Asia and Africa.

Furthermore, it is likely that some of these tropical dragonflies are rapidly extending their ranges in Australia. Some 50 years ago, the great student of Australian dragonflies, R. J. Tillyard, commented that the conspicuous species *Rhyothemis graphiptera* (Rambur) and *Pseudagrion aureofrons* Tillyard were known to occur as far south as the Clarence and Bellinger Rivers, N.S.W., respectively. Both now extend at least as far south as Sydney, Tillyard's home for many years, and *Pseudagrion aureofrons* is common near Canberra and Gundagai, N.S.W., in the mountains, and Wentworth, N.S.W., on the plains.

The Australian dragonflies thus present a situation closely parallel to that shown by the mammals. There are ancient, problematical dragonflies such as *Hemiphysalia*, analogous with the monotremes. There are groups which probably reached Australia during the

Mesozoic. Of these, the petalurids and neopetaliine aeshnids now comprise only a minor part of the fauna, but the synthemids have thrived, like the marsupials. So have some later arrivals, such as the genus *Hemicordulia*, which ranges over the entire continent and occupies a wide variety of habitats. Finally, there are the newcomers that have invaded the northern parts of Australia and, it seems, are spreading southwards. We may hope, though, that the ancient Australian dragonflies will withstand the pressure from the north better than the marsupials withstood the analogous pressure from the placental mammals. If not, as has already happened with the dragonflies of southern Africa, the ancient elements will all but disappear.

[The photos and the drawing of the larval head and thorax are by the author. The map is by Mrs G. C. Palmer.]



The geckos include some of the most interesting lizards. The Northern Leaf-tailed Gecko (*Phyllurus cornutus*), seen above, is the largest Australian gecko, reaching a length of 10 inches. The original tail of this specimen has been lost and the one shown has grown in its place. The Northern Leaf-tailed Gecko is largely an inhabitant of the rainforests of coastal eastern Australia. [Photo: Harold Cogger.]





An adult female sea-lion with a half-grown pup, estimated to be about 10 months old, on Dangerous Reef, Spencer Gulf, South Australia.

## *The Sea-lions of Dangerous Reef*

By B. J. MARLOW  
Curator of Mammals, Australian Museum

TRUE seals or phocids occur in Australia only as stragglers from the Antarctic, so all the resident seals are members of the family Otariidae, which are known popularly as eared seals. Eared seals are divisible into two main groups, fur seals and sea-lions, and both these forms are represented here by the genera *Arctocephalus* and *Neophoca* respectively.

It is only during this decade that any serious study of the general biology of these animals has been started, and at the present time intensive investigations of fur seals are being carried out near Melbourne by the Victorian Department of Fisheries and Wildlife.

The Australian sea-lion, *Neophoca cinerea*, has been much neglected in the past and virtually nothing was known of many aspects of its general biology, although it is a large and conspicuous animal which is confined to

the south and west coasts of Australia. The adult males, which have a white nape, may grow to a total length of about 10 feet, while the adult females are considerably smaller. These seals occur in groups of about 100 animals on various islands off the coast between Adelaide in South Australia and Houtman's Abrolhos off the west coast of Western Australia.

An opportunity of visiting some of these colonies occurred during October, 1966, when an invitation was received from the Department of Shipping and Transport to sail in the *Cape Pillar*, the vessel which services the lighthouses on various islands around the coast of South Australia. Colonies of sea-lions were seen on the South Neptunes, Four Hummocks, and Pearson Island but there was no evidence of breeding at any of these sites. On the other hand, a large number of very young pups was seen on a small rocky island called

Dangerous Reef (34° 49' S., 136° 12' E.), which lies in Spencer Gulf, South Australia, about 17 nautical miles southeast of Port Lincoln. Since this was obviously an important breeding site, which is visited at regular intervals by the *Cape Pillar*, it was decided that this would be an ideal place in which to study the general and reproductive behaviour of the Australian sea-lion.

Great assistance was obtained from Mr John Thompson, Regional Controller, South Australia, of the Department of Shipping and Transport, without whose co-operation it would have been impossible to carry out this study. Once permission had been obtained to stay on Dangerous Reef, an aluminium hut measuring 10 feet square was constructed at the Australian Museum and sent by road transport in sections to Adelaide. This hut, together with three 44-gallon drums of drinking water,

was loaded onto the *Cape Pillar* and carried to Dangerous Reef. There the hut was erected by members of the crew of the ship after it had been landed in a large amphibious vehicle called a LARC.

This hut was extremely comfortable and was equipped with built-in furniture in the form of two bunks, two tables, and a seat. The whole structure was lined with Caneite. A gutter and downpipe were fixed at the lower end of the sloping roof, which enabled extra rainwater to be collected. This roof water was adequate for washing but was not fit to drink, since it was heavily contaminated with the droppings of sea birds, particularly gulls and shags. Although stocks of fresh water were restricted, it was found that, with due economy, two people could get by quite easily on a gallon a day between them.

A large range of tinned food was taken onto the island and was replenished from



Aerial view of Dangerous Reef, showing the living-hut on the right and the light-tower. The island is 250 yards long and 100 yards wide. The right-hand edge of the photo faces north.

time to time with fresh food brought in on periodical visits from a privately owned boat from Port Lincoln. This boat, owned by Ray McDonald, was used for the transport of all the equipment and food to Dangerous Reef at the start of the project on 10th July, 1967, at a time when the water drums and hut had already been delivered by the *Cape Pillar* and erected. Two-way contact was kept on a daily schedule with Port Lincoln by means of a small transceiver radio, which was lent by A.W.A. Fuel for lighting and cooking was taken in the form of a 100-pound cylinder of Portagas; this was used to fill smaller bottles from which these appliances ran.

The stay on Dangerous Reef lasted from 10th July until 13th October, a total of 94 days. The party, which consisted of Howard Hughes, the Australian Museum photographer, and myself, arrived earlier than was necessary. Since the exact date of birth of the pups, which had been seen in the previous October, was unknown, it was decided to arrive well ahead of the breeding season, so that observations on the initial stages of the formation of territories could be made. These took place at the beginning of September, and the first month was spent in observing the general non-breeding behaviour of the animals.

## Rocky Island

Dangerous Reef is a rocky island measuring 250 yards in length by about 100 yards in width, which is 12 feet above sea-level at its highest point. In the centre of the island there is an unmanned light-tower about 45 feet high, with a balcony at the top, from which it was possible to view all parts of the island and observe the seals without disturbing them in any way.

The vegetation is extremely sparse and consists merely of about three species of small herbs, which are concentrated around the bases of rocks scattered over the surface.

A varied and abundant bird fauna was present which included silver gulls, Pacific gulls, cormorants, banded dotterels, crested terns, fairy terns, and sooty oyster catchers. Other species, including Caspian terns, fairy penguins, and ospreys, were represented by a few isolated individuals. All the more abundant bird species were breeding on the island during September and October, well in advance of the seals. The latter, together with the birds mentioned, were the only terrestrial vertebrates on the island, but a large number of invertebrates, including molluscs, crustaceans, and echinoderms, were present along the shoreline.

A general view of the campsite at Dangerous Reef, showing the living-hut on the right and the storage hut at the base of the light-tower.



Dangerous Reef consists of a granite base capped with a limestone top. Much of the shoreline consists of flat granite platforms which are awash at high tide. Inshore from these, the ground is covered with granite boulders of varying sizes.

The whole island was marked off in a grid pattern at 10-metre intervals by painting numbers on rocks with yellow road-paint. In this way it was possible to give a grid reference to any point on the island to the nearest 10 metres.

During July the population consisted of about 160 sea-lions, but as time progressed a steady decline in numbers occurred until October, when a total of about 30 animals was present. Although considerable daily fluctuations occurred, it was evident that the numbers were decreasing and it is considered that this was due to the presence of humans on the island. It was not possible to walk about Dangerous Reef without disturbing seals and if approached too closely they normally took flight into the sea. Because of this decrease in numbers, it was possible to observe the behaviour of individual seals and to follow their movements, since their activities were not obscured by the presence of a large number of animals. On arrival at the island, preparations had been made to mark selected individuals with coloured dye so that they would be recognizable, but this was found to be quite unnecessary since the majority of the animals bore natural scars and injuries which enabled them to be distinguished quite easily.

The adult females were accompanied by two pups of different ages, a smaller one, which was still suckling, about half her own size, and a larger three-quarter-size animal which was only suckling if there was no smaller pup present. Both sexes were present in these two age groups. A variety of age groups was also present among the males, ranging from medium juvenile males through large juvenile males and sub-adult animals to the large, heavy, fully developed breeding bulls. At least five age categories of males were easily recognizable. It was not possible to determine the chronological age which was represented by these different categories, but it is suspected that each stage may be separated from the next by one year. The medium-sized juvenile males presented some difficulty in identification, since they were

of the same approximate dimensions and conformation as the adult females, and it was only by careful examination of their genital region, while lying facing the observer, that their sex could be readily determined.

Most of the observations on the seals were made through an X20 telescope mounted on a tripod, and notes were dictated directly into a portable battery-operated tape recorder. These notes were then transcribed during the evening into field note books.

During the day the majority of seals spent much of their time sleeping, or grooming themselves by scratching their bodies with the claws of their hind feet or rubbing themselves against rocks. The adult females spent long periods in suckling their pups. Towards evening, individual animals would leave the groups in which they had been lying during the day, and move very gradually down towards the shore and into the sea, presumably to spend the night fishing. Many of the rock platforms were covered



An adult female sea-lion with severe wounds on the neck and shoulder, probably the result of shark attack.

with slimy algae, and the seals seemed to know the location of these slippery patches, which were used as slides to enter the water.

### Social hierarchy

Little aggressive behaviour was seen among the females, but all age groups among the males, except for the large adult bulls, spent a considerable amount of time in fighting. It was evident that a social hierarchy existed and that individuals established their position in this by fighting. In spite of this agonistic behaviour, little injury was sustained in these combats. The scars and injuries which were mentioned earlier appear to have been inflicted by sharks, since many of the scars were of a characteristic crescentic shape. On occasion these wounds were very severe, and at least three different adult females in the population had one hind flipper missing. However no seals were seen to die as a result of these injuries.

Towards the end of July, a number of premature stillborn pups were born, which were guarded most solicitously by their mothers. The adult female spends a great deal of time lifting the dead pup by the loose skin of its back, swinging it from side to side, and depositing it against her flank. This behaviour may persist for more than 5 days after birth has occurred. Adult females with either dead or live pups were the only animals in the population which showed aggressive behaviour towards humans

when approached closely. All other seals, including adult males, took flight under these circumstances. The females who had given birth to stillborn pups did not join other groups of seals but were ultimately joined by an adult male, who attempted to court them. The male was continuously repulsed and no copulation was observed at this stage. This temporary association between the adult male and female ended after about 5 days.

At the beginning of September, a sharp increase in aggressive behaviour took place between the males in the different age groups and the very large adult males began to defend certain areas against rival bulls. This territoriality was, however, extremely fluid, and after a few days the dominant male would desert the area in favour of a new piece of ground. In this way, ownership of territories was continually changing. It later became apparent that the presence of cows which were about to give birth was necessary for a permanent territory to be established. The majority of territorial conflicts were settled without actual fighting and it was obvious that position in the hierarchy was of considerable importance, since a dominant male could drive off a subordinate from the territory that he was holding by threat gesture and bluff alone. The impression was gained that a relict territorial system was being replaced by one based on social dominance.

An adult female sea-lion with the carcass of a stillborn pup. Females may continue to pick up and moult stillborn pups for more than 5 days after birth.





An adult male sea-lion with one of the two adult females in his harem and a 1-day-old pup. The pup shows the typical pale crown on the head.

At the end of September, the bulls were joined by cows, to form harems which contained a minimum of one and a maximum of four females. If a female tried to move away from the harem, the bull would immediately position himself in her path and head her back to her former position. In spite of this behaviour, the bulls were at all times very gentle with the cows, and on very few occasions were cows ever bitten savagely by the bulls.

At the beginning of October, the first live pups were born, but the aggressive behaviour of the cows made it quite impossible to approach them closely to examine and measure them at this stage. The newly born pups are very active at birth and have loose, wrinkled skin which falls into folds on the head and at the insertions of the flippers. The general body colour is a warm dark brown, with a paler crown and a dark mask across the face.

About  $6\frac{1}{2}$  days after the birth of the pup, the female comes into oestrus and mates with the bull. Copulation lasts for about 3 hours and consists of a varying number of separate acts of coitus with periods of rest between them. Unfortunately it was necessary to leave Dangerous Reef soon after the birth of the first pups, and because of this the disintegration of harems and the subsequent relations between pup and mother were not observed.

#### Future studies

It is hoped that future studies will be carried out during October at Dangerous Reef this year, when further aspects of reproductive behaviour will be investigated and a series of new-born pups will be marked. This marking programme will facilitate studies of the movements of the seals in South Australian waters and will enable us to relate an actual age in years to the various age groups which were described earlier in this article.

The study of a population of animals in the field is an excellent method of discovering many details of its ecology and behaviour. This method, moreover, is less liable to those errors and misinterpretations which attend laboratory studies of the behaviour of animals in captivity. The size and habits of *Neophoca cinerea* would render its study in captivity relatively impracticable and the only feasible way of becoming acquainted with it is to study it in its natural state. In spite of the isolation which occurred during 3 months on Dangerous Reef, far less hardship was experienced than was anticipated. Comfortable living conditions, a congenial companion and quite peaceful surroundings which contained a fascinating population of absorbingly interesting animals, made the stay there an extremely rewarding experience.

[The photos in this article are by Howard Hughes.]

# Fishes Beneath Antarctic Ice

By DONALD E. WOHLSCHLAG

Director, University of Texas Marine Science Institute, Port Aransas, Texas, U.S.A.

CAN a study of the ecology and physiology of Antarctic fishes add useful knowledge about fishes that cannot be obtained elsewhere? Besides the usual motives for biological exploration, discovery, and classification, do the motives for the study of ecological, physiological, and evolutionary processes justify the costly logistic support? Can classical descriptive and preliminary taxonomic phases of biological study be merged with contemporary experimental studies in the field? Is there a need to investigate the geographic generality of biological principles derived largely from studies of temperate organisms?

The fact that the answer to these questions about fishes—and other organisms as well—is an emphatic “yes” is verified by the large amount of current Antarctic research supported by many nations.

The Stanford University (U.S.A.) biologists, with whom the author worked as project leader from 1958 to 1965, were interested in the ecology of marine invertebrates and fishes of the McMurdo Sound area, where the sea ice is almost permanently adjoined to the Ross Ice Shelf and the ice shelf of the Koettlitz Glacier. During some summers the sea ice, which freezes to a depth of about 9 feet in 1 year, breaks up back to the Ross Ice Shelf; for several years in succession, however, the sea ice may continue to form at progressively decreasing rates until the thickness adjacent to the Shelf may vary from 14 to 30 feet. Beneath the sea ice and the terminal portions of the Ross Ice Shelf and Koettlitz Glacier tongue is an aquatic habitat that has a nearly uniform freezing temperature of  $-1.9^{\circ}\text{C}$  ( $28.6^{\circ}\text{F}$ ) and a remarkable assemblage of animals. How so many animals can be supported becomes a question of fundamental importance, because there can be photosynthesis beneath the ice only in the summer months.

## Methods of sampling

One of the first problems of studying environments and organisms beneath ice



An example of the remains of a fish head (probably *Dissostichus mawsoni*) frozen in the sculptured ice-shelf near the Dailey Islands in McMurdo Sound. [Photo: Jack L. Littlepage.]

involves methods of sampling. Natural cracks and seal breathing holes are not always strategically located, and these openings may refreeze at inopportune times. The techniques of chopping or blasting holes were abandoned when it was discovered that blocks of ice cut with chain saws could be removed in successive tiers. Over these holes could be placed portable heated field houses from which the investigator could fish or sample other organisms with almost all the comforts of a laboratory. An accompanying photo shows one of these field houses.

Fishing with hook and line or by baited traps that could be raised or lowered with a small powered winch became a relatively easy task. Transporting the fish at freezing

temperatures to the McMurdo Biological Laboratory was also simple, but maintenance of fishes in the laboratory required an involved array of large, insulated aquaria and cooling devices.

Five or six kinds of fishes are commonly caught beneath the McMurdo Sound ice, and another five or six are taken much less frequently; about ten additional species are rarely taken by trap or line, but occur in seal or fish stomachs. Superficially, these fishes very much resemble many fishes taken in other seas. Andriashev (1965) notes that there are about sixty-seven species in the continental coastal waters, of which 81 per cent are notothenoids, a group that is no doubt truly Antarctic in origin. Among the Antarctic species there is one family, the Chaenichthyidae, or ice fishes, that have neither red blood cells nor haemoglobin (Ruud, 1965). Ruud's charming story about his discovery of the white-blooded nature of these creatures years after their taxonomy was reasonably well-known from preserved

specimens is a good lesson for the necessity of studying animals in their natural environments.

#### Metabolic rates

One of the first studies we carried out was the determination of the metabolic rates of several of the common red-blooded nototheniid species by placing them (after acclimation to a given temperature between  $-1.9^{\circ}\text{C}$  and about  $+2$  to  $+3^{\circ}\text{C}$ ) in a circular enclosed plastic metabolism chamber in which their oxygen consumption rates could be measured. The oxygen consumption rates, as an indirect measure of metabolic rates, were unusually high—not as high as temperate fishes at moderate temperatures, but about three times as high as temperate fishes extrapolated through ordinary temperature decreases from  $20^{\circ}\text{C}$  to freezing, or about 13 times as high as tropical fishes extrapolated in the same way from  $30^{\circ}\text{C}$  to freezing! Thus, at temperatures at which temperate fishes would die or be extremely inactive, metabolically



A portable field hut over a fishing-hole in sea ice near Cape Armitage, Ross Island. Blocks of ice, removed in excavating the 4-foot-square hole, are scattered about the area. A small portable electrical generator (right) is nearly buried by drifted snow. [Photo: Author.]



speaking, these Antarctic nototheniids are truly cold-adapted.

As might be expected, the nototheniid metabolic rates differed somewhat among the species, but a zoarcid (eel pout) not only had less than half the oxygen consumption rate of the nototheniids, but it could be acclimated to above +4° C. The explanation seems to be that, because zoarcids have taxonomic affinities with areas outside Antarctica, they would not be expected to have developed the degree of cold adaptation that characterizes the nototheniids. Recently Hemmingsen and Grigg (1967), who had the unusual opportunity to study a McMurdo Sound haemoglobin-free chaenichthyid, found that its oxygen consumption rate was about one-third that of cold-adapted fishes having haemoglobin.

It is now clear that Antarctic fishes have much higher metabolic rates than might be predicted. But what happens to the metabolic energy? Part of the energy must maintain a fish and part must be utilized for growth. If maintenance requirements are large the fish would tend to be small and slow-growing. *Trematomus bernacchii*, a small red-blooded nototheniid, reaches a length of about 8 inches in about 8 years at -1.9° C in McMurdo Sound. In slightly warmer waters at Terre Adélie, the same species grows at a slightly greater rate (Hureau, 1964). But in South Georgia, where the waters warm to a temperature of at least zero for a portion of the year, the species (including a haemoglobin-free species) grow at rather great rates and to over 1 foot in length in 4 or 5 years (Olsen, 1954, 1955). There is little doubt that a good portion of the metabolic energy is available for growth.

### Fish sizes

While most of the Antarctic fishes are small (Andriashev, 1965), several species do grow to over 2 feet in length. At McMurdo Sound, Sir Robert Falcon Scott's party harpooned a Weddell Seal with the tail portion of a large fish in its mouth. Regurgitated remains of fishes much larger than those caught by any of the expeditions are also known. Debenham (1920) reported finding the headless remains of a very large fish and many sedentary invertebrates frozen in the ice shelf off the Koettlitz Glacier near the Dailey Islands in McMurdo Sound.

He suggested that these organisms were frozen into the bottom of the glacial ice where sea ice accretion added to the thickness of the glacier at the same time as ablation occurred at the supper surface. In this manner the animal remains would eventually be exposed at the glacial surface. Gow's (1967) report on the Koettlitz Glacier essentially verified this process, except that he considered the floating sea ice shelf, beneath which there was freezing, as a separate frontal portion of the true glacial ice tongue. He estimated that bottom ice would appear at the surface within about 50 years.

In 1960 a party working in the vicinity of the Dailey Islands discovered the remains of many invertebrates and large fishes—including fishes with heads—emerging from the ablating ice (Swithinbank and others, 1961). Almost exactly a year later, a live 53-inch, 58-pound fish was taken from a seal when the seal surfaced at the hole in one of the field houses. The fish was *Dissostichus mawsoni* (named after Sir Douglas Mawson). Subsequently many examples of this large species appeared when investigators learned to take advantage of seal feeding habits! Usually the seals had eaten the heads first; sometimes, presumably as a result of recovery from a very deep dive, the seals would return exhausted to the surface with the entire fish.

On one occasion Paul Dayton and Arthur DeVries captured a 51-inch, 46-pound female specimen, managed to return it to the laboratory in undamaged condition, and finally determined its oxygen consumption rate at 429 milligrams per hour at resting conditions. The predictive value of some of our previous work with other fishes now became obvious. The only pelagic fish for which we had data was the small schooling *Trematomus borchgrevinki* (named for C. E. Borchgrevink, a Norwegian who had been a school teacher in Australia and who made the first landing at Cape Adare in 1895). At freezing sea-water temperatures, this small species had yielded oxygen consumption data in relation to weight and swimming velocity to give the equation: Log oxygen consumption in milligrams per hour =  $-0.5661 + 0.7534 \log \text{weight in grams} + 0.0366 \text{ meters per minute swimming velocity}$ .

Because fishes generally have a quite regular increase in oxygen consumption with weight, the log of 21,000 grams was utilized in the above equation at zero swimming velocity to yield an oxygen consumption rate of 490 milligrams per hour, very near the observed value of 429. Interestingly, three other small bottom-dwelling members of the genus *Trematomus* would have lower rates for projections up to this weight. Although data are not available, the comparisons between the large *Dissostichus mawsoni* and the small *Trematomus borchgrevinki* might suggest that the amount of energy available for growth would be greater for the *D. mawsoni*, while the maintenance energy requirements would be greater for *T. borchgrevinki*.

### Energy conversion

Just how can this ecosystem beneath the ice support so many animals like fishes and seals, which are at the top of food pyramids? First, there is a considerable amount of photosynthesis beneath the ice. Second, there is a rather great mass of zooplankton and a rich assemblage of bottom invertebrate animals. But one of the most important considerations must be the efficiency of energy conversion from one pyramid (ecotrophic) level to the next. The high degree of scavenging among both vertebrates and invertebrates suggests that there may be a relatively smaller energy loss between ecotrophic levels from bacterial decomposition than may occur in more temperate marine ecosystems. There is still a rich field of ecological research in energetics of this under-ice ecosystem just awaiting investigators. Physiological mechanisms of cold adaptation are also important. Two examples of current research illustrate the diversity of physiological studies that are pertinent. Dr Arthur L. DeVries, now at the University of California at Davis, has discovered some unusual anti-freeze properties of the fish blood and is now studying their biochemical nature. Dr George N. Somero, at the University of British Columbia, is actively engaged in biochemical studies of enzyme systems involved in cold adaptation.

Perhaps the most interesting conclusion that can be drawn from our studies of Antarctic fishes is that both new ideas and

new techniques, along with new interpretations of older ideas, have evolved to the extent that Antarctic research results have already been the basis for new research in other less harsh seas.

Support for the studies on which this article is based was by a series of grants from the U.S. National Science Foundation during 1958-1965, when the author was at the Department of Biological Sciences, Stanford University, U.S.A. Gratefully acknowledged is the support by the members of the National Science Foundation's Office of Antarctic Programs, the various U.S. Navy Deep Freeze Task Forces who provided logistic support, and the many graduate students and technicians, of whom only a few are mentioned in the article.

---

## BOOK REVIEW

**PLANTS HARMFUL TO MAN IN AUSTRALIA,** by D. F. Francis and R. V. Southcott. *Miscellaneous Bulletin No. 1, Botanic Garden, Adelaide. 53 pp.*

As its authors indicate, this booklet is not intended for botanists but for the guidance of the medical profession and the general public. It is well written and presented, though the very brief descriptive notes and not very detailed line drawings (presented for some of the species only) will be of suggestive rather than diagnostic value for the identification of the plants concerned.

The booklet would have been more accurately entitled "Some Plants Harmful to Man in Australia". There are many toxic species which are not included, though most of the more notorious appear. It is surprising to find no mention, for example, of the poisonous properties of the Tung Oil tree (*Aleurites fordii*), of Inkweed (*Phytolacca octandra*), or of many other common species. The statements that marihuana or hashish (*Cannabis sativa*) is a narcotic and that its use is suppressed as being "a potent addiction-causer" are rather out-of-date in the light of many recent reports from pharmacologists that marihuana, illegal though its use may be, is neither a narcotic in the strict sense nor physiologically addictive. A few of the botanical names are out-of-date or misspelt.

The publication is a useful contribution to the semi-popular literature on poisonous plants in Australia but is certainly not a comprehensive handbook on the subject.—L. A. S. Johnson.

# Distribution and Adaptive Diversity of Trapdoor Spiders

By BARBARA YORK MAIN

Honorary Associate in Arachnology, Western Australian Museum, Perth

“UNIQUENESS”, “diversity”, “adaptive radiation”—these terms in reference to Australia’s fauna generally apply to marsupials, birds, or reptiles. Kangaroos and their allies, being the dominant mammalian group of the continent, naturally have attracted greater attention even than birds and reptiles and certainly a great deal more than the smaller and less conspicuous animal groups. Nonetheless, when carefully studied these, too, demonstrate the same phenomena of uniqueness, adaptiveness, and diversity. Certain invertebrate groups, by their very antiquity and their isolation from other continents, now represent the outcome of a long and gradual adaptation to the slowly changing environment of the Australian landscape. It is the *outcome*, as we see it today, of the radiation of trapdoor spiders that we shall discuss here. Of necessity, due to the absence of fossils of spiders, we must work “backwards” from what we observe today, in attempting to understand the present-day diversity.

If we consider, in the whole, the records we have made to date on the distribution of trapdoor spiders in Australia and Tasmania, against a background of observations on their natural history, we can make certain “guesses” regarding the relative ages of different forms and explain the persistence of some relatively unmodified forms in contrast to other less “stable” ones.

Firstly, by trapdoor spiders we mean all those spiders of the Mygalomorphae, which taxonomic group also includes “funnel-web spiders” and many other forms which do not in fact construct a door to the burrow. Structurally, spiders of this group are recognized by the presence of two pairs of lung books (breathing organs) and the horizontal, parallel chelicerae (jaws) of which the fangs, instead of being like pincers, strike like those of a snake (figure 1, a, b). Five of the eight (generally accepted) families of Mygalomorphae occur in Australia, although only three of these occur in



Plate 1. A spider of the genus *Ixamatus* (Dipluridae: Diplurinae).

Tasmania. Very generally, the basic structure of spiders of a particular family determines the sort of habitat its representatives can live in. For example, the Ctenizidae, of which all members have a digging rake of teeth, or rastellum (figure 1, c) on the front of the chelicerae, often occur in extraordinarily hard, compacted, and stony soils. In contrast, most Dipluridae, lacking such a rake, are restricted to more friable or sandy soils and forest humus and moss. They are generally the dominant Mygalomorphs of wet forest floors, having silken tubes and sheet webs in natural crevices, rotting logs, and debris. However, in dry inland areas several genera have developed tooth-like spines on the anterior inner angles of the chelicerae. Such genera parallel the Ctenizidae in their behaviour and similarly are proficient burrowers.

## Life-cycle of trapdoor spiders

Trapdoor spiders are tubicolous and essentially terrestrial; a few live in the moss and bark of tree trunks. The life-cycle is

long, spiders taking several years to mature, after which males live only a short time but females live on for several years, often raising successive broods. Except for "wandering" males, a spider lives out its entire life within the one burrow, which it enlarges according to its own growth. Mating takes place in the female's nest, where eggs are deposited in a silk cocoon. After hatching, the spiderlings remain in the parent burrow for several months before dispersing. The burrow, whether closed by a door or not, is thus a permanent retreat, a mating and brood chamber, and serves as an "ambush" site for prey capture. It is a shelter against the vagaries of weather and the dangers of predators, and during long periods of enforced fastings due to drought. Dispersal of young usually takes place simply by the spiderlings running out over the ground until they begin excavating their own burrows—except in the genera *Missulena* and *Conothele*, which are dispersed on gossamer. Wandering of males and, therefore, mating, and dispersal of young, are

dependent on seasonal rain. Thus we find that certain genera and species have their reproductive behaviour associated with autumn–winter rain, others with the late spring break of a "dry", some with summer rainfall, while some inland species are dependent on sporadic summer thunderstorms to stimulate the reproductive cycle. Because of the longevity of females and the great protection afforded by sealed burrows, the spiders (as populations) are able to persist through seasons of drought. During adverse periods dispersal and/or mating may be suspended for one or several seasons. This method of survival is in direct contrast to that of short-lived spiders, which may be exterminated in one area during an unfavourable season but which, because of aerial dispersal on gossamer, are able to colonize from other localities during subsequent more favourable seasons.

#### Adaptive diversity

Within particular groups adaptive diversity is expressed in several ways—morphological, burrow structure, method of prey capture, seasonal breeding time, and, presumably, physiologically. To illustrate more fully what we mean by adaptive diversity of a group we will select the genus *Ixamatus* (Dipluridae) (plate 1). This genus occurs in southeast Queensland, northeast New South Wales and southwest Western Australia. Such a disjunct distribution is interpreted as implying a once widespread range in perhaps a diagonal southwest–northeast trend across the southern part of the continent: the southwestern and eastern groups would thus represent terminal relics of a former range. This distribution has a rough parallel with the thicket-inhabiting scrub-birds (*Atrichornis*).

*Ixamatus* typically occurs in damp boggy situations which may be waterlogged in winter and which in summer may remain moist or, alternatively, dry out at least on the surface.

The eastern species have a simple, obliquely angled, open-holed burrow and occur in damp humus and open patches of damp friable soil in rainforest and southern beech forest. However, in Western Australia species occur in a variety of habitats, from the thicket-grown peaty bogs along gullies in the jarrah forest of the Darling Range, peaty bogs of the south coast, meadows fringing

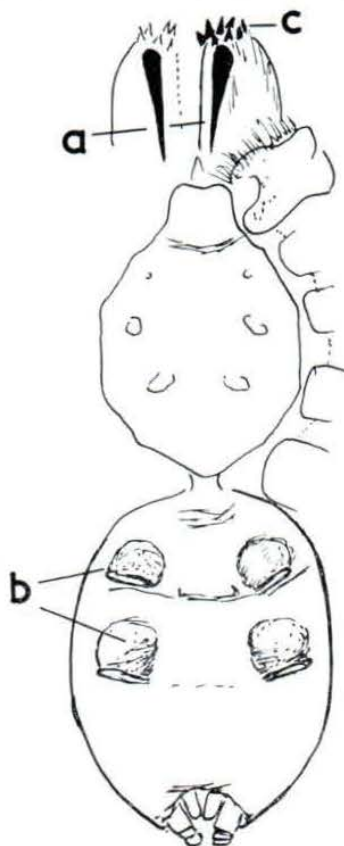


Figure 1. Ventral view of the body of a trapdoor spider, showing: a, parallel fangs; b, opercula of lung books; c, rastellum.

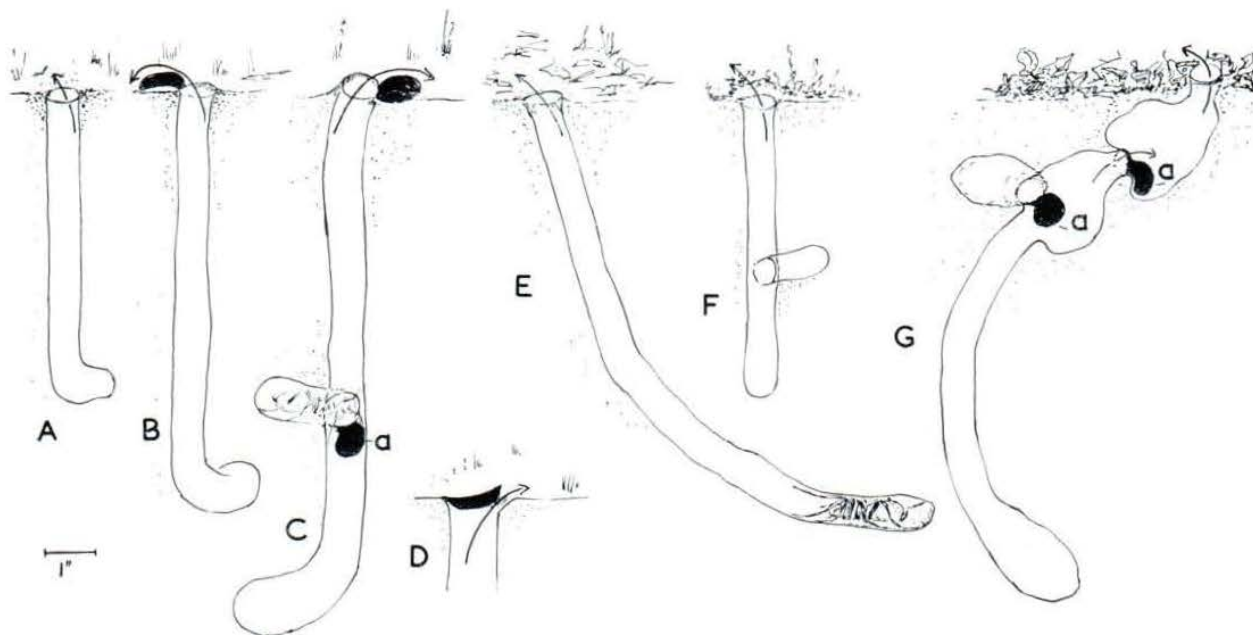


Figure 2. Sections of burrows of Dipluridae: E, F, G, *Ixamatus*; E, simple burrow; F, slightly modified burrow with simple side-shaft; G, complex burrow of the "goldfields" species, doors (a) in "open" position. A, B, C are burrows of three species of another genus which has independently developed a door-building habit, (a) being door of side-shaft in "open" position. D, section through the entrance of a burrow of a "typical" trapdoor spider (Ctenizidae). Note: the arrows indicate the position of spiders when in "feeding stance".

granite tors and cord-rush, summer-dry "bogs" of the inland wheatbelt, to the "islands" of braided creek courses of the eastern goldfields (east of Coolgardie-Kalgoorlie and south to Norseman). Most of these situations, although waterlogged or "boggy" for part of the winter, and sometimes subjected to sudden sheet-flooding, are for a part of the summer dry on the surface.

It is known from fossils that during the early Tertiary the Southern Beech (*Nothofagus*) occurred near Coolgardie. Furthermore, for part of Tertiary time a marine embayment extended northward to about the area where *Ixamatus* now occurs. In the light of what we know of Miocene climates and the requirements of *Nothofagus* we can assume that at that time the habitat for the spiders would probably have been, in many of its characteristics, close to that pertaining to some of the mountain habitats of the present eastern species. It is well known that the climate for the whole general region of Western Australia under discussion was also much more humid in a part of the Miocene than it is today, after which a fall in sea-level was accompanied by progressively drier conditions. Thus it would seem that

the pockets of western *Ixamatus* populations represent relics which have persisted with varying degrees of adaptation to a changing climate and physical environment.

It is significant that the forms found in the peaty bogs of the Darling Range are morphologically most like those of the eastern populations and have a simple burrow, except sometimes for a lateral pocket just above the high water "mark" of the waterlogged soil. During summer when the surface dries out the burrow is sealed with a soil plug and the spider retreats to the bottom of the burrow. It is the "goldfields" species which is morphologically distinct and has a highly modified burrow. Also, it does not mate in the spring as do the primitive eastern forms and little modified Western Australian forms, but in autumn-early winter. The burrow is complex (plate 2 and figure 2G). There is a small entrance opening into a large chamber which leads through a hinged door into the main vertical shaft, across which another door opens into a small horizontal side-shaft. This type of burrow is of particular interest because two diplurid genera (both in southwest Western Australia) have independently developed the

door-building habit. Such door-building in Diplurinae is unique and is convergent to the behaviour of Ctenizidae ("typical" trapdoor spiders) and to some extent Barychelidae and Migidae. However, the diplurids adopt a completely different stance in relation to the door when feeding. A "typical" ctenizid sits in the burrow with dorsum to hinge and facing the aperture of the burrow from beneath a slightly open door (figure 2D); it then leaps forth, emerging only partly from the burrow, to catch prey. The diplurids have the door opening flat, and the spider sits poised across the hinge line with legs spread out over the upturned underside of the opened door (figure 2, B and C) and thus catches prey at the "back" instead of the "front" of the burrow. While holding the prey the spider drops backwards into the burrow, pulling the door down as it does so.

In both door-building diplurids the doors are thought to be (in part) a protection against flooding. The "goldfields" species of *Ixamatus* lives in the deep litter and flood detritus which accumulate as "islands" around the butts of trees and against shrubs and logs in braided, spasmodically flowing creek courses. The entrance chamber is thus a feeding chamber and sometimes a prey trap, which mechanically could not support a flood-proof "plug" door at the opening into the litter—this has been accomplished at the bottom of the antechamber. Species of the other Western Australian genus, which occur in open, lightly littered or bare ground of low-lying areas subject to flooding, have their doors flush on the surface of the ground (figure 2, B and C). [For discussion of a similar anti-flooding device in aganippine trapdoor spiders (Ctenizidae), see my article in *The Australian Museum Magazine*, Vol. 12, No. 5 (1957)]. The side-shaft in both diplurid genera is probably used as a brood chamber.

Thus it would seem that the adaptive radiation of *Ixamatus* (and the other genus mentioned) has been in response to change from uniformly moist weather conditions to a climate having alternating wet and dry seasons, where sudden heavy rains present both a hazard in flooding burrows and a stimulus to breeding and dispersal. The main adaptations within the genus are diversity of habitats occupied; modification



Plate 2. View of a burrow, which has been excavated from the side, of the "goldfields" species of *Ixamatus*. See also figure 2G, an outline drawing of the same burrow, and the text, for explanation.

of burrows; method of prey capture in relation to modified burrow; and change in season of breeding and dispersal.

#### Role of trapdoor spiders as predators

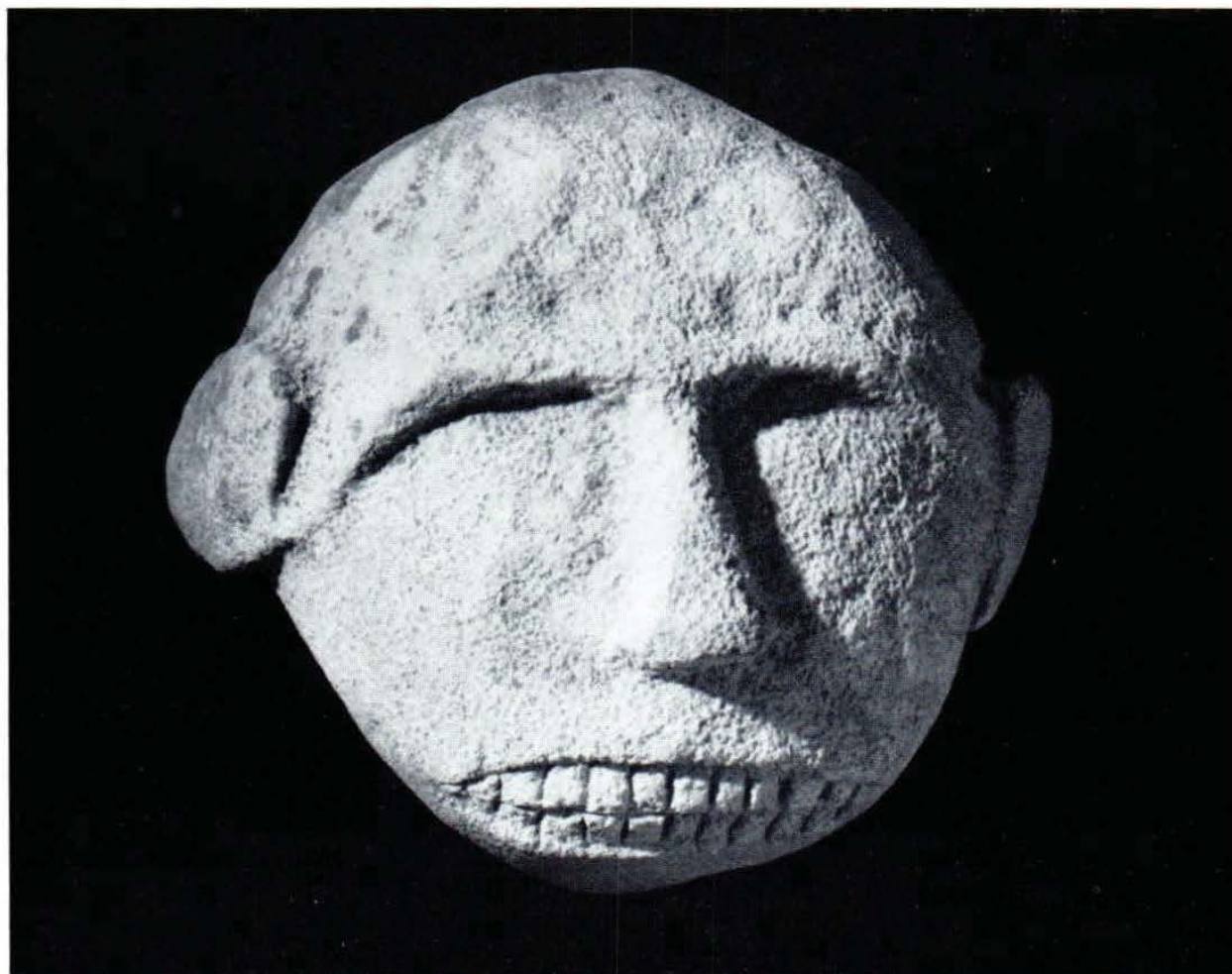
In Australia Mygalomorph spiders are probably the dominant group of invertebrate predators in terrestrial habitats. In semi-arid areas they are, apart from reptiles, almost undoubtedly the dominant terrestrial predators. In any one locality this is evident from the density of single-species aggregates. As many as twenty-six specimens of the trapdoor spider *Anidiops villosus* have been observed within the litter zone of a single isolated acacia shrub in mulga woodland. Within the same zone eight diplurid burrows were also present. Frequently six different species (representing perhaps three different families) may be found in close proximity within a habitat which

shows little apparent variety. Such density and diversity of species are all the more remarkable when one considers that individual spiders are almost completely sedentary, being confined, even when foraging, either directly to a burrow or at least within a very short distance of it. Unlike scorpions, centipedes, crickets, and even burrowing wolf spiders, trapdoor spiders do not roam away from the precincts of the burrow when hunting. This extraordinary predator density in semi-arid areas is associated with the abundance and variety

of ants and the density of litter-and-grass-foraging termites and, to some extent, of moths.

A comparable density and diversity of species may be found in the subtropical rainforests of southeast Queensland and northeast New South Wales, where the forest floor provides a multitude of minor habitats and a variety of prey unequalled anywhere else on the continent.

[Illustrations in this article are by the author.]



This remarkable prehistoric stone carving, of unknown antiquity and origin, from Gatakai Islands, Solomon Islands, will be one of the exhibits in the Australian Museum's new exhibition of Melanesian art, which will be opened by His Excellency, the Governor of New South Wales, Sir Roden Cutler, on 10th July. The display will occupy the whole of the third floor of the Museum's new wing.

# BOOKS ON BIRDS REVIEWED

**AUSTRALIAN BIRDS**, by Robin Hill, published by Thomas Nelson (Australia) Ltd, Melbourne. Price, \$16.00.

After the tremendous publicity given this book it is with sadness that one finds that, as regards accuracy, it is no better than the books to which the author refers in his preface when he says "even the best books readily available are rather poorly illustrated". Many of the plates are inaccurate, with wrong colours of the beaks and eyes, wrong numbers of wing feathers, and wrong proportions.

In the plate of the Golden Bower-bird on pages 160-161 there are far too many secondaries and secondary coverts shown, and the reviewer knows of no bird in the world with a single coloured feather on the crown as shown. The yellow on the crown is actually formed by normal-shaped yellow crown feathers forming a yellow area at the back of the crown. The illustration of the bower is also wrong. There should be a horizontal branch or stick across between the walls, on which the bird displays. The walls themselves are shown incorrectly; they are not upright, as in the avenue builders, but are formed of a maypole of sticks criss-crossed on top of each other.

On page 171 the female Grey-crowned Babbler is shown differing from the male in having a fawn and not a whitish throat, when in fact they are the same. On page 15 the Yellow-faced Cormorants are shown with black and not yellow faces. The Lewin Honeyeater on page 223 is shown with bright-blue ear patch instead of dark grey in front of yellow. On page 93 the tail of the male Red-tailed Cockatoo is too short and the pale bill is that of the female bird.

One last example of the many errors, both small and large, in the illustrations is the male Superb Lyrebird on page 139. The tail is wrongly illustrated, with the colours of the underside depicted as appearing on the upper side.

There are several cases of captions being wrong—for instance, on page 25 the adult Nankeen Night Heron is labelled immature. On pages 64-65 the captions are wrong and an attempt has been made at correction in the corrigenda on page 268, but this is still wrong. The bird on the left is a Masked Plover, the bird in the centre a Spur-winged Plover, and that on the right a Banded Plover.

The text is pleasant and easy to read, but again there are errors. In the Grey-backed Silvereye on page 256 it is stated that "in the winter the flanks of these birds become a much richer, tawny, buff colour than in the present summer dress". Dr A. J. Keast showed in 1958 that, although there is a body moult before and after breeding,

the plumage is similar, and the birds with richer tawny buff flanks are the southern breeding birds, which migrated north in winter and mixed with the local pale buff birds in the winter flocks.

There is a very useful chapter on the classification of birds at the beginning of the book, and also the *Royal Australasian Ornithologists' Union's Official Checklist* (1926) of the orders and families of Australian birds, which has long been out of print and unobtainable, and the more recent *Handlist of the Birds of South Australia* (1962) by H. T. Condon.

The bibliography at the end shows that a great effort was made to consult all the available literature, but it is sad that what should have been a valuable addition to Australian ornithology has been spoilt, apparently by being too hurriedly compiled. A book of this sort with so many errors is a nuisance to the expert, as he does not know, without checking elsewhere, what can be accepted, and the layman has no chance of finding out. Therefore, the book cannot be quoted as an authority.—H. J. de S. Disney.

**BIRDS OF AUSTRALIA: Eighty Lithographs of John Gould, with text by A. Rutgers. Two volumes, published by Methuen, London. Price, \$5.80 each.**

The reproductions of Gould's plates are good and they give an idea of the tremendous amount of work he accomplished. It is sad that the modern text does not really do credit to the plates. For example, the author should not have had the text for a Stone or Bush Curlew (*Burhinus magnirostris*) opposite the plate of the Beach Curlew (*Orthorhamphus magnirostris*). He would not have labelled all the Bronze Cuckoos opposite page 106 as the Shining Bronze Cuckoo, as in Gould's original folio, if he had consulted Gould's *Handbook to the Birds of Australia*, published in 1865, on page 626 of which Gould correctly states that the lower figure is an adult Narrow-billed Bronze Cuckoo and the upper figure a young one.

The author apparently has not checked the text carefully, otherwise he would not say that each egg of the Mallee-fowl weighs over 3 pounds, or about the weight of an ostrich egg. Volume 2 also contains incorrect statements on the plumage of several species—for example, that the male Flame Robin has a dull winter plumage like the female and that the adult female Black-faced Flycatcher has no black face and is all grey like the immature bird.

This book is worth buying for the plates alone, but the errors in text are regrettable.—H. J. de S. Disney.



# The Little Bent-winged Bat— Evolution in Progress

By P. D. DWYER

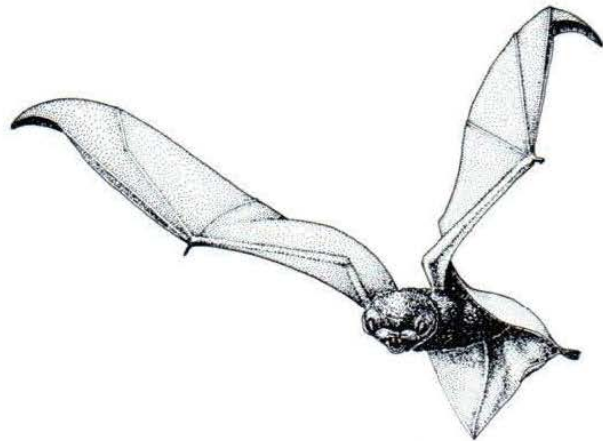
Lecturer in Zoology, University of Queensland, Brisbane

WHEN a species expands its range into areas of different climate, adaptive changes are likely to be called for. During the past century the Queensland Fruit Fly has extended its range southwards, through New South Wales to Victoria, and has, at the same time, undergone progressive physiological adaptation to the increasingly severe climatic conditions of more southerly latitudes.

Too seldom do biologists have the opportunity to witness such instances of evolutionary change. The emergence of populations of black Peppered Moths in industrial areas of Britain, where soot pollution led to blackening of tree trunks and, thereby, decreased the likelihood that black individuals would be preyed upon by birds, stands out as an unrivalled example of natural selection in action. Evolutionary change is, however, generally more subtle than this. Overt morphological changes are not the rule. Interactions between the environment and the genetic endowment of the species are complex, and the time scale is typically long. As a result, current evolutionary changes in populations are difficult to detect. The present article discusses the biology of Little Bent-winged Bats (*Miniopterus australis*) in New South Wales and suggests that here, at the southern limit of the species distribution, adaptive changes are occurring and that these are in such a direction that further range expansion may eventually be possible.

## Biology of *M. australis*

In New South Wales *M. australis* occurs as colonies in caves and mine tunnels of the subtropical coastal belt. It is found south to the Macleay River area, about 200 miles beyond the Queensland border. Unlike its larger relative, *Miniopterus schreibersii*, which is common at the higher and colder altitudes of the coastal escarpment and tablelands and which occurs further west on



A Bent-winged Bat in flight.

the slopes country, *M. australis* is seldom found away from the coastal lowlands. A few colonies have, however, been found in limestone caves of the escarpment at the southern limit of the species distribution.

The Macleay population of *M. australis* has been studied for several years. Visits to colonies at all seasons have revealed patterns of change in numbers, and in sex and age composition, through the year, while a mark-recapture programme involving some 1,600 individuals has shed light on movement patterns.

Diagram 1 shows annual changes at the Willi Willi Cave. This cave serves as a nursery at which all adult females in the population aggregate in spring to give birth and to rear their single young. In March, when the young are independent of their mothers, the nursery colony disbands and disperses from Willi Willi into other caves of the Macleay Valley. Willi Willi Cave is on the foothills of the coastal escarpment and the bats move up to 37 miles to wintering sites that are situated either on the coastal lowlands or at higher altitudes of the escarpment. Females that move to Willi Willi from lowland caves return to low altitudes and, similarly, highland females return to their original caves. Banded

individuals have not been found to move between highlands and lowlands, and it appears that the total population is split into two subpopulations that seldom exchange adult individuals. Young bats, however, probably disperse at random to highland and lowland sites.

The behaviour of these subpopulations of *M. australis* differs in some respects one from another. Mating in the Macleay area occurs through June and July but is, on the average, somewhat earlier in the highland subpopulation. Highland individuals show some increase in weight (about 4 per cent) before winter while lowland individuals do not, and, correlated with this, is the observation that lowland individuals are more active through the winter months, feeding more regularly and being less often found in a torpid state.

#### Comparative biology and the past

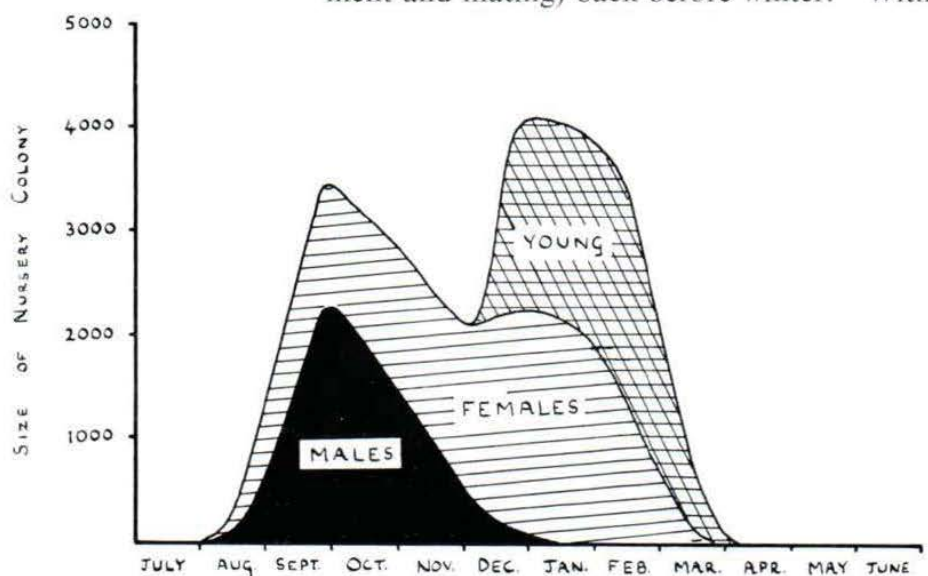
Evolutionary hypotheses derive from two broad classes of evidence: historical (essentially from the fossil record) and comparative. In the present study palaeontological evidence is of little help. There is no fossil record of the genus *Miniopterus* and, hence, we do not know when these bats originated. However, the distribution of miniopterine bats is primarily Indo-Malaysian and this suggests that Australian representatives entered from the tropics. In colonizing southwards, therefore, they were faced with increasingly severe environments — environments in

which cave temperatures became increasingly cool and inappropriate to their peculiar metabolic demands, and environments in which the availability of insect-food through winter became increasingly limited. Some adaptive changes would be likely in such circumstances and, in fact, these may be inferred by comparing the biology of the two species in tropical and temperate latitudes. In effect, this comparison of present-day populations to interpret the past amounts to the conversion of space into time; characteristics of tropical populations today are assumed to most nearly reflect ancestral conditions while cold-adapted populations are seen to have diverged from these.

The reproductive behaviour of *Miniopterus* varies with latitude. In north Queensland (i.e., Cape York) mating, in both species, occurs in August and the young are born in December. In New South Wales, however, *M. australis* mate through June and July. Thereafter, a period of delayed embryonic development occurs till mid-September, and the young are again born in December. The cycle in southern populations of *M. schreibersii* involves even earlier mating (late April and May) and a longer period of delayed development of the embryo (see diagram 2).

From these observations it may be surmised that colonization southwards, into cooler latitudes, by *M. schreibersii* has been paralleled by shifting the early phases of the reproductive cycle (i.e., sperm development and mating) back before winter. With

Diagram 1. Annual changes in the size and composition of the nursery colony of Little Bent-winged Bats at the Willi Willi Cave, Macleay Valley, New South Wales.



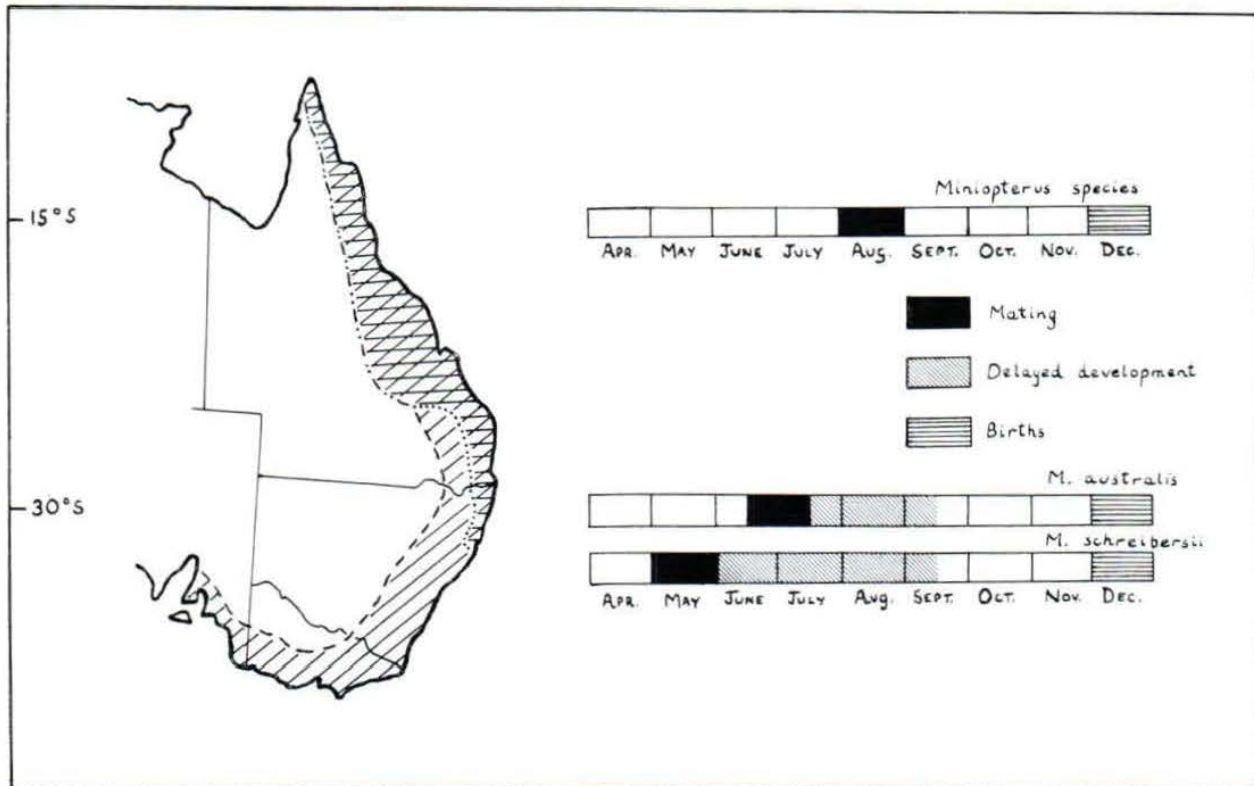


Diagram 2. The distribution of Bent-winged Bats in eastern Australia. *M. schreibersii* is shown by the total shaded area, *M. australis* by double crossing-hatching. The timing of the reproductive cycle is shown on the right. At 15° S. the cycle in both species is the same; at 30° S. the two species are shown separately.

mating behaviour accomplished before the onset of winter there would be no necessity to remain active through these months, and consequently "hibernation" could be expressed strongly in the season of food scarcity. In New South Wales wintering behaviour of *M. schreibersii* involves extended periods during which feeding ceases, and may involve as much as a 20 per cent increase in weight before winter. The southern population of *M. australis* is intermediate, both in reproductive and wintering behaviour, between populations of either species in North Queensland and populations of *M. schreibersii* in the south. It therefore represents a stage through which *M. schreibersii* must have passed at some time during its dispersal southwards. And, further, there is the implication that *M. australis* has arrived at southern latitudes since *M. schreibersii*; that it has had less time to achieve the same degree of reproductive modification as the latter species.

This last suggestion raises an additional issue. At southern latitudes the nursery

colonies of both species occur in caves of such a structure (i.e., domed ceilings or enclosed chambers) that the activity of the thousands of individuals comprising each colony warms the air inside the cave. In this way the nursery caves are converted into giant incubators in which the young can be successfully protected from the stresses of low temperature. This behaviour would not be necessary in tropical latitudes; unmodified cave temperatures would be naturally appropriate to nursery requirements. But the dispersal of species into new areas is typically the role of one, or a few, individuals and in the case of *Miniopterus* this would hardly seem possible. A few individuals would never be able to warm a cave to appropriate levels! Fortunately, a solution to this paradox is apparent for *M. australis*. In the Macleay area this species shares nursery quarters with a much larger (about 12,000 adults) colony of *M. schreibersii* and it is the latter species that is primarily responsible for warming the cave. Since *M. australis* appears to have colonized southwards later than *M. schreibersii*, it may

be that it has merely taken advantage of pre-existing nursery facilities. It would only be necessary for a few dispersive individuals to chance upon a nursery of the larger species for southward colonization to be successful. At present, however, the same paradox remains unresolved for *M. schreibersii*, though it is probable that the process involved was quite different to that in *M. australis*.

#### Evolution today

At the present time the distribution of *M. australis* in New South Wales is limited. To the south and west the winter climate becomes increasingly severe. Populations probably could not survive in these areas unless the reproductive cycle approximated that of *M. schreibersii* and wintering behaviour could, thereby, be expressed as strongly as in this latter species.

But the differences between highland and lowland subpopulations of *M. australis* from the Macleay area suggest that appropriate changes are currently in progress. In the highlands mating occurs somewhat earlier than in the lowlands. No such difference has been detected in *M. schreibersii*. All New South Wales populations of *M. schreibersii* show far more synchrony in mating than do the two geographically close subpopulations of *M. australis*. And this is so in spite of the greater range of climates with which *M. schreibersii* must contend.

Highland *M. australis* are exposed to consistently lower cave temperatures than individuals colonizing lowland caves. Earlier mating in the highlands could, therefore, be advantageous in permitting an increase in the length of "hibernation", and, thereby, enhancing the probability of survival through the winter. It may be argued then, that natural selection, operating through ability to withstand winter conditions, is favouring earlier mating in the highland subpopulation. The random dispersal of young through both highlands and lowlands would result in continual dilution of the lowland subpopulation by individuals that mated earlier. The detected differences between the two subpopulations merely express a time lag in this process of dilution. Given enough time, therefore, the reproductive cycle in the entire *M. australis* population may be shifted back to match that of *M. schreibersii*. If this happens, then the current limitations imposed

upon the distribution of *M. australis* would no longer apply, and further expansion of range southwards and westwards could occur.

The study of *M. australis* discussed here represents only a part of a far more complex whole. It was developed as an appendage to a continuing study of *M. schreibersii* in eastern Australia in the hope that clues to the past of this species might emerge. That this is considered to have happened should be apparent above. But what should also be apparent is that this study raises additional questions. The problem of the origin of *M. schreibersii* in southern latitudes has already been mentioned. Many other issues remain unanswered as well. Until all these can be accommodated within a single unifying hypothesis I must remain suspicious of current interpretations. What has happened in the past can never be known for certain. But despite this, the jig-saw puzzle of evolution calls insistently for solution. We can do no less, therefore, than to try.

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

---

## BOOK REVIEW

**POSSUM MOODS**, by Paule Ridpath. Published by Ure Smith, Sydney, London. Price, \$2.95.

The common Brush-tailed Possum (*Trichosurus vulpecula*) is a plentiful marsupial well known to the majority of Australian urban dwellers. However, very few people who encourage these animals around their houses in the suburbs have much knowledge of their general natural history.

Paule Ridpath's book, which is delightfully written and beautifully illustrated, introduces many fascinating aspects of the biology of the Tasmanian form of this species. This book could not help but awaken a sincere interest and appreciation of the native fauna on the outskirts of our cities.

With little capital outlay and without having to leave her own garden, Paule Ridpath has shown that it is possible to strike up a rewarding and stimulating acquaintance with a wild native marsupial.—*B. J. Marlow.*

#### CORRECTION

In the article "Mangroves and their Fauna" in the March, 1968, issue of this magazine, it was incorrectly stated, through no fault of the author, that an accompanying photo of the mudskipper *Periophthalmus chrysospilos* was taken in Mozambique. It was actually taken in Malaya.

# ECOLOGICAL ASPECTS OF SERPULID FOULING

By DALE STRAUGHAN

Zoology Department, University College of Townsville, Queensland

THE family Serpulidae (phylum Annelida, class Polychaeta) is composed of worms which secrete a calcareous tube. Anyone exploring exposed rocky shores in southern Australia will see masses of calcareous tubes of *Galeolaria caespitosa*. Along northern Australian shores, *Pomatoleios kraussii* occupies this zone. Most serpulids possess an operculum (plate 1) which is used to close the tube entrance. The operculum is either calcareous or chitinous and may be adorned with a variety of hooks or spines (plate 2).

The worms also possess a pair of branchiae (gills) which are arranged in semicircles (plate 1) or spirals. Most visitors to the Great Barrier Reef are familiar with the colourful Peacock Worm, *Spirobranchus giganteus* (large spiral branchiae), which is common in the coral. The coral grows over the tube and obscures it so that the worm appears to be living surrounded only by coral. The branchiae are used mainly for collection of food, and not, as their name suggests, for respiration. Respiration occurs through the surface of the thoracic membrane and collar.

## Economics and ecology

Usually serpulids cement their tubes to the substrate (plate 3A), but certain species in dense populations build tubes vertical to the substrate in clumps and cement the tubes to each other (plate 3B). Control of this type of fouling on submerged marine structures is a serious economic problem. The questions that now arise are: Why do some species form dense clumps of this kind and other species do not? What are the conditions that allow the former species to grow to this extent in some localities and not in others? In the Townsville, Queensland, region, for example, several species of *Spirobranchus* are abundant in coral at Magnetic Island but are rare at mainland localities. On the other hand, *Pomatoleios kraussii*, *Hydroides basispinosus*, and *Serpula vermicularis* are abundant at marine mainland localities but

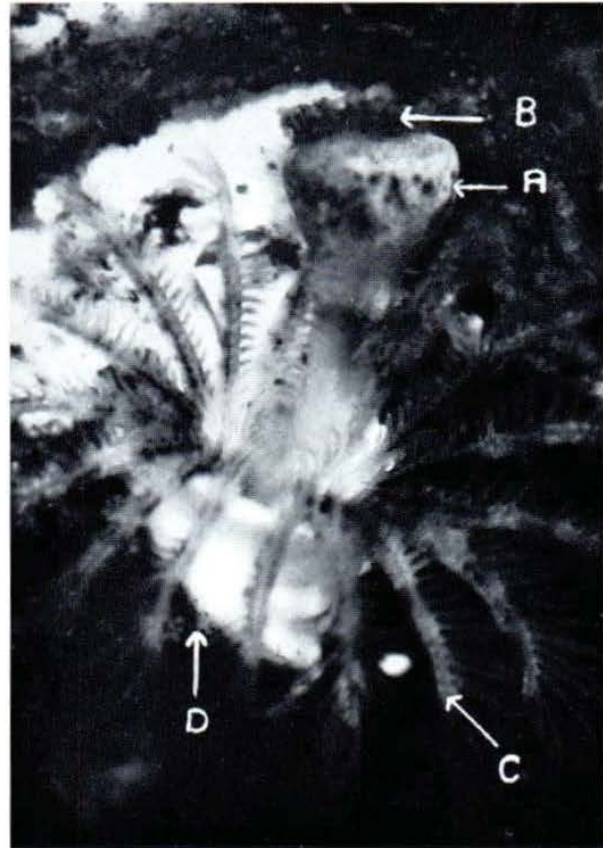


Plate 1. *Mercierella enigmatica* collected from the Brisbane River, Queensland. A, operculum; B, opercular spines with trapped mud; C, branchiae; D, tube. The diameter of the tube is approximately one-twelfth of an inch.

do not occur on the Magnetic Island coral, while *Mercierella enigmatica* commonly occurs in the Ross River nearby. These species live under different ecological conditions: *Spirobranchus*, on a coral substrate in clean well-aerated water; *P. kraussii*, the upper surfaces of a solid substrate in a more sheltered area, which is usually muddy; *H. basispinosus*, the upper surfaces of a solid substrate in a fairly exposed area, which may be a little muddy; *S. vermicularis*, the lower surface of a solid substrate. These species occur in sea-water, while *Mercierella* occurs in brackish water.

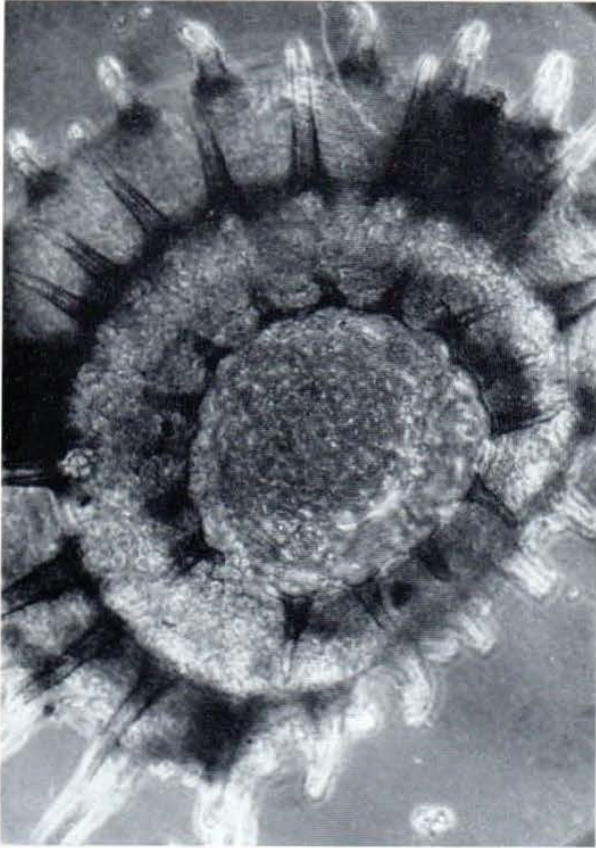


Plate 2. The cleared top of an operculum, showing three rings of chitinous spines.

Maritime installations often provide conditions not typical of an area, and the distribution and abundance of fouling organisms may differ from those found under normal conditions. Normally *P. kraussii* is abundant on solid substrate in a zone extending from 1 to 4 feet above mean sea-level. However, in the Northern Electricity Authority intake chamber at the mouth of Ross Creek, Townsville, *P. kraussii* is common from 4 feet above mean water-level down to mud-level, 25 feet below mean water-level. The subtidal fauna in the intake chamber is composed of fewer species than occur at similar levels outside the chamber, so that it is possible that reduced competition allows the serpulids to survive at lower levels. Within the normal range, competition from *Balanus amphitrite* causes the reduction in abundance of *P. kraussii*. Within its extended range, *P. kraussii* also changes its form of tube growth. Normally the tube has a wide dorsal ridge which protrudes over the mouth of the tube, while the ventral side is firmly attached to

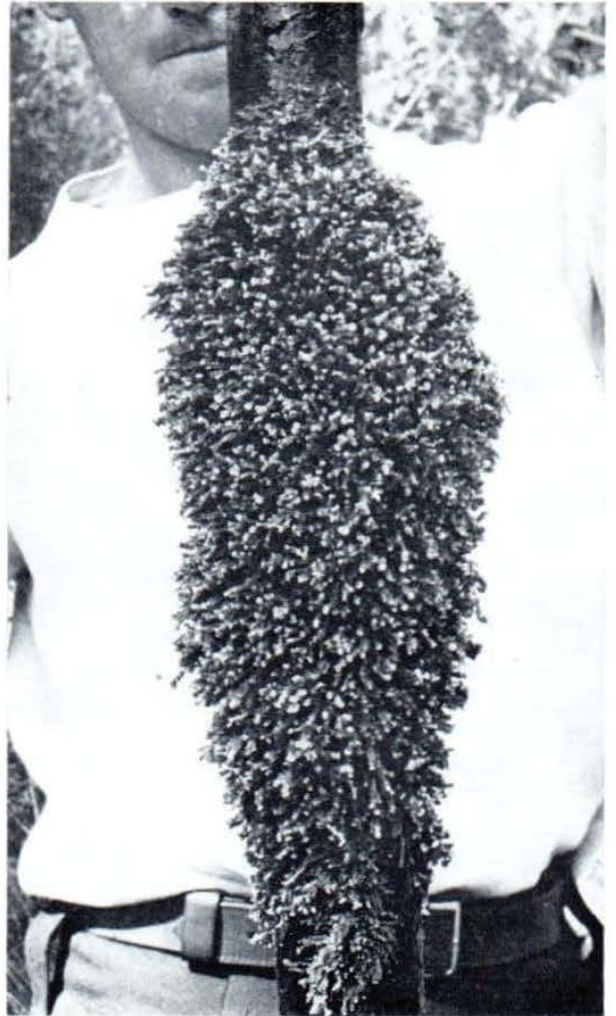


Plate 3B. *Mercierella enigmatica* on a jetty pile about 10 miles from the mouth of the Glenelg River, Victoria. [Photo: I. D. Hiscock.]

the substrate, which may be rocks, cement, or other *P. kraussii* tubes. However, subtidally within the intake chamber, the dorsal ridge is reduced and the tubes tend to grow vertical to the substrate with their ventral surfaces only attached to solid substrates at their base. Other fouling of a non-calcareous nature rapidly accumulates between these vertical tubes. This type of fouling can cause large reductions in the diameter of pipes—for example, a pipe 2 feet in diameter could have its effective diameter reduced by 2 to 4 inches in 2 months during summer.

#### Life-history of a serpulid

Before continuing the discussion of "which species settle where, and why", a brief survey of the life-history of a serpulid will be



Plate 3A. *Mercierella enigmatica* on stones in 6 inches of water at low tide, 5 miles from the mouth of the North Pine River, South Queensland. [Photo: O. Wiseman.]

helpful. The species chosen for description is *M. enigmatica*, which occurs from the river mouth upriver for 30 miles in the Brisbane River, Queensland, while in the Ross River the upstream spread of the species is barred by a weir a few miles from the river mouth.

The adult population is composed of males, females, and hermaphrodites which are at first male and later female. Eggs and sperm are shed on neap tides during the summer months. The eggs are irregular in shape when released and gradually become rounded in the water. Mature eggs have an outer orange cytoplasm surrounding a lighter coloured nucleus with a darker nucleolus (plate 4a). Plate 4 also shows large fertilized eggs with no visible nucleus (b), and small immature eggs lacking a nucleolus (c). The sperm have round heads and long, rapidly vibrating tails. They are released from the abdominal cavity in clusters. About 15 minutes later, all active sperm are concentrated around mature eggs. Small round spots on plate 4d indicate the presence of spermatozoa.

After fertilization, the fertilization membrane separates from the outside of the

egg. Two polar bodies are formed and these lodge under the yolk membrane (plate 5A). The egg divides (plate 5B) into numerous small cells until it looks like a mulberry (the morula stage). The cells then become rearranged to form a hollow sphere called the blastula, which is covered with waving hairs known as cilia. All this happens within 3 hours of fertilization at temperatures of 25° C. Blastulas develop into a stage called trochophores within 18 hours of fertilization at 25° C. These free-swimming trochophores have an apical tuft formed by several long cilia, a band of waving cilia (the prototroch) in front of the mouth around the equator (plate 5C), and, in addition, some cilia around the mouth and anus. Rotation of the trochophore is maintained by beating of the prototroch cilia, and forward motion by pulsation of the upper portion of the animal. For the first 2 to 3 days, trochophores swim near the water surface. They disperse during the next 10 days, and later congregate near the substrate.

A large stomach develops by the third day (plate 5D) and a ciliated gut is well formed by the sixth day. The gut continues to develop and elongate during larval growth. After

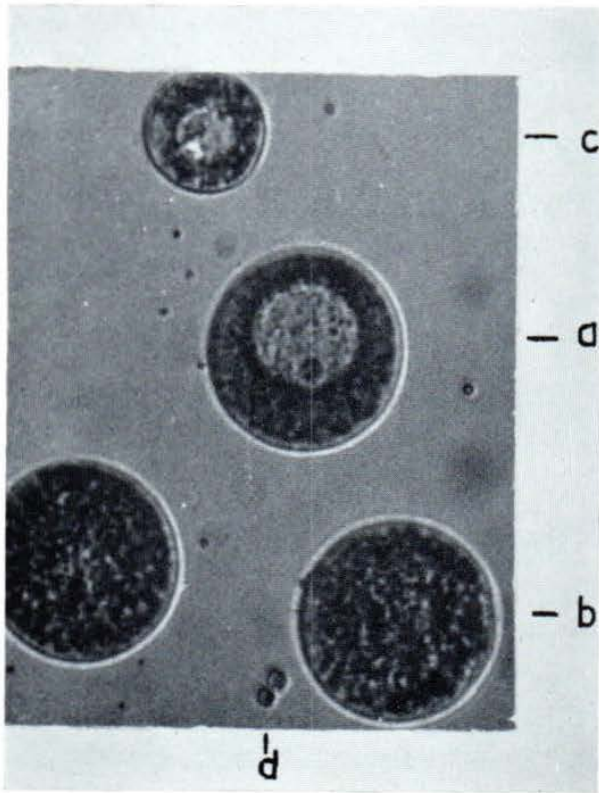


Plate 4. *Mercierella enigmatica* eggs: a, mature eggs; b, fertilized eggs (0.2 mm diameter); c, small immature eggs; d, spermatozoa.

the sixth day, the animal becomes elongated posteriorly and there is a gradual reduction in size anterior to the prototroch. Two setigerous segments develop posterior to the prototroch by 13 days and a third by 17 days.

Once the larvae have developed three setigerous segments posterior to the prototroch, they start to "search" for a suitable place to settle. The larvae move over the substrate for a short distance with their anterior end opposed to the surface, then swim for a short distance before examining the surface again. This enables the larvae to avoid unfavourable areas for settlement and so "choose" a settlement site.

#### Factors influencing *Mercierella* settlement

Field experiments on larval settlement, when different types of solid substrate were offered, show that there are marked differences in the abundance of settled larvae on different types of surfaces. Settlement is more abundant on a rough surface than on a smooth surface, on an opaque surface than

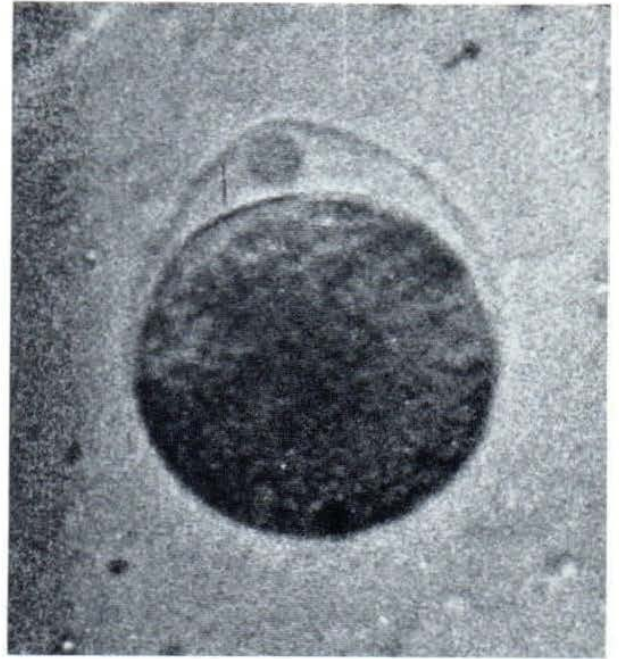


Plate 5A (above). *Mercierella enigmatica* egg with first polar body under the yolk membrane.

Plate 5B (below). The first cleavage of eggs. Eggs are approximately 0.2 mm in diameter.





on a transparent surface, on a dark surface than on a light surface. Likewise, the angle of the exposed surface, exposure to tidal currents, exposure to river currents, stage of development of initial layer of microorganisms on the surface, presence of other species of fouling organisms, and presence of already settled *Mercierella*, all influence the abundance of larval settlement on a surface.

As stated previously, *Mercierella* breeds on neap tides during the summer months. Larval development takes approximately 3 weeks, so that peaks in larval settlement occur on spring tides. Settlement is not of equal intensity during all periods of summer spring tides. Riverflow during the free-swimming stages is one factor that can change the abundance of larval settlement. If there is a heavy freshwater runoff in the river while the larvae are dispersed in the water, larval settlement is very low in numbers. (The larvae are killed by the lower salinity and/or washed out of the river.) If there is freshwater runoff in the last few days of the free-swimming stage, larval settlement occurs closer to the river mouth than prior to the fresh.

The Brisbane River catchment is in an area of relatively dry winters and wet summers, so that there is a gradual increase in river pollution during the winter months. Following very dry winters in 1960 and 1961, when the river became very polluted (oxygen level less than 1 part per millilitre in some areas), the peak in larval settlement occurred on spring tides 4 to 6 weeks after the first heavy freshwater flow in the Brisbane River each summer. In 1962-64 the settlement peak occurred on spring tides 8-12 weeks after settlement commenced for the summer. This peak occurred between early November and mid-December, depending upon the time when water temperatures were high enough for breeding to commence. Settlement at these peaks reaches a density of 1,000 individuals per 1,600 sq mm in the absence of competitors, and is often greater than the entire settlement over the remaining summer. Larval settlement occurs at salinities from 10-30 parts per thousand on slack water at high spring tides. Therefore, by keeping river craft moving in this region of the river during this settlement period and removing those craft not in use, heavy fouling by *Mercierella* can be avoided.

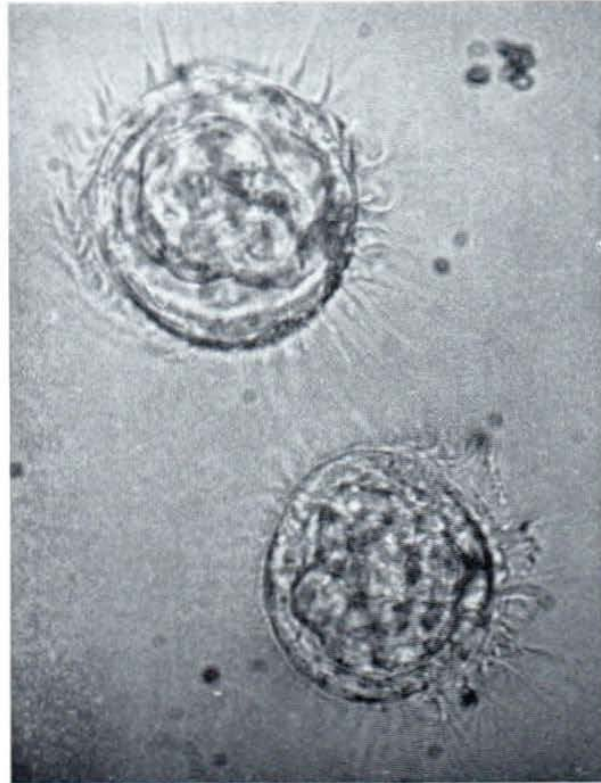
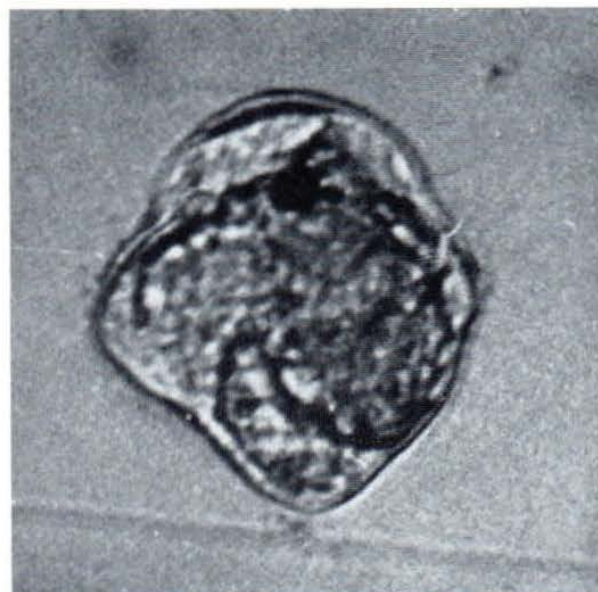


Plate 5C (above). A dorsal view of swimming first-day *Mercierella enigmatica* trochophores, showing the actively beating cilia of the prototroch. Plate 5D (below). A lateral view of a three-day *Mercierella enigmatica* trochophore, showing eye spot and stomach. Trochophores are approximately 0.2 mm in diameter.



### Development and settlement in other species

Larval development follows a similar pattern in most serpulids. In one group, the Spirorbinae, development proceeds almost to the settling stage either in a brood pouch in the operculum or in the tube. In these species the free-swimming stage usually lasts only a few hours and the larvae do not disperse far from the adult. In laboratory experiments with one species, while all larvae settled within 50 mm of the adults, they also settled more abundantly on some types of substrate than on others.

In general, the important factors governing *Mercierella* larval settlement influence the larval settlement of other serpulids. Take waterflow, for example. When water was pumped rapidly through the intake chambers at the Townsville Northern Electricity Authority Power Station, no serpulids settled on fouling plates in the chambers even when they were settling abundantly on fouling plates outside the chambers.

Larval settlement of most marine fouling organisms is concentrated in short defined periods. There is often a correlation between these periods of settlement and tidal or lunar cycles. Although in some cases it may be argued that this is purely coincidental and of no significance to the animal concerned, it is of considerable assistance to anyone wishing to control these organisms. Approximately 70 per cent of fouling organisms, including serpulids, in the Townsville Northern Electricity Authority Power Station intake chambers, settle on tides with a range of 10 feet or more, while over 90 per cent settle on tides that have a range of 8 feet or more. Hence, in this case, settlement is concentrated into periods of spring tides.

### Control of fouling

The best method of controlling fouling is to prevent larval settlement. Methods that can sometimes be used to prevent fouling include keeping water moving over the submerged surface or removing the submerged surface from the region of larval settlement during the period of larval settlement. Antifouling paints are used on large craft, but it is impossible to use these methods in some industrial pipes and drains. Adding freshwater to the effluent or raising the temperature will solve the problem.

However, when chemicals are added they can be used most effectively and economically during larval settlement periods, because smaller doses are needed to kill settling larvae than established adults and one avoids wasting chemicals when no settlement is occurring.

[The illustrations in this article are by the author, except where otherwise stated.]

---

## BOOK REVIEW

**BIRDS OF PARADOX**, edited by Jack Pollard. Lansdowne Press Pty Ltd, Melbourne. Pp. i-xv, 1-246, plus 16 pages of photographs. Price, \$5.95.

*Birds of Paradox* is an anthology of Australian and New Zealand bird lore collected from many sources by Jack Pollard, an experienced anthologist with three earlier companion volumes to his credit. Prose and poetry, fact and fiction, seem to jostle for position on the pages of this attractive volume, which is set off by a colourful jacket. Doubtless the thick sheets and the quarto size of the book represent a modern trend in publishing, yet such a format, if carried to excess in the future, could lead to uncomfortable fireside and bedside reading.

The items chosen by Mr Pollard are interesting and informative and have popular appeal; they are also in sufficient variety to satisfy a wide reading public. The selection has been made from the published writings of men and women well known in the realm of Australian natural history and in other fields of literature. The reader finds himself in the pleasant company of such personages as (Sir) Joseph Banks, John Gould, Dr George Bennett, E. J. Banfield of "Beachcomber" fame, Katherine Mansfield, Judith Wright, and many other nature writers whose experiences reveal so much that is fascinating in the world of birds.

Unfortunately, the captions to the excellent photographs illustrating some of the subjects discussed are often either erroneous or misleading. Examples are: a Stone Curlew standing over its two eggs is said to be ". . . on guard over brooding and young birds"; the White-necked Heron is given the scientific names of the Nankeen Night Heron, and even then the generic name of that species is spelt wrongly; adult Fairy Penguins are referred to as young birds; Demoiselle Cranes are titled Brolgas; a Golden Bower-bird at its large bower is said to be on a nest estimated to contain 50 cubic feet of sticks and which stood 8 feet high; a Wedge-tailed Eagle is noted as being the world's largest eagle, whereas it is fourth on the list according to those who have studied the matter closely. Such mistakes as these are inexplicable and inexcusable in an otherwise carefully prepared, well produced and very readable book—a book to be opened at leisure and with pleasure.—K. A. Hindwood.

# THE AUSTRALIAN MUSEUM



## **PRESIDENT OF TRUSTEES:**

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

## **CROWN TRUSTEE:**

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

## **OFFICIAL TRUSTEES:**

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

## **ELECTIVE TRUSTEES:**

SIR FRANK McDOWELL; R. J. NOBLE, C.B.E., B.Sc.Agr., M.Sc., Ph.D.; PROFESSOR A. H. VOISEY, D.Sc.; G. A. JOHNSON, M.B.E.; PROFESSOR J. R. A. McMILLAN, M.S., D.Sc.Agr.; S. HAVILAND, C.B.E.; K. L. SUTHERLAND, D.Sc., F.A.A.; PROFESSOR L. C. BIRCH, D.Sc., F.A.A.; PROFESSOR D. P. MELLOR, D.Sc., F.R.A.C.I.; PROFESSOR H. N. BARBER, F.R.S.; R. C. RICHARD; W. H. MAZE, M.Sc.

## **DIRECTOR:**

F. H. TALBOT, Ph.D., F.L.S.

## **DEPUTY DIRECTOR:**

C. N. SMITHERS, M.Sc.

*The Australian Museum's field is the animal kingdom, minerals, fossils, and anthropology. The Museum is open free, daily, at the following times: Tuesday to Saturday, and public holidays, 10 a.m. to 5 p.m.; Monday, 12 noon to 5 p.m. (during school holidays, 10 a.m. to 5 p.m.); Sunday, 2 p.m. to 5 p.m. It is closed on Christmas Day and Good Friday. Special facilities for study are available to schoolteachers and pupils on application to the Education Officer. A rooftop cafeteria is open daily, except Sundays, from 10 a.m. to 4.30 p.m. An annual subscription (four issues) to this magazine is obtainable at the Australian Museum or, by post, from the Government Printer, Box 4050, G.P.O., Sydney, N.S.W. 2001. Price, \$1.40 posted.*



# Australian Museum Card

REG.NO.: **PUN4857**      DATE: **28 Jul 2014**

No image

ITEM: **BODY ACCESSORIES arm ornament**

GEOGRAPHICAL AREA[am locality ref]: **Comparable to other examples of arm ornaments in Pacific collections, with known shell species Trochus niloticus.**

HOW ACQUIRED: **Old Collection**      NAME(S): **Unknown**

ACQUISITION HISTORY:      NAMES:      ROLE      DATE

OBJECT NAME CHANGE:

INDIGENOUS NAME OF OBJECT:

CULTURAL ASSOCIATION:      NAMES:      ROLE

RECORDS:

BIBLIOGRAPHY:

NOTES:

RESEARCH:      **This arm ornament is possibly made from the species, Tectus niloticus. Is a very large (up to 15 cm) Indo-Pacific top shell, which has a very thick inner layer of nacre. This species is commercially exploited to make mother of pearl buttons, mother of pearl beads, pendants and so on.**

DESCRIPTIONS:      **A cross section arm ornament made form shell.**

DIMENSIONS:      Height:      Length:      Width:      Weight:

Diameter: **10.5**      Circumference:      Depth:      Clothing Size:

PERMANENT LOCATION: **[P3-11-05-01]**

