AUSTRALIAN NATURAL HISTORY

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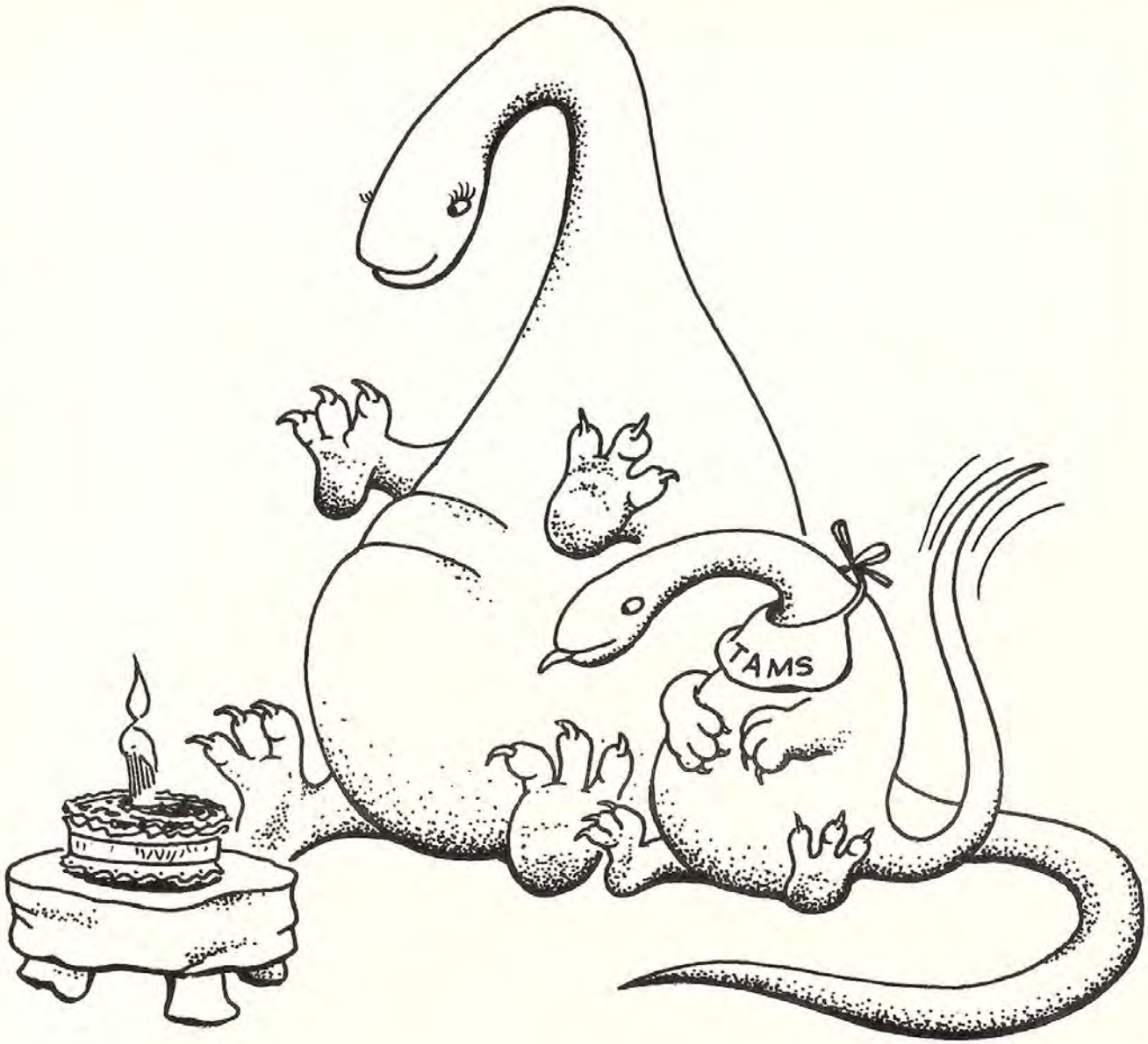

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COVER: The sea anemone, *Adamsia palliata,* lives commensally with the hermit crab, *Pagurus prideauxi.* (Photo: U. E. Friese)

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CSIRO Mineral Physics

A SATELLITE VIEW OF THE AUSTRALIAN ENVIRONMENT

BY JON HUNTINGTON

Since late 1972, our knowledge of factors influencing terrestrial and near-shore environments and our means of surveying natural resources have benefited from information from an important new source. This source is a family of experimental, Earth-orbiting satellites, some of which are capable of photographing the entire Earth's surface every 18 days, and others which can resolve detail as small as 30 metres.

The first of the present family of Earth Resources Technology Satellites (ERTS) was launched by NASA on July 23, 1972 and was designed specifically to examine the value of satellite data for efficient management of the Earth's resources. (On January 13, 1975 the Earth Resources Technology Satellite was officially renamed LANDSAT.) Earth photography from space, of course, is not new, and dates back to 1946. This was the first time, however, that the Earth's resources were to be examined systematically, using technology largely developed for the lunar space programme.

The quality and potential value of the photography returned by this satellite led NASA to launch a second, identical satellite on January 21, 1975, nine days out of phase with the first. Though both satellites are still in operation, photography of Australia all but ceased in late 1975 due to difficulties with the systems required for recording information for later transmission in the absence of an Australian ground tracking station. Between July 1972 and July 1975 the two satellites acquired some 212,252 photographs of Earth, equivalent to total world coverage 14 times over.

The LANDSATs orbit the Earth every 103 minutes passing across Australia, from north to south, at an altitude of 907km. Their orbits are sun-synchronous and cross the equator each day at 0942 local time, progressing across the globe from east to west. This means that each point on the Earth is photographed at approximately the same time of day and under similar conditions of solar illumination, limiting the major differences visible in the photography to environmental and seasonal changes only.

The resolution and cartographic accuracy of these satellite photographs have been particularly useful in surveying the many inaccessible and still unmapped parts of the world. New lakes and rivers have been discovered in Brazil and a Fijian island is reported to have been out of position by 3.2km on published maps. In Australia, satellite-indicated shapes and sizes of some off-shore reefs differ from those on published maps. Elsewhere, the satellites have provided valuable information on crop production, tree diseases and illegal gravel dredging at sea, as well as regional views of geological structures and other natural resources. Satellite pictures showing patterns of effluent discharge in Lake Champlain in Vermont have been accepted as evidence in the Supreme Court in the USA.

Whilst the LANDSAT data are available to virtually anyone for any part of the world, several Australian investigators have collaborated with NASA in studying the potential usefulness of the LANDSAT data in agriculture, land use, forestry, geology, water resources, oceanography, geography and the study of natural disasters. In addition, growing numbers of people are incorporating the use of the data into their day-to-day operations.

The value of the current satellite photography stems from the following attributes:

—the large area or regional view obtained of the Earth's surface under relatively uniform conditions. Each picture covers 185x185km of the Earth's surface.

—the repetitive coverage of the entire Earth's surface every 18 days, (weather permitting). The dynamic nature of our environment means that continuing sensing is of great value in recording changes in land use patterns, seasonal differences in vegetation communities and ephemeral events such as fires and floods.

—the use of multispectral sensors; that is, the division of the energy reflected from the Earth's surface into a number of discrete wave-length bands, equivalent to the green, red and two infrared portions of the spectrum. These provide four pieces of information about each point on the ground instead of the single piece normally available from conventional aerial photography. Such a division provides a greater chance of reliably discriminating between different terrain features. The satellite also sense reflected energy in and beyond the range of standard photographic films and well beyond the sensitivity of the human eye.

Since the sensors carried by the LANDSAT are not conventional cameras, the pictures produced are

Colour enhancement of subsurface water detail, sand banks, submerged reefs, current patterns and islands in the Torres Strait between Cape York and Saibai Island off Papua New Guinea. Skewed shape is due to earth rotation during passage of the satellite.

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An enhanced LANDSAT view of the regional geology of the east Pilbara between Marble Bar and Nullagine, Western Australia. Inter-relationships of many important rock units and geological structures are shown in this active exploration area. Huge, rounded, tin bearing granite batholiths (light tones) are surrounded by strongly folded greenstone belts (dark bands) and sediments, host of copper and gold mineralization.

referred to as images rather than photographs. As the satellites orbit, the sensors simultaneously record four, filtered, black and white images, each in one of the parts of the spectrum mentioned above. These four images, each covering the same 34,225sq. km of ground, go to make up one scene of the Earth's surface. Some 402 such scenes are needed to completely cover the Australian continent.

The image data sensed by the satellite are available either in photographic form or as digital magnetic tape data suitable for computer processing. Further, the user may examine each of the four multispectral images separately in black and white, or reconstitute them, using appropriate filters, into a single colour composite image. In the latter case, the colours approximate those of a conventional colour infrared photograph.

On each of the multispectral images, particular terrain materials (rocks, soils, vegetation, buildings) will appear a different tone, according to the reflective properties of those materials. For example, healthy deciduous vegetation is highly reflective in the infrared and appears much lighter in tone on infrared images than on red images. The difference for evergreen, dry sclerophyll forest is not quite so strong. Further, whilst all water is totally non-reflective(i.e. black) on infrared images, muddy, sediment-filled water can be highly reflective on green spectrum images.

The amount of detail visible on a LANDSAT image is largely determined by the contrast between the objects being sensed and the 78x78 metre ground resolution of the sensors. Each image is made up of some 7.5 million of these overlapping 78x78 metre areas, or over 30 million per four-image scene. Translation of this information from magnetic tape to photographic film inevitably leads to a degradation of the information, whilst the type and number of photographic steps involved can reduce the quality and value of the images even further.

Research in the CSIRO Division of Mineral Physics has largely overcome these problems by returning to the original digital data and creating, via computer-processing, the best possible image for each investigator's problem. This research has also illustrated that, whilst analysis of the satellite data on film remains the simplest and most economic method, computer processing techniques are essential if we are to take full advantage of *all* the data collected by these satellites.

Agricultural problems being investigated in Australia and overseas involve the suitability of the satellite data for soil surveys, crop species identification, estimation of crop area and production, detection and measurement of crop diseases, and agricultural land use surveys. The LANDSAT concept is potentially well-suited to these aims and, given further successful

Enhanced black and white infrared image of part of South Australia's wheat growing district near Kyancutta. Regular-shaped cropped and fallow fields, which are traversed by a longitudinal dune system, contrast with un-reclaimed Mallee scrub country. Image measures 180 km across.

research, holds promise for improving the efficiency of our agricultural food production. The value of any such successful methods to the world food situation are quite obvious. Using the satellite data, US researchers have claimed approximately ninety percent accuracy in wheat yield estimates several months prior to harvest. Even more impressive results have been reported but only from one season. Exciting though these possibilities are, it is clear that fully automatic crop-yield forecasting methods are a long way from being applied operationally in this country.

Investigation into the management of Australia's vast interior rangelands by an assessment of their condition, and possibly the trend of this condition, is potentially of great interest. LANDSAT images of Frome Downs (SA) and Broken Hill (NSW) demonstrate the purely visual differences in the condition of grazing lands and illustrate the cumulative effect of different management practices and animal grazing habits. At scales of 1:250,000, classification of Level 1 land-use units (e.g. urban land, agricultural land, rangelands, forests, water, etc.) is quite feasible in units of about five hectares. Even greater resolution of detail is possible from computer processing of the digital tape data.

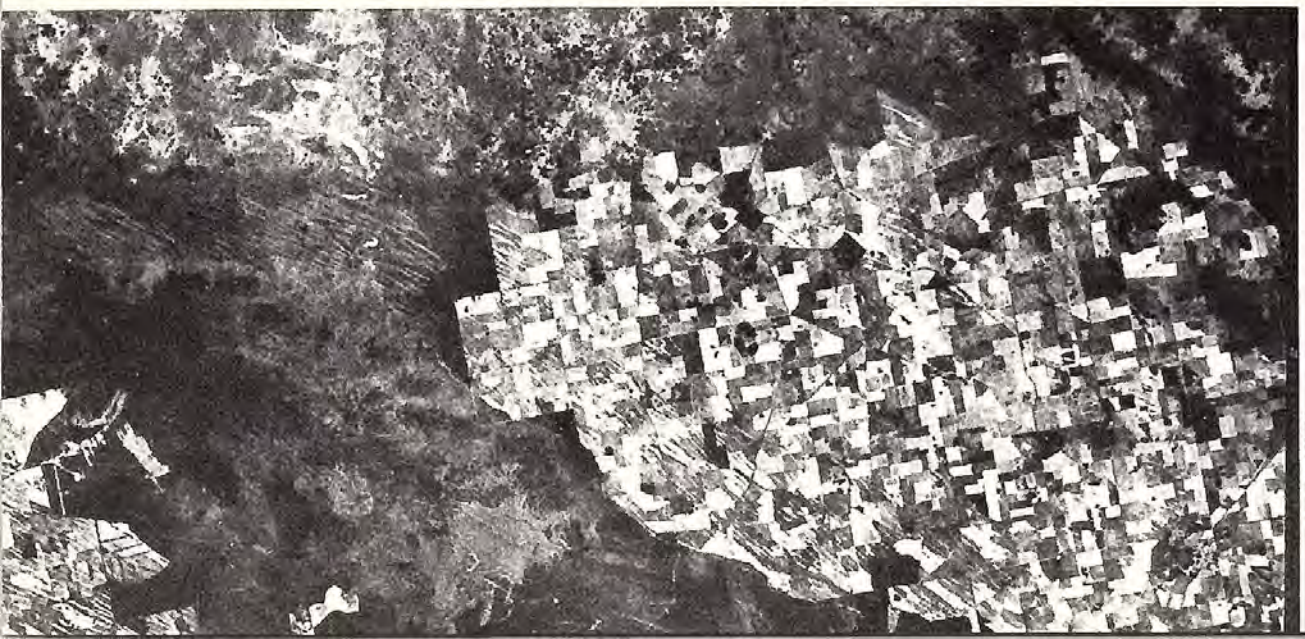
Whilst most of Australia's interest in the LANDSAT data is still at the research stage, many geological survey, mineral and petroleum exploration groups are using the imagery on a routine, operational basis. The advent of LANDSAT-1 coincided with an increased and subsequently accelerated interest in world-wide lineament patterns, believed to relate to major fractures in the Earth's crust. A growing number of geologists believe such fractures may have played an important role in the genesis or localization of mineral and petroleum deposits. The small scale (typically 1:1,000,000 or 1:500,000) and extensive coverage of satellite imagery is ideally suited to mapping these lineament patterns.

Considerable attention is being given to mapping very large regional geological structures, not previously obvious from aerial photographs, as well as some relative rock type differentiation in well-exposed terrain. Features that have been located in several parts of Australia include fossil river channels and previously unknown basement faults and folds covered by desert sands and superficial deposits.

Repetitive coverage by the satellite is of value in geology. Though geology does not change with time,

US Geological Survey

White smoke plumes identify two active bush fires south and east of the coastal mining town of Weipa on Queensland's Cape York Peninsula. Other blackened, high contrast areas identify previously burnt areas now in various stages of regrowth. Image measures about 90 km across.



CSIRO Mineral Physics

CSIRO Mineral Physics

LANDSAT infrared colour composite of Sydney, Katoomba, Lake Burragorang, Penrith plains, Broken Bay, Newcastle and Port Stephens. Healthy vegetation, shades of red. Roads and urban areas, light to dark blue.

the ways in which it is manifest in the patterns of drainage, vegetation and soil moisture do change. Winter imagery, for example, is of value in structural mapping where considerable enhancement of subtle features results from the lower position of the sun. Sun angles down to eighteen degrees above the horizon can be achieved in Tasmania and provide excellent enhancement of those geological structures expressed in the topography.

Floods, fires and drought are disasters which appear most amenable to satellite sensing in this country. Overseas, the study of earthquakes, volcanic eruptions, crop failures, glacier movement, and water pollution are also promising applications.

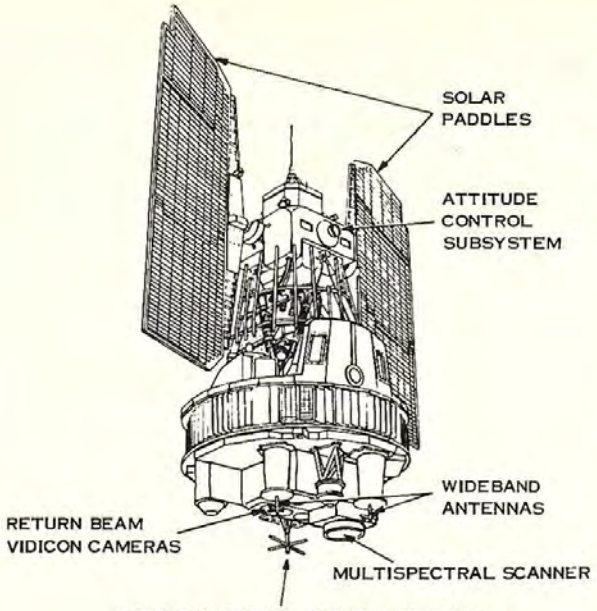
Two assets of the satellite data make it particularly attractive for flood mapping. Firstly, the total absorption by water of radiation in the infrared means all water bodies appear black on such imagery. As a result, exact water – land boundaries are extremely easily and accurately delineated. Secondly, evidence of the extent of flood waters can be interpreted from the imagery several days after the flood has receded due to changes in the reflectance of the flooded ground. This is clearly of importance when the 9-or 18-day satellite cycle does not coincide with the flood peak. An historical knowledge of maximum flood levels clearly has a bearing on areas suitable for development, and the monitoring of floods and flood trends over a period of years is likely to increase the overall value of the information even more.

After flooding, bush fires are probably Australia's main disaster problem and are equally amenable to study using the satellite imagery. Assessment of areas damaged by fire is currently made by subjective reporting by inspectors. This method is slow and cannot be expected to be completely accurate. The problem is in mapping both the occurrence and extent of bush and forest fires and the rate of regrowth after fires.

In mountainous country, forest fires also cause accelerated erosion. To appreciate the temporal and economic consequences of both wildfires and controlled burning on land management and productivity, repetitive satellite coverage is required.

The use of satellite imagery in forestry has only been considered by a relatively small group of researchers in Australia. The imagery is generally regarded as having value in forest inventory work and, using a simple classification, could aid locating of areas for more detailed consideration in subsequent stages of a multi-stage sampling/mapping programme. Species mixtures and timber volumes cannot be consistently interpreted, though major site alterations, forest clearing, exotic species plantations and wildfire occurrences can be recognized and monitored. In this area as in most others, further research, particularly with computer enchanced imagery and computer classification methods, is believed likely to improve (at least to some extent) the value of the data.

A good deal of attention is being given to studies of water sediment concentrations, turbidity, depth measurements and water pollution patterns using LANDSAT imagery. The green spectral image of the LANDSATs is ideally suited to examining water depths and suspended sediment loads in rivers, lakes and coastal waters. In clear water, depths down to 20 metres can be determined fairly simply by contouring the grey levels of the green spectral image film positives. In the range 0-14 metres, depths to an accuracy of ± 1 metre have been reported. The existence of suspended sediment or turbidity which may even be visible on red spectral images or infrared imagery in some circumstances, largely negates the depth studies. However, detection of the sediment itself is an important feature indicative of accelerated erosion in a neighbouring area, illegal waste dumping, sand-mining activities or offshore currents. The importance of depth measurements and current mapping from the satellite data becomes most critical in very shallow, inshore, reef areas, where depths and shoals are constantly changing and where access is not easy for conventional survey methods. Imagery of the Torres Straits, for example, indicates major changes in the shapes and sizes of some reefs when compared to hydrographic charts. LANDSAT appears to offer a relatively simple way of monitoring the dynamic processes affecting our coastlines and the consequences of these processes as well as a means of updating maps of these areas. Other features that have been located on LANDSAT imagery overseas include algal blooms, red tides and oil-slicks.



It is the writer's belief that satellite sensing of the Earth's environment is here to stay as an applications technology. In the vast majority of cases the digital data or imagery supplied is likely to be used in conjunction with many other data from different sources and from different remote sensing devices. In the case of large area studies, such as the ecological survey of Australia, the feasibility of which is currently being examined by the CSIRO Division of Land Use Research, the satellite data, itself a unique source of information, would also increase the efficiency of other more detailed and more expensive survey techniques.

In the future, four additional spaceborne Earth observation programmes are likely to yield still further information for resources evaluation. In 1977, NASA will launch LANDSAT-3, similar to LANDSAT-2, but with an increased resolution of 40 metres and including a heat mapping sensor. This will be followed by a heat capacity mapping mission (HCMM) in 1978 which will generate thermal imagery likely to be of value in regional soil moisture and rangeland condition mapping. An ambitious SEASAT programme, designed to examine Earth's marine and fresh water environments, is also planned for 1977 and will extend well into the 1980s with a whole family of satellites. These SEASATs are likely to provide data on sea state, ocean temperatures, currents, tides and wave patterns, of value to meteorological forecasting, fishing industries and shipping.

Two further possibilities are being considered by NASA for the 1980s. One is a geosynchronous satellite carrying a very high resolution Earth-pointing telescope capable of examining a particular area in detail over an extended period of time. The other is the space shuttle, which may carry into orbit either automatic or man-controlled sensors for specific operations.

The value to Australia of all of these Earth observation systems will, to some extent, depend upon the extent and direction of our current research. It will also depend on our desire and ability to link into these satellite systems and read off their sensed data about the state of *our* environment in real-time over Australia.

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Two colour infrared images of different levels of flooding along Cooper Creek, SW Queensland in March 1973 (left) and February 1974 (right). Different colours reflect different landforms and vegetation cover. Blue colour of 1974 flood waters reflect turbulence and heavy sediment loads. Each image is 185 km on either side.

A MOST SUCCESSFUL INVASION
THE DIVERSITY OF AUSTRALIA'S SKINKS

BY ALLEN E. GREER

There are approximately nineteen families of lizards recognized in the world today and of these, five are represented in Australia. These are the largely nocturnal geckos (Gekkonidae), the snake-like flap-footed lizards (Pygopodidae), the dragons (Agamidae), the predatory goannas (Varanidae) and the skinks (Scincidae). Of these, skinks are the largest and most diverse. They are also the family about which we know least.

Family	Genera	Species
Gekkonidae	16	63
Pyropodidae	8	28
Agamidae	10	53
Varanidae	1	21
Scincidae	20	193

What makes a skink?' Firstly, as in many other families of lizards, skinks have little disc-like bones in each of the scales covering the animal. These are called osteoderms and in skinks each bony osteoderm contains a very distinctive pattern of minute canals. The function of these little canals is unknown, but they are virtually unique to skinks. The second characteristic of skinks is a bony shelf across the roof of the mouth that separates the air passage above from the food passage below, much in the same way that the secondary palate separates these two passages in mammals. Again, the functional significance of this is unknown, but it distinguishes skinks from almost all other lizards and also helps to sort relationships within the skinks.

The secondary palate in skinks is made up basically of one pair of bones that extend out toward the midline of the roof of the mouth. In primitive skinks these bones do not extend all the way to the midline and hence the air and food passages are only incompletely separated. Although this is a perfectly natural situation in skinks it is structurally similar to the pathological condition of a cleft palate in mammals. In the advanced skinks the bones of the secondary palate do meet or at least come very close and the palate is said to be complete. It is also important to note that primitive skinks are distinguished by distinct frontal bones (the bones between the orbits on the top of the skull) while advanced skinks have the frontal bones fused into a single bone.

The primitive skinks number about two hundred species and are found today only in North and Central America, Asia, Africa, Madagascar and some of the islands of the western Indian Ocean. The species diversity is rather rich in Madagascar and southern Africa but as one moves closer to southern Asia, the distribution becomes more fragmented and the animals are harder to find since a larger proportion of the species are deep burrowers. The reason for this peculiar distribution seems to be that the primitive skinks gave rise to the advanced skinks in southern Asia and were then driven to extinction by their descendants. The only primitive 'survivors' would have been those species that either already occupied or were forced to occupy underground niches that the advanced skinks had been slow to fill, except in the Australian region.

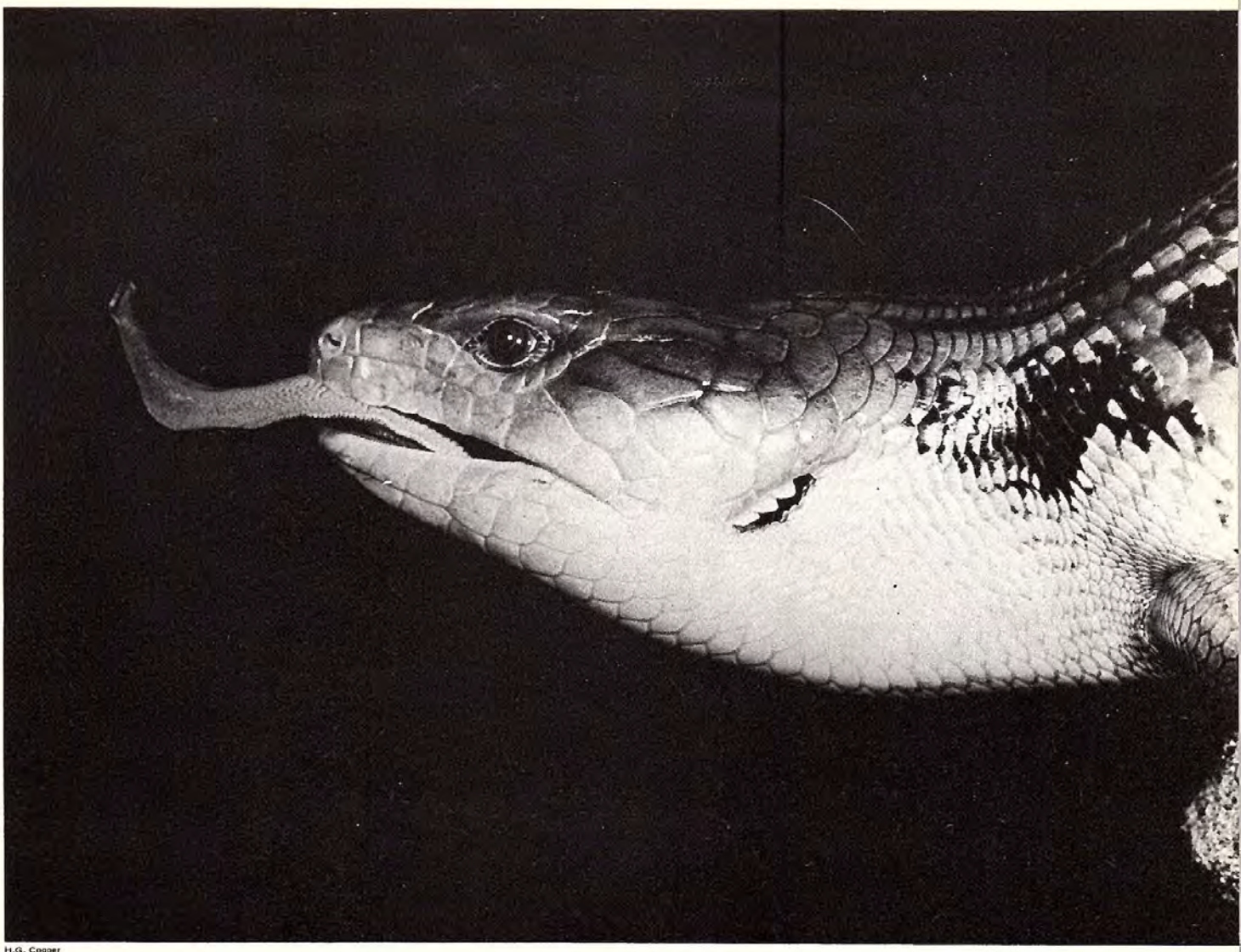
After their initial evolution in southern Asia, the advanced skinks immediately spread out along all the major land routes. Their advance was truly spectacular, for there are now about six hundred species and they occur on all continents. They have occupied habitats ranging from the upper intertidal in many areas to over eighteen thousand feet in the Himalayas where they set the altitudinal record for cold-blood vertebrates. They also occur in all major terrestrial habitats within their distribution range.

The advanced skinks that moved southeast along the Indonesian Archipelago and into the Australian region were the most successful emigrants of all, for like many other animals and plants they found that many of the niches that were potentially available to them were still unfilled due to the region's long isolation.

Three different groups of advanced skinks have made successful invasions into Australia, but the order in which they arrived is not known. The first of these groups includes some of Australia's largest and best known skinks such as the Land Mullet and its relatives *(Egernia)* and the Blue-tongues, Pink-tongues and Shingleback *(Tiliqua)*. It also includes the giant Solomon Islands Tree Skink *(Corucia)*. The members of this group are primarily terrestrial, but some are rock dwellers and a few species are semi-arboreal. The Solomon Island Tree Skink is almost exclusively arboreal.

Many species of *Egernia* and some *Tiliqua* live in burrows of either their own or another animals making, while *Corucia* apparently favours natural cavities in trees. Some of the burrows dug by *Egernia* are quite elaborate in design and may have escape routes where exits are plugged with only a thin layer of dirt or sand.

ALLEN GREER is an American currently visiting this country on an Australian-American Fellowship. Based at the Australian Museum, he is continuing research into the evolution and biology of scincid lizards, a group on which he has specialised and published widely over many years. Most of his work has been carried out at the Museum of Comparative Zoology at Harvard University.



H.G. Cogger

A northern blue tongue lizard, *Tiliqua scincoides intermedia,* from Arnhem Land. This is one of Australia's largest skinks.

Some of the most diverse feeding habits are found in this group, for in addition to including species that prey largely on arthropods as do most skinks, the group includes species that eat snails, carrion and a variety of plant material such as fruits and leaves. Indeed, *Corucia* is said to eat nothing but vegetable matter. The plan eating habits of the group are especially interesting in that they exemplify a general trend, evident in other lizard families, for the large species to be plant eaters.

Many species of this first group are active only during the day, but others are nocturnal, at least during the warmer months. A few nocturnal species such as the desert Skinks *Egernia inornata* and *E. striata* have evolved the hallmark of many nocturnal animals, a vertically eliptic pupil. This feature does not occur in any other group of advanced skinks as far as we know, although it does occur in one North African desert species of primitive skink, *Scincopus fasciatus.*

All of the skinks in this group bear live young. Curiously, some species (e.g. *Tiliqua scincoides)* bear a large number of relatively small young while others (e.g. *Corucia* and *Tiliqua rugosa*) bear a small number of relatively large young. The adaptive significance of these two life history patterns is unknown. One last noteworthy feature of many species in this group is the tendency to form social groups. This is most pronounced in certain species of *Egernia,* but also seems to occur in *Corucia.*

The skinks of the second advanced group in Australia are largely diurnal and are surface-dwelling to arboreal in their habits.

One of the most interesting things about this group is the fact that many of the genera appear to be very adept at crossing large areas of ocean and hence include Australia as only part of a much wider distribution. The genera *Emoia* and *Eugongylus,* for example, are very widespread in the southwest Pacific and just enter Australia at the tip of Cape York Peninsual. Similarly, the little skinks of the semi-arboreal and rock dwelling genus *Cryptoblepharus* range throughout the tropical and subtropical Pacific, and they have even crossed the Indian Ocean to reach Madagascar and the east-central coast of Africa. These skinks also occur throughout most of Australia including the arid interior; indeed one wonders whether the ability of these skinks to

H.G. Cogger

Egernia inornata, is a burrowing skink which is found throughout the sandy, arid regions of central and southern Australia.

travel and survive so well in the Pacific where there is "water water everywhere but n'ere a drop to drink" may not have pre-adapted them for the colonization of Australia's arid regions.

The genus *Leiolopisma* (including the genus *Pseudemoia)* is restricted in Australia to the cooler and wetter parts of southwestern and southeastern Australia and Tasmania. Despite its limited Australian distribution however, it has remarkably broad distribution in the temperate and subtropical islands of the southwest Pacific. It occurs for example in the Loyalty Island, New Caledonia, Lord Howe Island, New Zealand the Chatham Islands. There is even a species that has managed to cross most of the Indian Ocean and reach Mauritius and nearby islands.

The small skinks of the genus *Anotis* are close relatives of *Leiolopisma,* and their distribution pattern is similar. The two Australian species *(A. maccoyi* and *A. graciloides)* are restricted to the moist, shaded forest of southeastern Australia and the three other known members of the genus are found only in New Caledonia.

As remarkable as these distribution patterns are, they may be surpassed by the distribution of yet another genus in this group. The Garden or Penny Skinks *(Lampropholis)* abundant in many suburban gardens around the major southeastern cities are probably the best known small skinks in Australia. They have slightly more primitive relatives in the rainforests of eastern Australia. The distribution of this genus today is restricted to the wetter parts of the east coast from roughly southeastern South Australia north to the vicinity of Cooktown. Now what is remarkable is that in the rainforests of Africa are skinks which, if caught in an Australian rainforest, would be unhesitantly described as new species of *Lampropholis.* These skinks are currently placed in a genus of their own *(Panaspis),* but only becuase of their distinct geographical distribution. How did the African relatives of the Garden Skinks and their rainforest relatives get to Africa? Was it over water as so many other members of this second group of skinks seem to have moved around, or was it overland through southern Asia? Continental drift does not seem to be the answer because these skinks are relatively advanced and none of their more primitive relatives such as *Leiolopisma* nor any of the other skinks in Australia for that matter, seem to have distribution patterns which have been affected by drift.

A notable feature of this group is the conspicuous and often striking colour patterns which often differ between the sexes. These colours are most evident in the genera *Carlia, Leiolopisma, Morethia* and *Menetia.* The skinks in the other two groups often have bright colours, but these are generally hidden on the belly and only rarely are there sexual colour differences.

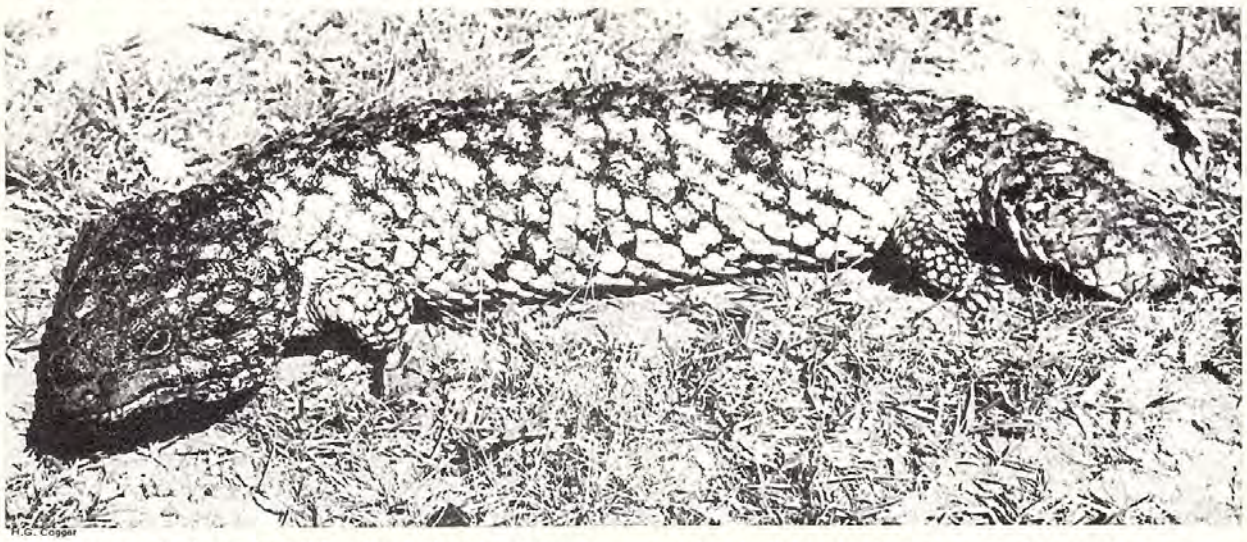
Another interesting feature of this second group of Australian skinks has to do with the morphology of the four separate evolutionary lines, represented by

H.G. Cogger

Stokes'skink, *Egernia stokesii,* is a large, rock-dwelling skink which is often found in small social groups.

the genera *Cryptoblepharus, Morethia, Menetia* and *Proablepharus,* that have invaded the arid interior. The remarkable fact about these lines is that each involves animals of small size and with a clear spectacle or brille permantly covering the eye—a structure that is probable best known in snakes. The functional significance of the spectacle has never been explained in any reptile beyond the passing suggestion that it helps keep grit out of the eye. In these skinks, however, it would seem that the spectacle may have evolved to help retard water lost by evaporation from the surface of the eye. We know that smaller animals have proportionately larger eyes relative to their volume compared with their larger relatives, and small skinks in arid environments may have found it adaptively advantageous to cap this source of water loss with a clear cover. Other skinks seem to show a similar relationship between small body size, life in arid or semi-arid habitats, and the evolution of a spectacle but it remains to be seen whether this association figured in the evolution of the spectacle in other groups of reptiles.

All of the members of this group are egg layers except for the majority of *Leiolopisma* which bear their young alive. The reason for the live-bearing habits of *Leiolopisma* seem fairly straightforward and illustrate a principle that is common in other reptiles. In general, the skinks of the genus *Leiolopisma* have a more southerly distribution than any other skinks in the second group. This, plus the fact that they generally occupy moist upland environments means that they are probably exposed to generally cooler conditions than their relatives. This poses no serious threat to a free-ranging individual, because even though it can't raise its internal temperature to suitable levels by the physiological processes that are available to birds and mammals, it can achieve those temperatures behaviourly either by basking directly in the sun or moving next to a rock or piece of wood warmed by the sun. The egg, of course, has no means of controlling its own temperature. The solution to this problem, however, turns out to have been remarkably simple, for the egg has simply undergone some minor morphological adjustments that allow it to stay with the mother and take advantage of her thermoregulatory behaviour until development is complete. Hence the common association of live birth and life in cool climates not only in *Leiolopisma* but a good many other reptiles as well.



The shingleback, *Tiliqua rugosus,* is widely distributed in southern Australia. It produces a small number (usually two) of large, live young.

While on the subject of reproduction in this group, it is worth noting that the only examples of communal nesting in Australian skinks come from this group *(Lampropholis* and *Leiolopisma).* The Garden Skinks *(Lampropholis delicata* and *L. guichenoti)* are the most well known in this region. Nests often contain over one hundred eggs and to judge from average clutch sizes must represent the efforts of thirty or more females. There are two unusual facts about these communal nests. Firstly, in habitats where the two species occur

H.G. Cogger

The firetailed skink, *Morethia taeniopleura*, is widely distributed throughout the northern half of Australia, mostly in more arid habitat. It has a clear spectacle or brille permanently covering each eye.

together and where they are nesting more or less at the same time, only rarely do the nests contain the eggs of more than a single species. And second, the eggs generally hatch over a remarkably short period of time. Unfortunately the process by which females recognise their own species nests and the causes of the more or less synchronous hatching of eggs is unknown as yet. Indeed, even the adaptive significance of communal nesting is unclear at this point.

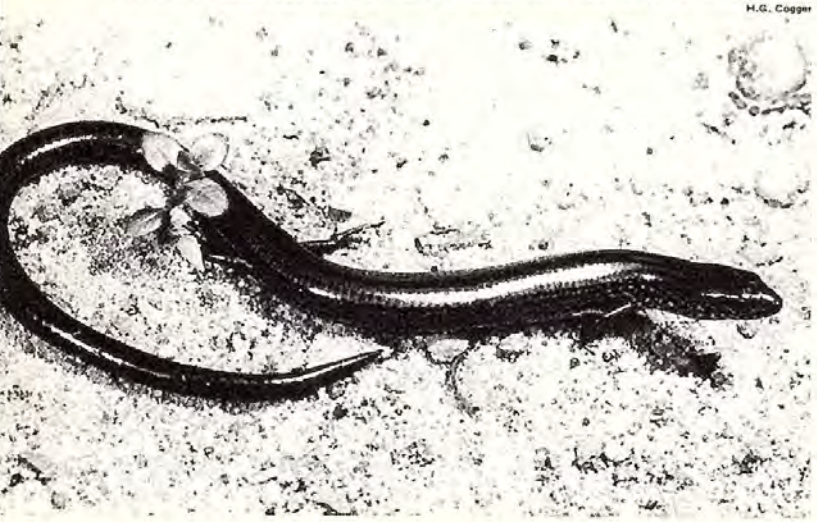
The third and last group of advanced skinks in Australia is very diverse. In contrast to the other two groups, the basic systematics of this group of skinks are not well enough understood to allow us to proceed to an orderly investigation of their biology, we are still in the frustrating stages of sorting out the basic relationships of the species in this group. In general this group includes lizards that either rarely or never come out into the open or do so only after dark.

A comb-eared skink, *Ctenotus impar*, from southwestern Australia. It belongs to a large group of active, diurnal skinks which has radiated largely in Australia's arid regions.

The burrowers in the group show many interesting modifications which have, in most cases, evolved independently each time an evolutionary line 'went underground'. The external ear opening, which is relatively large in surface dwelling skinks, is reduced in size or lost altogether; the head scales are often reduced in number either through outright loss or through fusion with other scales; most noticeable, however, is a lengthening and narrowing of the body, a reduction in the number of digits and the size of the limbs, and sometimes a total loss of the limbs.

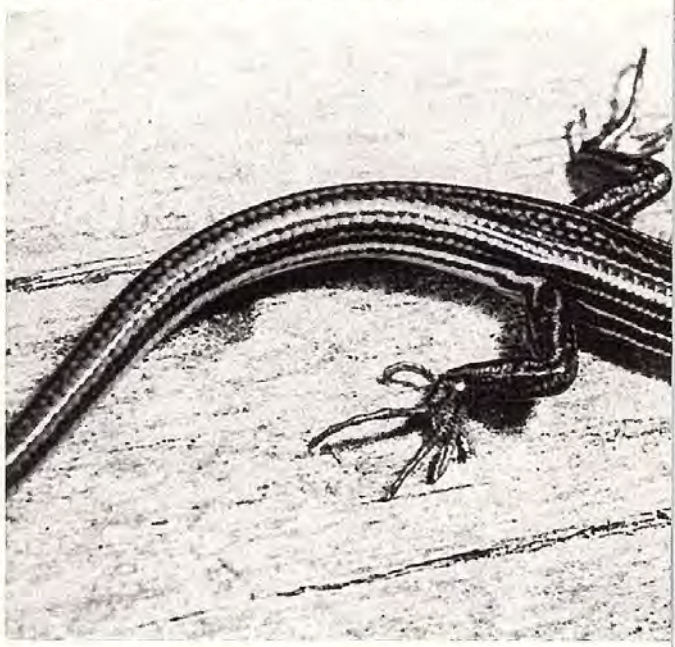
This small ground-dwelling skink, *Hemiergis peronii*, is a live-bearing lizard from southern and southwestern Australia.

H.G. Cogger



One of the most primitive genera of this third group and the genus that seems to have given rise to all of the burrowing skinks in Australia is *Sphenomorphus*. These skinks are confined to the more equable northern and eastern parts of Australia, and they include a great diversity of species. Among them, for example, is a small undescribed cryptic species from the rainforests of Thornton Peak in northeast Queensland that is so heat sensitive that it will perish from over heating when held gently in the fignertips for only a few minutes. At the other extreme in the genus are the large aggresive Water Skinks of the *quoyi* complex which are often seen basking in full sun next to small creeks which they do not hesitate to jump into if startled or pursued.

A possible close relatiave of *Sphenomorphus* that bears special mention is the bizarre Spiney Skink *Tropidophorus queenslandiae*, a species that only occurs in the rainforests of northeastern Queensland where it

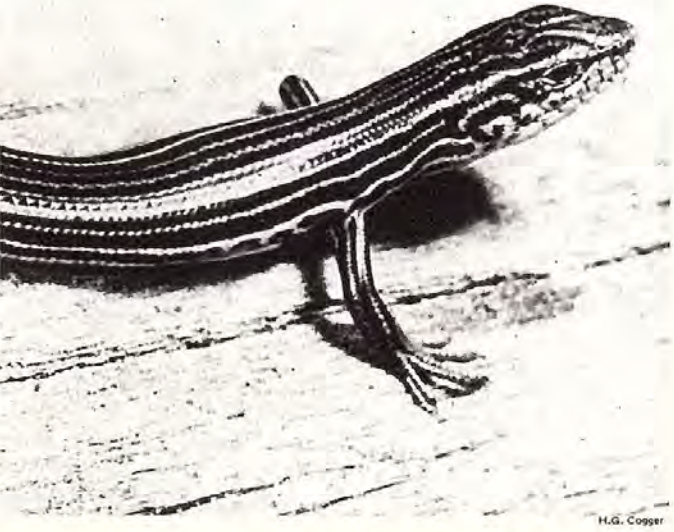


is found in or under rotting logs. At present this species is considered to be a member of a genus of skinks that does not otherwise occur outside southeast Asia. This distribution and the species morphology cast doubt on the idea of a close relationship with those Asian skinks—but remember the case of those rainforest and Garden Skinks and their presumed African relatives! In all likelihood, as we come to know more about the Spiney Skink, it will be regarded as a very specialised relative of *Sphenomorphus*. It is interesting to note that this specis and *Sphenomorphus murrayi* are the only Australian skinks known to volcalize beyond the hiss emitted by some *Tiliqua*. Both species make brief little cries of protest when grasped.

Although most members of this third group of skinks are cryptic animals, an exception to this rule are the Comb-eared Skinks of the genus *Ctenotus*. This is a

large group of basically arid to semi-arid adapted skinks that carry out most of their activities at the surface during the day. These skinks can tolerate, and even seem to prefer, higher body temperatures than most other skinks, or most other lizards for that matter, and when they are warm they can move exceptionally fast. The different 'life style' of these skinks may be partly related to the fact that they seem to be an early evolutionary offshoot from the rest of the members of this group and hence may have had quite some time to develop their own way of doing things.

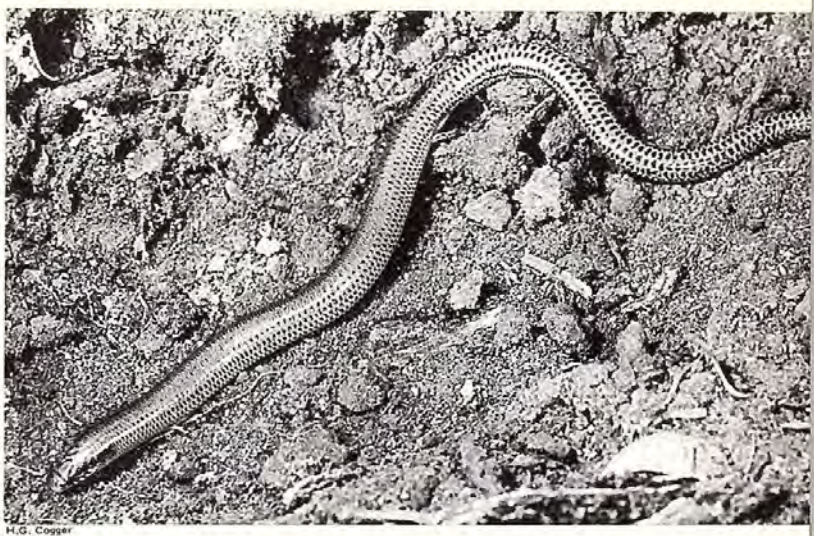
Both egg-laying and live-bearing habits occur in this third group of skinks, and while some genera are characterised by one mode of reproduction or the other (e.g. egg laying in *Ctenotus* and live bearing in *Hemiergis),* others include both egg layers and live bearers (e.g. *Anomalopus, Lerista* and *Sphenomorphus).* The adaptive significance of these modes of reproduction is not clear in all cases, but some live bearers such as the Water Skinks, *Hemiergis* and certain *Lerista* have a very southern distribution compared to their near relatives and may have evolved their live-bearing habits for the same reasons that *Leiolopisma* evolved these habits.



H.G. Cogger

It is perhaps appropriate to mention here that detailed anatomical studies have demonstrated that the live bearing species in all three groups of Australian skinks have developed a placenta between the developing embryo and the mother. The role that the placenta plays in development is uncertain, although it seems fairly clear that it does not have a major nutritive role as in mammals due to the fact that the egg is provisioned with a large amount of yolk prior to ovulation. This problem is currently being investigated at the University of Sydney.

Compared to other Australian lizards, we are woefully ignorant about skinks. New species are still being discovered at a much higher rate than in any other family of lizards—sometimes from areas close to large urban centres. Their abundance and diversity in Australia makes them a rich source of study for herpetologists and amateur naturalists alike.



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In this burrowing skink, *Lerista punctatovittata,* the limbs are greatly reduced, with only a single toe on each forelimb, and two toes on each hindlimb.

ACKNOWLEDGEMENTS

The author would like to express his great appreciation to the Australian-American Educational Foundation for its basic financial support of his work in Australia. He would also like to acknowledge the supplementary financial and logistical support provided by The Australian Museum Trust and the intellectual stimulation and friendship provided by the staff of The Australian Museum.

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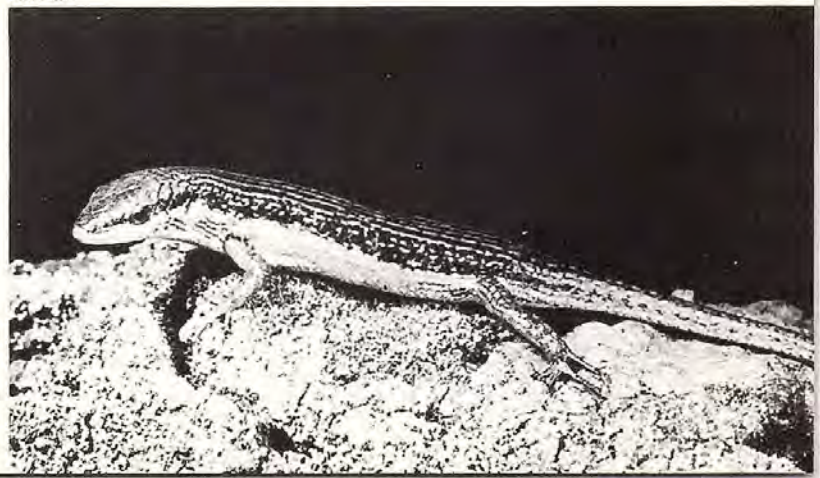

One of the most colourful of Australian lizards is this small four-fingered skink, *Carlia jarnoldae,* from northeastern Queensland. Only the male is brightly coloured.

Barry Goldman

Streamside habitat of Fiji Ground Frog, in dense rainforest.

The flora and fauna of islands has fascinated biologists since the time of Darwin, who derived much of his inspiration and understanding of the process of evolution from a study of the Galapagos Island finches. Part of this fascination stems from the peculiar nature of many island faunas, and part from attempts to work out how and from where the animals orginally came.

Compared with the continental islands and land masses surrounding the Pacific Ocean, the islands of the South Pacific generally have fewer species of terrestrial fauna. This is due to both the size of the islands and their distance from the mainland. Larger islands have a greater habitat diversity and hence a larger number of species than smaller islands. Similarly, the nearer an island is to the continental area, the easier it is for animals to 'island hop' or cross the ocean barrier and colonise the island.

Animals which frequently move from one land mass to another, colonise rapidly and often show little variation from one island to another. Others less adept at crossing ocean barriers become isolated from their parent population and may evolve to meet the demands of selection in the new environment. This may result in the species becoming morphologically, behaviorally and ecologically different from the ancestral population. Continuation of this process may lead the zoologist to classify them as different species or even place them in a new genus to the parent population.

Apart from the introduced cane toad (*Bufo marinus*), these are the only two amphibians in Fiji. Both are closely related and belong to the family Ranidae.

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BOTANIVITI

THE ELUSIVE FIJIAN FROGS

BY JOHN PERNETTA AND BARRY GOLDMAN

Whilst working on the terrestrial vertebrates of Fiji, the authors were fortunate in finding several localities where the endemic Fijian frogs were relatively abundant. Although specimens of these animals have been known in museum collections for about a hundred years, their ecology is relatively unknown. They are characterised by the presence of pads on the tips of the toes and fingers. The species are easily distinguished in the field, the tree frog (*Platymantis vitiensis*) having large pads on the fingers and being on the whole smaller than the ground frog, (*Platymantis vitianus*) which has smaller finger pads and two yellow spots on the shoulders behind the tympanum; these spots are never present in the tree frog. The tree frog has a variable background colour ranging from a light yellow-green through to darker brownish black. The ground frog is generally darker in colour though both species appear to be capable of changing colour according to their surroundings.

The general lack of knowledge concerning the ecology of these frogs stems from their nocturnal habits and the general inaccessibility of their preferred habitats, along streams and creeks in thick primary forest. They are not seen in cleared areas which suggests that as their habitat is reduced by forest and agricultural activity, these animals will become more restricted in their distribution. This is certainly the case in areas of the island of Ovalau where they were once common and are now extremely difficult to find.

During the day the tree frogs may be found in the leaf axils of pandanus trees which grow alongside the stream beds. At night they emerge to sit on the flat, narrow leaves of the pandanus and feed on passing insects. In captivity they have no difficulty in catching quite large moths by jumping at the insect rather than using a long sticky tongue as do most other frogs. During the day the frogs are generally dark in colour and blend well with the decaying vegetable matter found in the pandanus leaf axils; when emerging onto the leaf surface at night they are generally paler and some shade of green or yellow.

The ground frog, as its name suggests is less arboreal than its smaller relative, particularly in the case of large individuals. Where they hide during the day is not known, but the abundance of rocks and logs at the stream edges provide many suitable dark, moist retreats. At night they emerge and sit at the stream edge, whilst the smaller individuals may climb onto the leaves of low-growing vegetation. Both species swim well and if disturbed will quickly jump into the stream and swim actively out of sight.

The breeding ecology of these animals reveals a fascinating adaptation to their habitats and may also provide a clue to the arrival of tree frog in Fiji. Many of the streams along which the frogs occur are in mountainous areas, the frogs being found to altitudes of several thousand feet. Periodic floods during the rainy season may result in these streams changing rapidly from trickles a few inches deep to raging torrents several feet deep. Such a current would be disastrous for a slow-swimming tadpole which would be swept downstream and out of the forest habitat. To avoid such a catastrophe, these frogs lay their eggs on land, the tree frog in the leaf axils of pandanus, the ground frog in rotting logs. The tadpole stage is now passed completely within the protection of the egg which has a thick gelatinous coating for protection. After about thirty days' development, metamorphosis occurs and a miniature frog a few millimetres long emerges. As a result of the prolonged development within the egg, the tadpole has to have a massive yolk and the eggs of both species are gigantic when compared with normal frog spawn. Each tree frog egg is

Barry Goldman

Light colour phase of Fiji Tree Frog in feeding position on Pandanus leaf.

between four and seven millimetres in diameter and so the female only lays about thirty at any one time.

The tiny hatchling frogs probably feed on small night flying insects such as mosquitoes and as they grow in size the size of their prey will increase. How long it takes them to reach sexual maturity is not known. The mortality of these hatchlings is probably quite high since they are likely to fall into the water and unable to resist strong currents, would be swept away. Examinations of a number of localities in which these animals are found has shown that they tend to occur in small clumps of ten to thirty frogs along a twenty or thirty metre stretch of stream. This suggests that these animals are adapted to low population density, occurring in small semi-isolated populations throughout suitable habitat. Outside the breeding season they may be found away from the stream bed, dispersing through the surrounding forest habitat.

Barry Goldman

Eggs prior to hatching, showing well developed frogs inside.

Because little data is available on the ecology of these animals their natural predators are unknown. Undoubtedly the Pacific Boa (*Candoia bibronii*) would eat frogs should it encounter them. In captivity this snake will eat a variety of geckoes and skinks, many of which are larger than the Fijian frogs, and may be found in primary forest and stream beds at night. Frogs, due to their nocturnal activity, are probably unaffected by other potential predators although the introduced mongoose may be an important predator on Viti Levu.

The interaction of the native frogs with the introduced Cane Toad poses some interesting questions. One might expect that since both are nocturnal insect feeders, competition between them would be important. This is unlikey for a variety of reasons: firstly, the toads never climb and therefore feed at a different level in the habitat; secondly, toads appear to prefer more open areas, occurring in cleared agricultural land and open secondary forest much more commonly than in primary forest; and finally, they reach much larger sizes than the frogs and would therefore eat larger insects. Occasionally one encounters large toads in stream beds in forest at night but rarely are they found together with the frogs. It is possible that the larger toads, should they occur sympatrically with the frogs, would act as competitors, but for the reasons outlined above such a relationship seems unlikely.

Fiji Ground Frog *Platymantis vitianus*, showing characteristic yellow shoulder spot, and smaller finger pads.

Barry Goldman

How did these frogs arrive in Fiji? The family Ranidae to which they belong is widely distributed throughout the world whilst their nearest relatives in the genus *Platymantis* are confined to the Philippines, the Solomons and Papua New Guinea. Since Fiji has never been joined to these land masses, they must have come by sea, although the unlikely possibility of freak transport by waterpouts cannot be ruled out! Unlike many reptiles, amphibians and their eggs are incapable of tolerating exposure to salt water and would be unable to survive the long journey from the New Guinea region perched on a floating tree or vegetation mass. In additon, ocean currents move in the wrong direction for such a means of transport to Fiji. Certainly their origins pre-date the arrival of

the Europeans in the Pacific as many different local names are found for these animals, in contrast to the single name used throughout Fiji for the Cane Toad.

The close association of the tree frogs with pandanus plants may provide a clue to their origins. The pandanus is an important plant in the cultures of Melanesians and Polynesians, its leaves being used for mat-making, basket work, thatching and sail-making. Perhaps the early colonisers of the west Pacific carried pandanus plants in their canoes, and maybe hidden deep in the axils of their leaves they carried the eggs or adults that formed the ancestors of present-day tree frog populations. Botanical evidence does exist for the movement of pandanus from the New Guinea region in the Pacific to Fiji.

Although such an explanation may apply in the case

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Newly emerged Tree Frog.

of the tree frogs, the ground frog probably represents a separate introduction. Possibly the eggs of this species were accidentally concealed in earth and moss used to transport root crops such as taro during migrations from the Papua New Guinea region. Zoologists agree that the two Fijian species are more closely related to species from this region than they are to each other. Therefore, the possibility that a single species introduced into Fiji has diverged to produce the

Barry Goldman

Fiji Tree Frog, *Platymantis vitiensis,* note very large finger pads, and dark colour phase.

two present-day species is unlikely. A further possibility is that this species was deliberately introduced by early man as a food source or totem animal. In support of this, many older Fijians on different islands claim that prior to the arrival of the Europeans, the ground frog was extensively eaten.

One of the problems for animal colonisers of oceanic islands faces them upon arrival. Unless they arrive in or near a suitable habitat, they may die before they can establish a viable population. If early man was in any way associated with the transport of frogs to Fiji this problem would be lessened in that human colonisers of these islands would beach their canoes either in or near a source of water, and at that time most of the islands were heavily forested down to the coast.

With the passage of time, the increase in the human population, and the consequent increase in agricultural land-use, much of the coastal forest has now disappeared. Primary forest is now restricted to the centre of the major islands and the frogs themselves are more restricted in their distribution. As agricultural and forest clearance activities increase further, the habitat of these attractive animals decreases. Although it is unlikely that their habitat will disappear completely every effort should be made to ensure their survival, as they represent an outpost of amphibian distribution in the Pacific.

THE SPECTACULAR SEA ANEMONE

BY U. ERICH FRIESE

At the lowest ebb-tide level, among the mussels and rock oysters in crevices and small tidepools left behind by the receding sea live the sea anomones*. When out of water they appear as roundish, rather limp blobs, but as the tide rises over them, their true beauty is revealed.

With their often brightly coloured, stem-like bodies and their graceful tentacles waving gently like delicate petals in the surging tide, sea anemones so resemble flowers that Aristotle considered them to occupy an intermediate position between plants and animals. This concept survived into the 18th Century in the term Zoophyta (Greek: *zoon* = animal, *phyton* = plant), a group which also included many other soft-bodied animals that normally remain fixed in one place, such as sponges and sea squirts. Research by naturalists such as Linnaeus, Lamarck and Cuvier in the early 18th Century demonstrated that sea anemones (and their close relatives, the corals, hydras and jellyfishes) have only superficial resemblances to plants and are members of the Animal Kingdom. In 1847, Leuckhart established the phylum *Coelenterata* for these animals but modern usage favours the name *Cnidaria,* and sea anemones are placed in the class *Anthozoa.*

Approximately a thousand species of sea anemone have been described, ranging in size from a centimetre or so to about 1.5 metres in diameter. They occur in all oceans and are found at depths from the intertidal zone to about 10,000 metres. They are almost exclusively marine, but a few species have been able to penetrate brackish water. *Metridium schillerianum* has been found in areas where the salinity drops as low as two parts per thousand.

All cnidarian animals are characterised by a basically simple body plan. The body is covered by a single layer of cells (epidermis), and another single cell layer (gastrodermis) lines a large, sometimes branched, digestive cavity. A jelly like supporting tissue (mesoglea) lying between these two tissue layers forms the bulk of the body. The digestive cavity has only one opening—the mouth, which is used both to take in food and to get rid of undigested material.

Cnidarian animals are radially symmetrical with the mouth at the centre. Internally, the symmetry may be modified and, in the anemones, the existence of two longitudinal ridges or septa in the digestive cavity creates a biradial symmetry. They have no special sense organs.

The body of the sea anemone is divided into three major parts: the oral disc, with its mouth opening and tentacles; the column or body stem; and the base or pedal disc. The column, which may be compressed or elongated, is usually coloured, often striped or spotted in vivid yellows, reds, blues or greens. Many species are multi-coloured. The oral disc may bear a single ring of a dozen or so rather thick tentacles, or several rings of thousands of small, fine, feathery, often branched ones. There are countless intermediate variations between these extremes but tentacles always occur in multiples of six, as do the septa, which subdivide and increase the surface area of the digestive cavity as the animal ages, with a corresponding increase in the number of tentacles. The actual shape of individual tentacles varies greatly, although they are most often of a simple conical form, which tapers off to a point. Partial structural restrictions in them may lead to a slightly bulbous appearance.

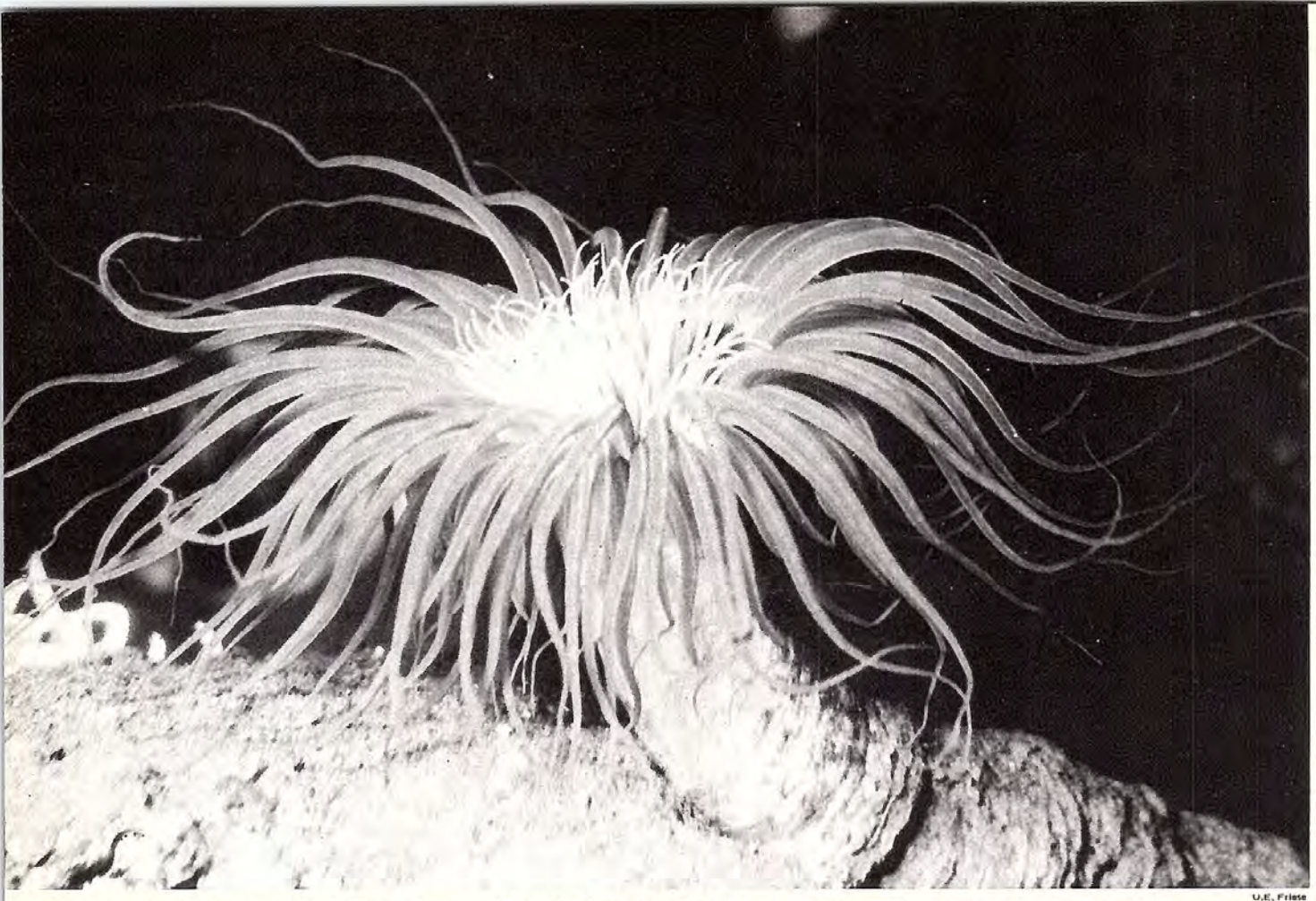
Multitudinous tiny stinging cells, the nematocysts or cnidoblasts (from which the name *Cnidaria* is derived) are distributed over the entire body, although they are most strongly concentrated on the tentacles. These cells contain toxins which cause paralysis and their role is both offensive and defensive—to seize and hold prey or to defend the anemone against possible predators.

Basically, a cnidoblast consists of a bulbous double-walled structure, containing a spirally folded hollow thread, with a minute barb at its end. The outside of the cell bears a tiny sensor which, when stimulated physically or chemically, causes the cell to discharge,

Many sea anemones have a cosmopolitan distribution and the genus *Actinia,* occurs in all temperate seas. *A. equina* (pictured) is commonly found along the central and southern European coastline.

U. ERICH FRIESE, is Curator of Fishes at Taronga Zoo. His research interests are centred around marine invertebrates with particular emphasis on crustacean parasites of Fishes.

U.E. Friese



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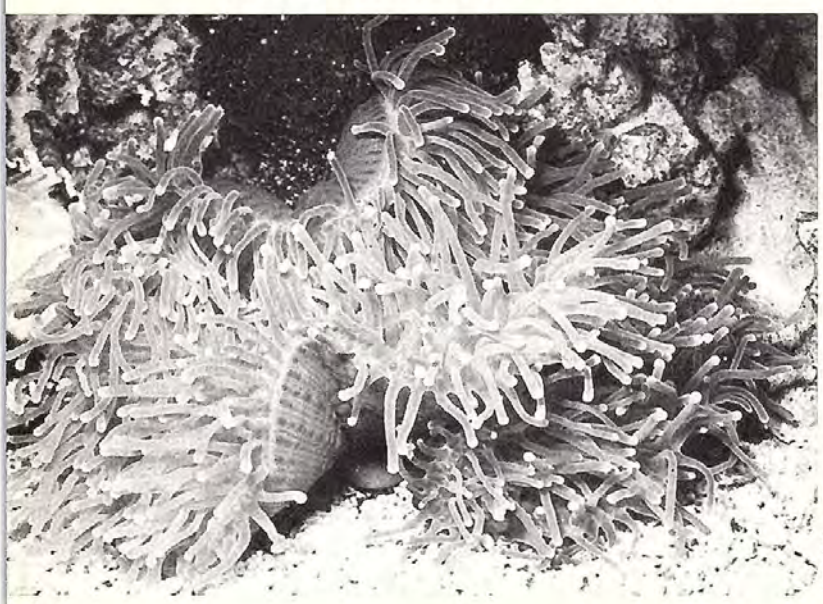
The burrowing sea anemones, *Cerianthus sp.* live in the sand and mud of the sea floor.

ejecting the hollow thread with sufficient speed and force for the barb to penetrate the victim's skin and inject the toxin. Since these cells are microscopic, their individual effect is minimal, but when hundreds or thousands are activated simultaneously, they may be lethal.

Most anemones are solitary and sessile; though some live buried up to their tentacles in sand or mud, through which they can move by muscular movements of the column, and others have a planktonic way of life, floating just beneath the surface with their tentacles and oral disc pointing downward, sustained by a gas contained in spongy tissue in the pedal disc.

Sea anemones of the genus, *Radianthus,* are among the largest in the world.



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Because of the relative immobility of most sea anemones, they cannot flee from their enemies but have other means of resisting predation or avoiding destruction in addition to their poison darts. The animal can, indeed, withdraw into its own protective interior. Even a slight disturbance in the water around a sea anemone may cause it to expel most of the water from its body cavity, whereupon the oral disc and tentacles invert into it. The surface area of the sea anemone is now greatly reduced and offers less opportunity for attack. This mechanism also reduces dehydration when the animal is exposed at low tide.

Those species inhabiting sandy or muddy bottoms escape from their enemies by withdrawing completely into the substrate. The only sea anemone known to move actively away from a predator is *Stomphia* which, when approached by the leather seastar, *Dermasterias,* suddenly releases its foothold and, with alternate lateral contractions of the body, propels itself away from its slow-moving predator.

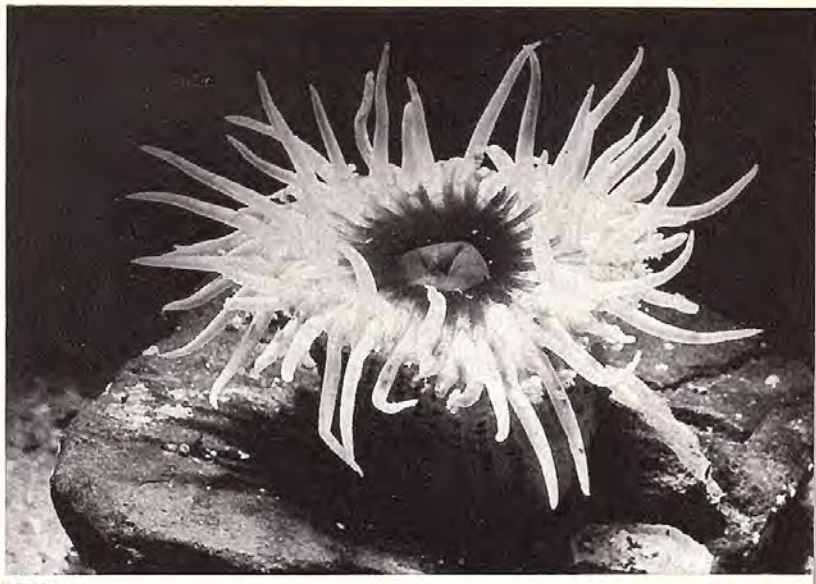
Despite their apparently stationary life, sea anemones are capable of locomotion by slowly gliding on the pedal disc. This is usually too slow to be perceived by the human eye. Some species move about a great deal.

Time—lapse photography demonstrates this and other movements. The Plumed Sea Anemone, *Metridium,* slowly and almost continuously sways from one side to the other, by contracting and expanding opposing sets of muscle bands. It also expels the entire water content of its gastric cavity, then refills it by expansion of the column and ciliary action of the oral disc.

Anemones may be divided into two categories in terms of their feeding behaviour. The particle feeders, such as *Metridium* , obtain microscopic food with the aid of cilia on their tentacles and oral disc. Minute floating organisms stick to the adhesive cilia, and are transported by uniform, directional beating toward and into the mouth. Predators, such as the large *Tealia columbianae,* which have strong tentacles equipped with particularly powerful stinging cells, are able to paralyze their prey instantly. These species feed predominately on small fishes, some shrimps, crabs and other invertebrates.

Chemical tests with sea anemones have shown a variety of very interesting responses. *Metridium* can recognize dilutions of clam or mussel homogenate at a concentration of one part per million, and will turn its oral disc towards this food source. *Actinia* and *Anthopleura* will accept tiny pieces of paper drenched in meat juices, water-soluble amino acids (especially glutamic acid) or even an inorganic acid.

Anemone reproduction may be sexual or asexual.



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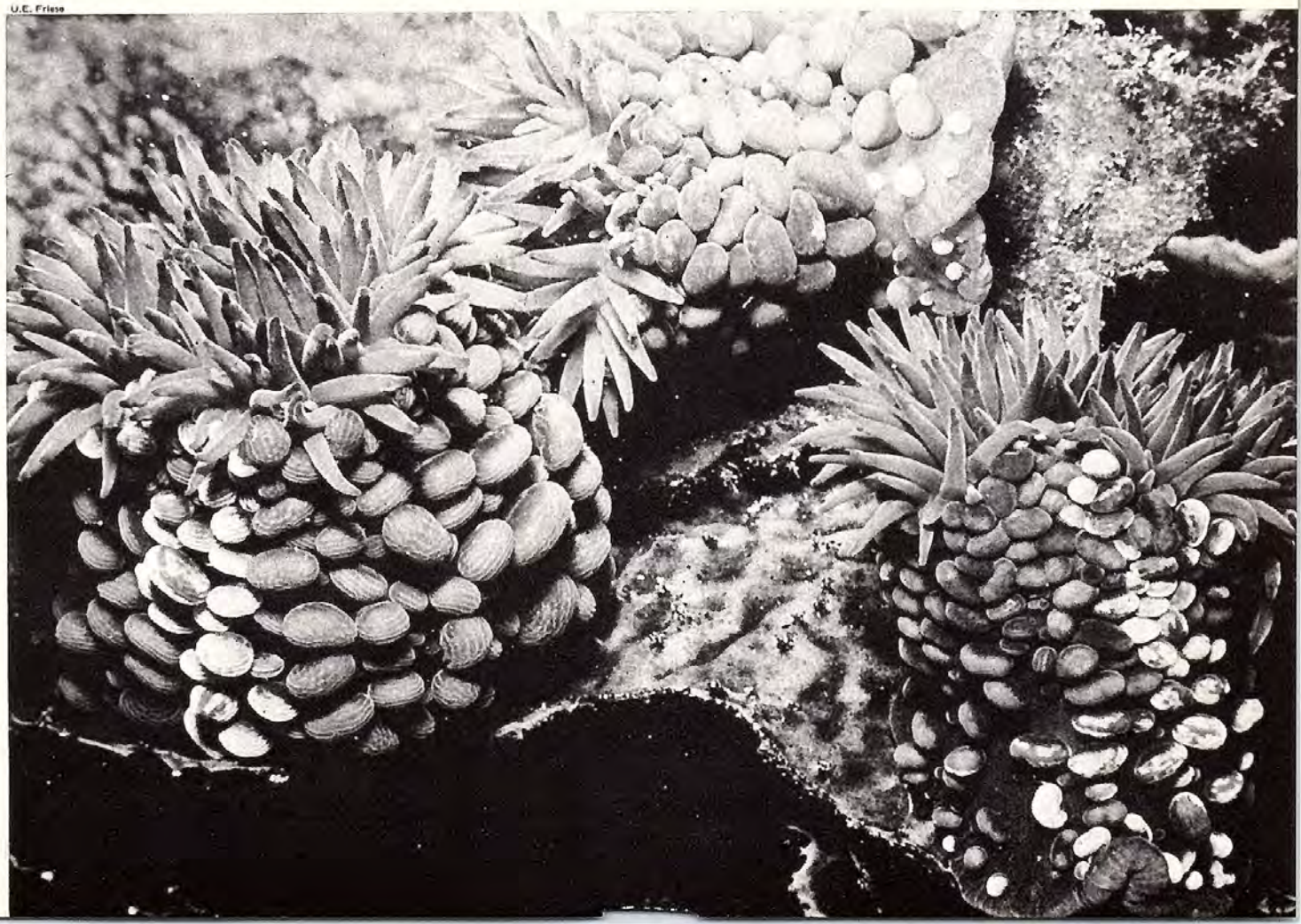
The speckled sea anemone, *Oulactis muscosa,* camouflages itself against the debris of the sea floor.

The swimming sea anemone, *Phlyctenactis tuberculosa,* lives amongst kelp against which it is well camouflaged.

During sexual reproduction the male releases spermatozoa into the water, through the oral opening, from the tips of the tentacles, or from pores in the body wall. (The method varies with the species and one or a combination of these apertures may be used.) This invariably stimulates a female to release her eggs into the water, where they are fertilized by the free-floating spermatozoa and where the early development takes place. In some species the female closest to the male will bend

U.E. Friese



toward the male; in others the female moves toward the male to increase the likelihood of fertilization of her eggs. In Arctic waters, the female *Tealia felina* retains the eggs within her body, but the same species in the North Sea releases its eggs into the water for fertilisation.

Asexual reproduction usually takes place by division of one individual into two. A longitudinal furrow develops in the column and extends until the animal splits into two new anemones. In some species the parent animal sheds small pieces of its tissue, from which tiny anemones develop.

U.E. Friese

Commonly encountered along the coastline of south-eastern Australia is the beautiful Waratah Anemone, *Actinia tenebrosa,* which often lives above the low tide level, in small tide pools. This anemone varies in colouration from dark brown to bright red, and is usually found in small groups in locations well protected from the pounding surf. Several closely related and very similar species occur in other temperate zones, such as *Actinia equina,* which is common along the northern shoreline of the Mediterranean.

Another fairly abundant sea anemone along rocky shores is the speckled sea anemone, *Oulactis muscosa.* Around Sydney this species is commonly found in water-filled cracks and crevices in places like Harbord, and Long Reef off Collaroy. *Oulactis* can be easily recognised by its speckled column and the light-coloured margin around a dark-coloured centre of the oral disc. It is characterised by its habit of attaching bits of gravel, shell fragments or coarse sand over its tentacles and column, which can make it rather difficult to find.

A rather delicate sea anemone, either brilliant green or bottle green with long graceful tentacles, is the Green Sea Anemone, *Cnidopus verater,* which remains in tide pools with an ample amount of water and is never found completely exposed.

An unusual species occuring in eastern Australia and often found in the kelp beds in the outer bays of Sydney Harbour is the Wandering Sea Anemone, *Phlyctenactis tuberculosa.* The column surface is covered with large numbers of little blister-like vesicles, with two or three distinct vertical stripes of silvery grey or blue, and its coloration varies from deep red to yellow. The tentacles may vary from yellow to orange, or even be bluish. It is rarely found attached, but appears to wander aimlessly about propelled by lashing movements of the tentacles and alternate muscular contractions and expansions of the column.

A truly colonial sea anemone is the small Orange Sea Anemone, *Corynactis australis,* which forms large mats over rocks at and below the extreme ebb tide level. Apart from its being found in colonies, this species is easily recognised by its tiny, club-shaped tentacles. It used to be quite common in the outer Sydney Harbour area (e.g. Bottle and Glass Rocks), but

it occurs most abundantly along the open coast, near the pounding surf but always protected from direct wave impact by boulders or deep crevices.

Anthothoe albocincta also lives in large colonies along the eastern coast of Australia. It is characterised by a longitudinally striped column and radial stripes on the oral disc. The stripe patterns are usually white and yellowish to light brownish, but white may also alternate with dark green.

While the preceeding species of sea anemones are all relatively small and rather inconspicuous, some spectacularly large sea anemones are found in the tropical waters of northern Australia, particularly on the Great

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Barrier Reef. These are the giant, stichodactyline sea anemones. The average height of a fully grown specimen is only 20 to 30cm, but some species have very large oral discs. *Radianthus* has a disc diameter of about 25cm, *Discosoma* often in excess of 1m, and the giant *Stoichactis* sea anemones in excess of 1.5m.

These three genera are commonly found in relatively calm waters on coral reefs, and are known for their symbiotic relationships with reef fishes of the genera *Amphiprion, Premnas* and *Dascylius* (family *Pomacentridae).* These depend heavily on their host anemones for survival, living almost continuously among the tentacles of a host anemone. In return for the protection that it gives, the sea anemone receives left-over food from the fish; in some cases these fish appear to deliberately feed from their host. Other fishes, however, seem to be well aware of the dangers posed by the stinging cells, since most of them carefully avoid contact with the tentacles.

Sea anemone also form close relationships with other marine animals. A particularly well-defined symbiosis exists between certain anemones and many hermit crabs. The hermit crab *Pagurus arrosor,* actually helps the sea anemone *Calliactis parasitica,* to move onto the dead mollusc shell in which it lives. An even closer relationship has been observed between the hermit crab *Eupagurus prideauxi* and the sea anemone *Adamsia palliata,* the latter having never been found without its host. In fact, this anemone secretes a substance that builds up around the entrance of the shell in which the hermit crab lives, enlarging it as the crab grows so that this hermit crab has to leave its 'house' for more spacious quarters less frequently than do other species. Presumably, such relationships have developed to the benefit of both animals, the hermit crab receiving added protection from the anemone's powerful stinging cells, and the anemone gaining more opportunities to come into contact with food while being carried about by the crab.

Conversely, some tropical sea anemones have crabs living among their tentacles. For instance, it is fairly common to find small Porcelain Crabs, *Petrolisthes maculatus,* on the oral disc of stichodactyline anemones.

A few words should be said about the age of sea anemones, which, in the absence of direct observations, usually has to be estimated. There are a few isolated records of some speciments having living from 30 to 90 years in captivity. However, the laurels for known longevity of sea anemones must go to an *Actinia* specimen collected by the scottish naturalist, Dalyell, from a rock pool at North Berwick. He kept it in a little bowl, feeding it on bits of oyster and mussel, and changing its water regularly. Eventually this sea anemone became known as 'Granny', and as such it outlived Dalyell and three successive caretakers. When it finally died it was given a newspaper obituary half a column long.

Corynactis australis, occurs in large carpet-like colonies along the east coast of Australia.

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A young Enga girl, during her wedding. Although she handles the pigs, ties them and gives them, she is directed from both sides—for the wedding ceremony is a prelude to future *tee* transactions between men of her natal clan and her new husband's clan.

Anyone who has lived with New Guinea Highlanders for any length of time will easily, probably nostalgically, remember incidents and happenings involving pigs and people—the concern over a pig that was sick or had died, the deafening squeals of pigs waiting to be fed their sweet potatoes in the evening; the small motherless pig being wet-nursed by a woman; the uproar and disputes among neighbors when a pig of one had destroyed the garden of the other. The relationship and interdependence of pigs and people is a basic one in Papua New Guinea.

Pigs are almost everywhere used to obtain wives and cement alliances between clans; they placate the ghosts of the deceased who may be causing harm to the living; they are used to pay compensation for insult or injury; they are a principal wealth item in systems of ceremonial exchange where big-men seek and compete for prestige by trying to out-give others and, not incidentally, they are the major sources of protein for people who are protein-deficient.

My own impressions and information about pigs and people comes from a period spent in the Western Highlands near Kompiama, with a group of Enga people. The Enga, sedentary horticulturalists and pig-raisers, are the largest ethnolinguistic group in Papua New Guinea with only minor differences in custom and dialect among 140,000 people.

The Enga are 'classic' Highland pig-keepers and their reliance on pigs includes all of those aspects mentioned above. Despite this reliance, the Enga equally realize that pigs are a burden to feed and care for, and are the source of numerous, often serious quarrels. Most of these quarrels involve accusations between fellow clansmen that one's pig has broken into a garden and damaged or destroyed it.

The damage that a loose pig can do in a very short time is quite remarkable. Enga pigs are allowed to forage unattended during the day, searching the bush for insects, then returning at night to be fed by the women and sleep in the warmth of a woman's house. Gardens are made in close proximity to the living areas and are fenced, before they are planted, with cut timber to keep out the curious pigs. While the fences are certainly a deterrent, the Enga voice a sort of hopelessness in their efforts to keep pigs out. Older gardens, though still in use, with older, less secure fences, are a primary target of pigs; however, strong pigs can sometimes get over even new, well-made ones. Despite the trouble of intruding pigs, the Enga often speak admiringly of the strong, hard-to-control, half-wild qualities of such animals, comparing them with the strong-willed, outspoken big-men of influence. Like such a man, once a pig had made up his mind, the Enga say they are powerless to do anything about it.

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PEOPLE, PIGS AND PUNISHMENT

BY D.K. FEIL

During my first two months (April-May 1974) among the Mamagakini clan, I recorded over thirty five separate cases involving gardens damaged by pigs. I was not keeping strict tabulation; these are only those cases that came to my attention and a higher figure perhaps up to fifty would probably be more accurate. Furthermore, I have no reason to believe that this number of pig offences is higher than normal. These clashes between fellow clansmen are frequently highly emotional and involved and are brought before an informal *kot* where rules of procedure and evidence have been standardized and are strictly adhered to. Before the advent of Europeans and *kots* such garden abuses, I am told, were handled more simply and easily. The owner of the offending pig told the offended party to kill the pig and eat it; the case was settled. However, seeing how the Enga verbally manoeuvre, deny and debate now within these informal proceedings leads me to believe that such settlements were never quite so simple. During a *kot* the damage done by a pig is surveyed, evidence such as a pig's foot prints and their direction is given and eye-witnesses give their versions where appropriate. The person hearing the case then weighs the testimony and awards compensation if any. In these thirty-five cases, fines ranging from $A1 to two live pigs were paid. I also recorded two instances where the offending pig was killed when caught 'red-handed'.

The obvious problem from an outsider's view is that the Enga just have too many pigs in too small an area, though I have never heard an Enga complain that he had too many pigs. My preliminary pig census showed a population of over 2100 pigs for a human population of about 500 people (average of over four pigs per person) and roughly eighteen pigs average per household.

Of these thirty-five cases, many of them represent multiple offences by the same pig or offences by pigs of the same owner, i.e. *kots* are not generally convened or compensation awarded on the basis of just one garden violation especially if the damage done was not too extensive. What usually happens after the first offence, is that the offended party, on discovering the damage (usually about 6am), makes a loud, verbal outburst within the hearing range of the offending party accusing him of not looking after his pigs. He grossly exagerates the damage done and emphasizes the fact that the garden is now of no human use. These outbursts serve as a warning to the pig owner that he must 'do something' to prevent further abuses lest a *kot* be brought against him.

The options then open to the owner of the offending pig are several. Firstly, he may decide to give the pig away to a friend, a practice called *mena yukupae* (to 'lift out' a pig). This pig will later be reciprocated within an overall system of exchange called *tee* in which the Enga take part. The Enga say they will 'try the pig at another man's house' to see whether it behaves better or, in any case, to relieve themselves of it. Pigs are in constant movement between persons, being exchanged and handed on in *tee* transactions, and the offending pig may be so given. This movement of pigs from house to house may, though, be a genuine source of the problem, for these pigs tend to stray and wander more in unfamiliar areas. Secondly, the owner may exchange the hard-to-control

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An offending pig is tied to a stake before being blinded with hot cane juice *(kolo ipange)*.

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In *tee* ceremonies, men vie for rank and social prestige by displaying and giving away items of wealth, particularly pigs.

pig with another man who requires a pig to be killed immediately. Bride prices, *tee* payments, death payments and nowadays, killing pigs to make 'bisnis' for money all involve 'spending' pigs—and so a pig that is 'rough' may be exchanged with another and then be killed soon after by the new owner to meet some obligation. The reciprocation in this case usually comes sooner that in *tee* transactions. The third option, one on which I wish to dwell, is the performance of one of several 'pig operations' to make the pig less mobile and less likely to do damage. These operations are performed as follows:

(1) *Mena nenge longenge* (breaking a pig's teeth into small pieces): This dental operation is performed if a pig has been seen pulling down a fence or has killed another pig. A long stick is inserted lengthwise into the pig's mouth and shoved back deeply so the pig cannot close it. A stone is placed inside along the front teeth and an axe is used to break the teeth, both uppers and lowers. This prevents the pig from clamping down or biting, but, I am told, still allows the pig to eat using his back teeth.

This pig, caught red-handed' in an Enga garden, will be exchanged, mutilated or killed for his offence, the degree of punishment depending upon the extent of damage to the garden and upon his past offences.

(2) *Lyaa langa pingi* (breaking the nose): If a pig has used his nose to uproot a fence or caused extensive damage by burrowing, this operation is performed. An insert is made at the top of the snout. A small bone called *lyamungi kuli* (bone of the nose-septum) is cut and removed. This is the bone that gives the nose the strength to dig. This is thought to be an especially harsh punishment for it prevents the pig from finding insects and worms in the bush.

(3) *Kongapu nyingi* (cutting the tendon): If a pig has jumped over a fence to enter a garden, this operation is in order. Two cuts are made horizontally across the back of each foot, exposing two tendons running lengthwise. A strong stick of black palm is forced underneath the tendons and they are cut and removed. This prevents the pig from jumping or even walking properly.

(4) *Lenge lukungi* (putting out the pig's eyes): If a pig is difficult to manage or tends to stray and not return, etc., this most common of pig operations is performed. The pig is fastened to a stick. A length of cane called *kolo* is heated in the fire until very hot. It is then twisted and its juice *(kolo ipange)* allowed to fall into the pig's eyes. The hot juice turns the eyes white and after a week or so of scabs and sores, the eyes are fastened and the pig is permanently blind. "He cannot see the road into another man's garden."

The Enga tell me that these are only the most common forms of mutilation. I have occasionally seen a pig without a leg or foot and was told that in a fit of anger the owner or offended party simply slashed its limb with an axe.

Without exception, each of these operations results in a pig which is more dependent on human care than before. They must be watched more carefully or tethered continually for the disability renders them helpless. The Enga dispute my claim that these mutilations have dubious preventative value, especially putting out the eyes (pigs have notoriously bad eyesight and rely heavily on their olfactory systems), and they insist that these operations help control the wayward pig. These disabled pigs soon become a very big nuisance and may be the first to be used or killed when an occasion requires it. Their disability marks

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While a native pastor perched on a tree, preaches the evils of wasting time on the *tee*, the *tee* participants carry on with their business. The pastor himself on other occasions is heavily involved in *tee* business.

them for expendability and, generally, the sooner the better. A possible exception to this rule is when the mutilated pig is a sow. Sows are mutilated in the same ways as males but their breeding potential allows a greater tolerance to be shown them. I have two examples where mutilated sows, not in litter, were given to be killed and soon after, their reciprocation came in the form of roughly equal, unmutilated ones. However, there are examples of mutilated sows which are looked after continually and have had several litters after mutilation. Pigs marked by mutilation as hard-to-control form, in a way, a collective, expendable herd available to all for use. In this way, very rough animals are continually trimmed from individual Enga herds.

Mutilation is also, I would maintain, in garden cases where *kots* are not immediately pressed, a public demonstration by the owner of the offending pig that he is taking steps to prevent or deter the pig from further garden violations. An owner who shows little or no concern that his pig has damaged another man's garden is liable for a more severe fine later if brought to *kot*, and recrimination from clansmen for doing nothing. A man thus demonstrates that he is reasonable and responsive and might well point to these mutilations later as proof of his good intentions and magnaminity.

These mutilations too, tell us something more, though maybe less tangible, about the Enga relationship with their pigs. I think it could be argued that these mutilations represent, in Enga minds, a punishment to the pig for his offence. Although there are no contemporary examples, I am told that in times past, a person who was a chronic thief might have a finger cut off, or an adulteress might have a tendon in her leg or ankle severed or the side of her nose lopped off as a punishment and permanent stigma by her outraged husband. It is tempting to make some sort of connection between the pig mutilations and these human ones: that perhaps the vital place of pigs, their total absorption into all phases of Enga life render them liable for the same treatment as humans, like being fed at the breast, but similarly including punishment when a breach has been committed. Human relations are almost always highly-charged and emotional, and I think this is also a very apt description of the Enga-pig bond. The Enga often remark, somewhat ironically, that although they expend so much energy and time discussing pigs, exchanging them, caring for them, fighting each other over them, and such like, the pigs themselves say very little, and they wonder how the pigs can be so seemingly impervious to all the rancor, dispute and intense feelings they cause.

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Pearl shells *(mamaku)* and cassowary *(liama)* are also exchanged in the *tee*, but they are not as valuable as pigs.

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Courtesy of the Publisher

Splendid wren, *Malurus splendens*—Page 410 RDCBAB

READER'S DIGEST COMPLETE BOOK OF AUSTRALIAN BIRDS, many authors, *Readers Digest Services Pty.Ltd., Surry Hills, 1976; 615 pages, illus; $33.00.*

EVERY AUSTRALIAN BIRD ILLUSTRATED, author uncited, *Rigby Limited, Adelaide, 1975, 320 pages, illus; $24.95*

The general format of these two books is similar; both are large lavishly illustrated volumes presenting Australian birds in a manner never before attempted on such a public scale. Each begins with a brief coverage of habitats of Australian birds, and follows with the portraits of approximately 700 species known to occur or have occurred in Australia. The Reader's Digest book portrays all its birds with colour photographs while *Every Australian Bird Illustrated* utilizes some paintings (about one fifth of the illustrations) where photographs were not obtained. The majority of the text in the Rigby book is devoted to discussion of the families of birds with the data on component species limited to a short caption giving common and scientific names, average length, habitat, status (common, rare, etc.), and a small amount of general information. In the *Complete Book of Australian Birds* the emphasis is on the species. For each there is given alternate names, lengths, plumages of adult and immature birds, voice, nesting data, and distribution including a map. In addition, there are several paragraphs of text examining certain points in greater detail. Although the order and family of each bird are identified at the bottom of the page, general comments about the families are brief and are relegated to the back of the photographic section. A final portion of the book augments the bulk of the volume with a concise presentation of such topics as behaviour, migration and origins of Australian birds.

Significant differences, apparent in even a cursory examination, exist between the two books. *Every Australian Bird Illustrated,* the first to appear, gives the impression that it was rushed in to print to capture as large a proportion of the market as possible prior to the production of the Reader's Digest book. Most aspects of it suffer from what appears to be the insufficient time allowed for its production; consequently, the overall quality of the book has also suffered.

It is a tabletop book, only for the adornment of one's library with no pretense to serving as a reference source of information. It is aimed at the casual bird-lover and treatment of the subject matter will have little appeal to the more serious student of ornithology.

The text is generally accurate but it is difficult to determine who has actually contributed to it. Often anthropomorphic, it occasionally runs to such ludicrous statements; for example, in the description of courtship in the Superb Lyrebird, the male's behaviour 'is typically masculine, sometimes pleading and coaxing, at other times full of bounce and business' while 'the hen is just as typically female, utilising the wiles of her sex, playing hard-to-get, neatly timing her eventual response'. The information contained in the captions is brief and of varying quality.

In a book of this nature, the illustrations are the fundamental component. The use of paintings is, in itself not objectionable, particularly when it fills those spots which would otherwise be left blank for lack of available material, as is the case with a number of Australian birds which have rarely been photographed. The absence of photographs of such common species as Japanese Snipe, Golden Bronze Cuckoo, and the near ubiquitouse House Sparrow, however, merely reinforces the feeling that the Rigby book was rushed into print without an adequate effort at assembling its material.

Several of the paintings suffer in reproduction. The work of John Gould and Gregory Mathews are frequently washed out. As one would expect with the

ALIAN BIRDS AND OTHER ANIMALS

paintings of six artists being used, there is a range of quality. In most instances, these are at least adequate, often very commendable, but some, such as the species of Riflebirds, leave much to be desired.

Every Australian Bird Illustrated contains some superb photographs, the Black Swan is particularly notable. Unfortunately, there are far too few of these in relation to the number of mediocre and poor pictures also used. Many of the photographs are out of focus, some quite badly e.g. Owlet-night-jar, Turquoise Wren, Pictorella Finch, to mention a few. It is disturbing that no better pictures of Grey Teal, Galah, Silver Gull, and Superb Lyrebird, all common and easily photographed species, could be found for inclusion. The 'nationwide search for the best work by bird-watchers in each State' which was made to acquire this material must have been a cursory one at best. The colour in the reproduction of many of the prints is too heavy and in some, such as the Fairy Prion and Spotted Catbird, an otherwise good portrait has been marred because of the odd colouration. These are not the only examples which deny the dust cover's claim that 'Every illustration gives clear details of colour, plumage, beaks, and other aids to recognition'.

It is also stated that "Each bird is shown in its natural surroundings". Here, too, a significant number of exceptions to this statement can be found. Many are captive birds in enclosures or cages; others have been posed in unnatural surroundings. Studio pictures, an accepted and acceptable method, are used frequently with parrots and finches. These are often made against a solid colour background with a few vegetational adornments added. While technically well done, they can hardly be forwarded as 'natural surroundings'.

Several errors in identification are apparent in *Every Australian Bird Illustrated* despite the dust cover's announcement that each picture has been 'expertly checked for accuracy'. Obvious errors are the Oriental Cuckoo, labelled Pallid Cuckoo and a ruffled female White-browed Scrubwren misnamed Mangrove Warbler. The Marbled Frogmouth is in reality a Tawny Frogmouth and the Black Kite is an immature Brahminy Kite. In a book of this variety it is unfortunate that such lapses should occur.

There is a disturbing quality in many of the portraits that makes one apprehensive about the treatment received by the bird. The obviously contrived nature of the posed Black-shouldered Kite is apparent from the visible string around its leg, but, despite the blatancy of this action, it is the more subtle implications in other photographs which are more objectionable. The unnatural stances of the Southern Figbird and Black-headed Pardalote are those of distressed birds. The Mountain Duck and Koel only serve to further suggest that these birds have been handled in such a manner as to make them 'more willing' subjects. This type of nature photography can only be looked upon in the most unfavourable light. Yet the continued use of such material by publishers can only encourage and promote its perpetuation.

After *Every Australian Bird Illustrated,* The *Complete Book of Australian Birds* is a pleasure to inspect. Although it will certainly appeal to the same audience, the depth of information places it on roughly the same level as the best works on Australian birds currently available, for example J.D. Macdonald's 'Birds of Australia'. It is, therefore, capable of fulfilling many of the needs of the serious bird student, as well

Courtesy of the Publisher

Red-capped robin, *Petroica goodenovii*—Page 360 RDCBAB

as serving as an attractive addition to one's home. Despite the amount of information presented, the word 'complete' in the title is an unfortunate choice. It is far from being a complete treatment of the Australian avifauna and cannot be said to meet the requirements of a handbook which is so badly needed.

There is an impressive list of contributors who have written the text, each discussing species with which they have worked and are thus familiar. Consequently, the information is accurate and in several instances, new data has been presented.

A large majority of the photographs have been taken from those represented in the National Photographic Index of Australian Birds. This has assured that there is only the occasional deviation from a uniformly high standard.

Even in a book of this quality, there are a few points which deserve some critical comment. In the introductory section, vegetational, climatic and attitudinal maps are presented in a narrow range of colours. The similarity of tones causes unnecessary difficulty in their interpretation.

A book such as this undoubtedly presents the editor with a difficult task to standardise the various styles of the numerous contributors. The differing emphases given by each author according to his or her particular interests is sometimes apparent. Overseas breeding records are given for some seabirds and not for others. Egg measurements are also haphazardly presented. This somewhat reduces the reliability of the book as a source of information.

Some sections are not as well placed as perhaps they should be. The brief summary of orders and families would be more appropriately positioned preceding the species accounts than following them. Integration of these synopses throughout the text, as has been done in the Rigby book seems a more useful arrangement. Contributors, both of text and photographs, are not acknowledged until the final page of the book. These are very crowded and the authors of the last section are not given.

A small number of the photos, such as the Wompoo Pigeon and Hooded Robin, are oddly coloured. After a comparison with the National Photographic Index print, it is evident that these have suffered in reproduction. The photograph of the Fairy Martin has been rotated 90 degrees so that the nest appears to open at the top rather than at the side. The White-lined Honeyeater is actually a Brown Honeyeater and the Red-eared and Red-browed Firetails have been transposed.

Where *Every Australian Bird Illustrated* relied on paintings to fill the gaps in the absence of photographs, the Readers Digest Book has usually chosen not to illustrate such species. In some instances, a blurred photograph has been supplied for rarely observed birds. Although somewhat distracting at times, identification is usually possible from the pictures. In the Red Goshawk, however, the out of focus photograph does little to enhance the work and the bird itself is indistinguishable. In such a situation, the illustration should have been left out; it subtracts more than it adds to the overall quality of the book. A few of the photographs of common species e.g. Brolga and Golden Bronze Cuckoo, appear slightly fuzzy. This seems unnecessary considering the resources available to the project.

There is a variety of studio photographs. Some utilise a solid background and are easily recognised. These are crisp and sharp, however, there is almost an over reliance on them. Indeed this may be the most feasible technique for furtive or treetop species, but for abundant species such as the Sulphure-crested Cockatoo and Lewin Honeyeater, it is a shame not to illustrate them in their natural surroundings, regardless of the technical excellence of the studio shot. Another method involves the natural habitat serving as a background. This is brilliantly demonstrated in the photograph of the rare Marbled Frogmouth. The use of captive and handheld birds, although at a bare minimum, stands out among the other illustrations.

With the high standard of the Reader's Digest book, any faults are more conspicuous than perhaps they should be. In an overall perspective, the deficiences are minor, the good points far outweighing the bad. The accuracy of the text is a major plus as is the quality of the illustrations. It is difficult to choose favourites among the pictures, but some, such as the Barn Owl nestlings, stand out. The inclusion of the portraits of the Marbled Frogmouth, Chestnut-breasted Cuckoo, and Green-backed Honeyeater, seldom, if ever, previously photographed Australian species, also merits mention. The care with which the contents were collected and assembled is evident throughout the book.

Every Australian Bird Illustrated and the *Complete Book of Australian Birds* lie at opposite ends of the spectrum. It is sad that the publishers have seen fit to offer the former to the public. With more effort, it could have been a worthy acquisition for popular libraries. As it is, the Rigby book is too poorly constructed to recommend to any but those few individuals who desire to have all Australian bird books in their collection, regardless of price or individual merit. Although all both books can be obtained for the same price, it is excessive for *Every Australian Bird Illustrated;* with the Reader's Digest book it is more justified. It is only hoped that the price will not prevent it from reaching the varied audience it deserves. *Reader's Digest Complete Book of Australian Birds* is highly recommended. All those connected with its production have just cause to be proud of their achievement.—*Walter Boles, Department of Ornithology, The Australian Museum.*

FROGS, by Michael J. Tyler, *Collins Sydney*, 1976. 256 *pages, illustrated, $12.95.*

Amphibians are undoubtedly the least well represented vertebrates in popular scientific Australian literature, and Michael Tyler's *Frogs* does much to fill this niche. It is written largely in an anecdotal fashion which makes it thoroughly readable, but sometimes leads to digression from the subject in hand, and occasionally to awkward phraseology and grammar.

The use of similes to convey basic scientific principles and concepts does much to enhance this book for the general reader who might have little or no knowledge of these subjects. This is perhaps best illustrated in the section dealing with taxonomy, where reference is made to the categorisation of animals and plants as following the same basic principle as occurs in the automobile industry, hence we may have Order: Automobilia, Family: Sedan etc. This is not to say that *Frogs* talks down to the audience, but rather that it endeavours to remove a certain mystique that has grown around scientific literature and terminology. The occasional use of cliches is unwarranted however, and at times these are inaccurate in the context in which they are used.

Unfortunately the book is not entirely consistent with the aims of the Australian Naturalist Library series of being ". . . . about the Natural History of Australian plants and animals", as it relies heavily on the author's knowledge and experience in other parts of the Australasian region. Although it is unwise to regard Australian fauna in total isolation from such closely allied areas, the depth at which some of these examples are dealt is, at times, excessive.

Frogs has ample diagrams, the majority of which complement the text but a few are of dubious value. Unlabelled djagrams of two frog parasites and a virtually meaningless life cycle of a tapeworm could well be omitted. Some other diagrams lack adequate labelling, sometimes of features pertinent to basic frog identification. A diagram of the osteological characters of the pelvic region would be useful as reference is made to these as being important to higher frog taxonomy. The lack of indication of the scale of some diagrams is, at times, annoying.

Although the majority of the plates depicting frogs are good, there are a few poor examples. The habitat photographs are generally poor. References in the text to two plates are inaccurate. Plate 20 (ref. p. 102 and 103) should read plate 8, whilst reference to a "brown tree frog" (p. 125) might refer to plates 1, 6, or even 16, but definitely not plate 2 as is stated. The Australian frog habitats depicted in plate 18 are meaningless as no indication is given as to which frogs are likely to be encountered at these localities. One plate (9 lower) is credited to two different contributors.

There are a few surprising omissions in this book. One particular instance of this is to be found in the chapter on reproduction where only the briefest mention is made of the transition, in the tadpole, from gill to lung breathing, more emphasis being placed on gills, in a later chapter, with regard to their function in filter feeding. Similar discontinuity of subject material is noticeable in other cases. Mention is made of a giant frog, genus *Discodeles* (of the Solomon Islands), but it is not until 120 pages later that its maximum size is given. Confusion occurs with repeated references to New Guinea and other non-Australian frog fauna, resulting in such statements that the frogs of the families Microhylidae and Hylidae are ". . . . to be found together in the same trees", which although perfectly true in New Guinea, is not the case in Australia where all the microhylids, known at present, inhabit the forest floor with a single exception which may be found in low shrubs and bushes. The Midwife Toad of Europe does not carry the eggs entwined round his legs and groin until ". . . . he finds a suitable place to lay them", but rather constantly seeks out moist areas or enters and re-enters water until the tadpoles are ready to hatch, at which stage they are released as free swimming forms, usually into a pond.

Obviously in a book of this nature it is impossible not to generalise on many topics, but some of the assumptions made are open to speculation in the absence of more specific information: does a *Pseudophryne* toadlet really feign death, as a means of passive defence, under normal conditions, or only when it is flipped on its back by a curious naturalist?

Frogs is logically set out, leading from a general introduction through the first five chapters which deal seperately with the four frog families in Australia, and the introduced Cane Toad, to frog biology, functional anatomy, prey, predators and parasites, dispersal, distribution, and a brief history of herpetology in Australia. The final chapter entitled 'The Study of Frogs', provides necessary guidelines for further study of both live and preserved material, a subject often omitted in popular literature.

The appendix contains a useful current listing of frog species for each Australian state, and it is pleasing to see such a full reference section, especially as these are listed under each chapter heading, facilitating investigation of pertinent literature.

This book does much to stimulate interest in frogs in general and provides the basic information necessary for further study of the subject. It is unfortunate that Tyler has not concentrated on Australian frogs, rather than digressing onto the faunas of other countries, which limits the depth of coverage of the former yet only touches on the large frog faunas found in other parts of the world.—*Paul Webber, Department of Herpetology, The Australian Museum.*

SPIDERS, by Barbara York Main, *Collins, Sydney 1976; 296 pages, illustrated, $12.95.*

The study of Australian spiders is still at an early stage and only a fraction of the fauna has been characterised at species level. Nevertheless some 1500 species have been described and a good deal of biological knowledge has been accumulated during the one hundred year history of Australian arachnology. Most of this information is not readily available to the layman nor is the existence of such a body of literature generally appreciated.

Over the past few years the popular literature dealing with Australian spiders, in common with that for many other groups, has increased considerably. Until fairly recently, the only popular work available was Keith McKeown's 'Australian Spiders', an entertaining series of behavioural essays which illustrated the life-styles of a variety of spider groups. More recent publications have generally taken the form of guides to families and selected species, often with valuable biological notes appended.

However, there has been a definite need for a more comprehensive review of current knowledge and this has now largely been filled by the recent publication, *Spiders* by Barbara York Main, in the Australian Naturalist Library series.

Dr. Main is a Research Fellow at the University of Western Australia and is best known for her extensive research work on the Australian mygalomorph spider fauna. As might be expected, this group of large and often fearsome looking spiders is treated with particular thoroughness and the author is able to provide many original insights arising from her work on them.

The bulk of this book is about the behaviour of spiders—the many ways in which these animals have adapted to a multiplicity of environments. However, the opening sections provide an adequate account of the basic morphology and anatomy of spiders in relation to the evolution of the group. This is followed by a general account of life history and behaviour in which a variety of topics from embryological development to social behaviour and mimicry are discussed.

In the section on 'Defensive Counterplay', two points of issue arise. The author refers to the stabilimentum (bands of silk of varying configurations placed at the centre of the webs of certain species of Orb Spider), as 'probably a strengthening strut for the web' when most evidence now suggests that its primary function is defensive—a means of predator avoidance. The second point concerns the reference to the western leaf-curling spider *(Phonognatha melania)* which is said to conceal its egg sac inside the leaf retreat. East Australian leaf-curlers place their egg sacs in a separate curled leaf remote from the retreat leaf in the web, a mode of behaviour with which the author is apparently not familiar. This would appear to be a most interesting behavioural difference between the eastern and western species.

The major part of the book is taken up with discussions of each of the families of spiders. In the mygalomorph spider section, particular emphasis is given to the authors own research in explaining the adaptations and evolutionary diversity displayed by these spiders. This is an excellent account which also provides numerous examples of the way in which data are gradually accumulated and pieced together to provide an overall picture of the animal in relation to its environment. The only quibble I would have with this section is the somewhat unnecessary and confusing use of the expression 'trapdoor spider' when referring to the Mygalomorpha in general.

The chapters dealing with the 'true' spiders or Araneomorpha are somewhat bedevilled by the current inadequacies in the systematic classification of these spiders. In discussing the araneomorph families the author has avoided this problem by using a behavioural classification. This was probably wise though the wisdom of creating two categories of hunting spiders 'Vagabonds and Nomads' and 'Ground Dwellers' is questionable since considerable behavioural overlap exists.

Of particular interest in the chapters on the web-building families are the various accounts of web reduction from elaborate snares to single threads and even complete loss of snare-building behaviour. This has occurred independently in several lineages. The author does not mention the web of *Pasilobus* in her account of snare reduction in the Araneidae. This is a pity because it demonstrates very graphically the probable pathway of reduction in the lineage *Poecilopachys—Pasilobus—Dichrostichus.*

One of the most interesting sections of the book is that dealing with patterns of distribution. In particular this provides the reader with an idea of the historical perspective necessary to appreciate contemporary distribution patterns.

The final part of the book examines the relationship of spiders and man from diverse viewpoints. These include among others, the usefulness of spiders in reducing agricultural insect pests, an account of the history of arachnology in Australia and the sequence of colonisation of houses by domestic spiders.

The text is accompanied by numerous photographs and line drawings plus an extensive bibliography. However, it is rather curious to note that not a single reference to W.J. Rainbow, one of the major workers on Australian Spiders of the turn of this century is listed.

This book is thoroughly recommended as a valuable addition to any naturalists library. Besides providing a wealth of information it also poses many questions which should further stimulate interest in and promote the popular study of Australian spiders.—*Mike Gray, Department of Entomology, The Australian Museum.*

Left: The peacock spider,
Saitis

Photos: Courtesy of the Publishers

Right: The corroboree toadlet,
Pseudophryne corroboree

Left: An ambushing spider,
Arcys

Right: The marbled toadlet,
Pseudophryne semimarmorata

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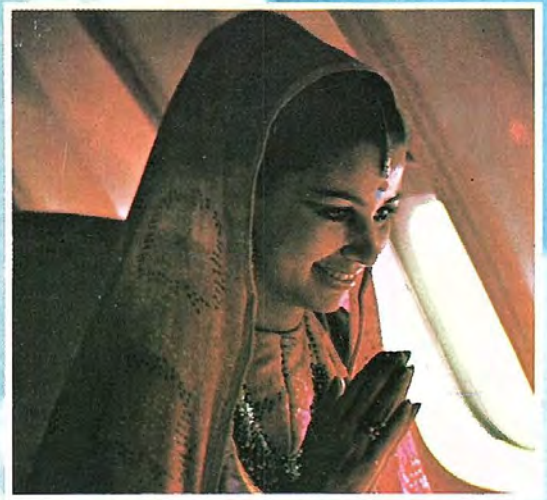

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