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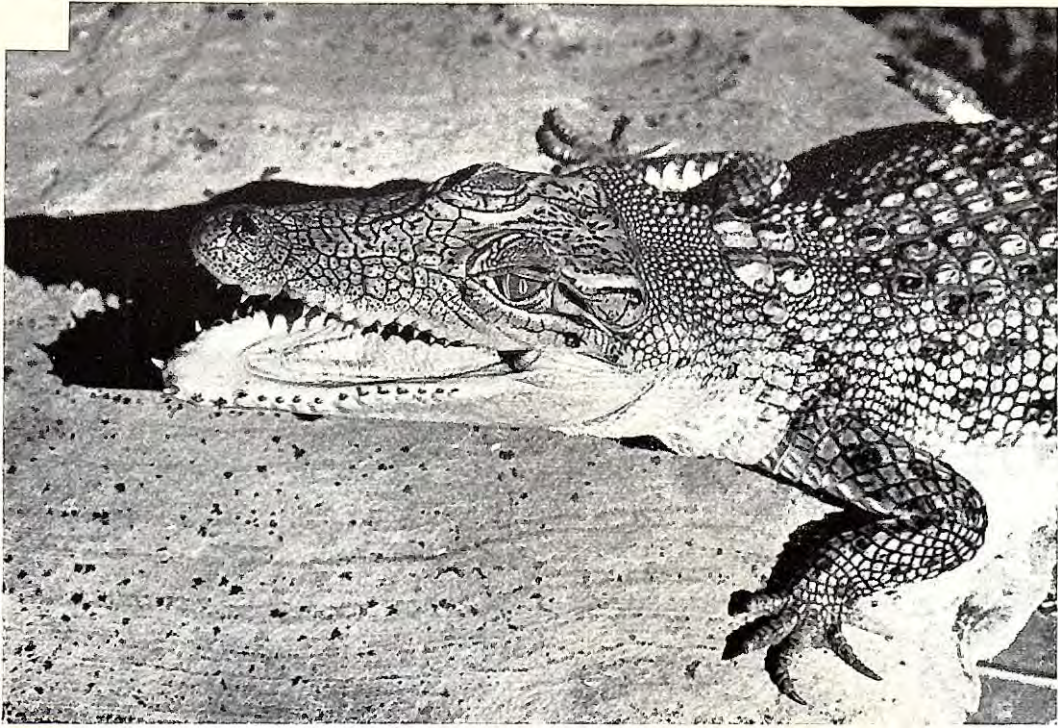
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● **FRONT COVER:** This insect is *Stilbopteryx*, a large member of the lacewing order and peculiar to Australia. Though reminiscent of a dragonfly, it is readily distinguished by the way it holds its wings. The clubbed antennae remind us of its close relationship to the ant-lion family. Its colour is predominantly brown. The wing expanse is nearly 4 inches. **BACK COVER:** These grass-trees or blackboys (*Xanthorrhoea*) were photographed in southwestern Western Australia during a recent Australian Museum expedition. Grass-trees are distributed widely over the Australian continent. The plant family to which they belong is restricted to Australia and New Caledonia. The trunk of the specimen in the photo is about 4 feet high. [Photos: Howard Hughes.]



An Australian Saltwater or Estuarine Crocodile. [Photo: Author.]

AUSTRALIAN CROCODILES

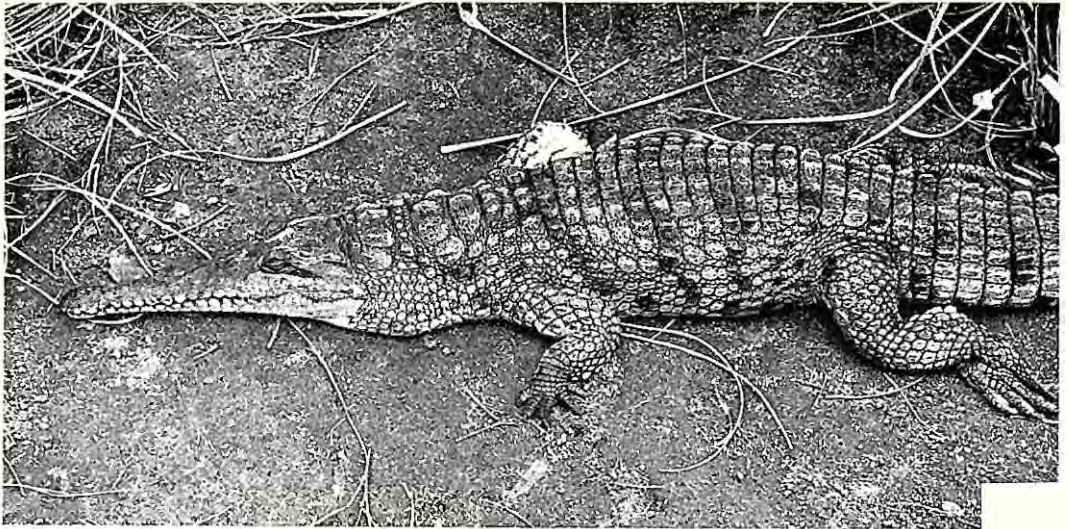
By H. ROBERT BUSTARD

Population Ecologist at the Research School of Biological Sciences, Australian National University, Canberra

CROCODILES are one of the most maligned animal groups. They are widely loathed, very little understood by most people, and surrounded by a number of myths. In this article I hope to be able to convince the reader that crocodiles have a place in nature and are no more than a master predator in their environment, as is a lion in his habitat.

In Australia there are two species of crocodile, the Freshwater or Johnson's Crocodile (*Crocodylus johnsoni*) and the Saltwater or Estuarine Crocodile (*Crocodylus porosus*). These two species illustrate a number of points which have been central to evolution and distribution of the crocodile group. There has been a radiation or

evolution in two main directions, namely, the development of long-snouted species with slender jaws and of short-snouted, broad-jawed species. The Australian freshwater species and the estuarine crocodile are representatives of these two groupings respectively. The distribution of freshwater crocodiles is usually closely circumscribed, since saltwater forms a barrier to their dispersal. Hence, adjacent areas of the world separated by even a narrow area of sea may have evolved quite distinct freshwater crocodiles. Such is the case in Australia and Papua-New Guinea. The Australian Freshwater Crocodile is found only in Australia. In Papua-New Guinea there is also a freshwater crocodile (*Crocodylus novaeguineae*),



An Australian Freshwater or Johnson's Crocodile. [Photo: Author.]

but even the novice could readily distinguish it from the Australian freshwater species.

The saltwater crocodiles on the other hand, like many seagoing animals, have been able to disperse and colonize other suitable habitats. Probably no crocodile has been as successful at this as the estuarine species (*C. porosus*). This crocodile is widely distributed in Asia from the Indian sub-continent eastwards, and extends southwards through the Malay peninsula and Indonesia to northern Australia. It often occurs on fairly small, remotely-placed Pacific islands having, for instance, been recorded at least once in the Fiji Islands, which are thousands of miles from any substantial land-mass.

Crocodiles "unpopular"

Crocodiles are reptiles, as are lizards, snakes, tortoises, turtles, and the remarkable New Zealand tuatara (*Sphenodon*). This may in large measure explain why they enjoy such low public esteem, as the general public tend to dislike reptiles, and, since they are ill-informed about them, credit them with many harmful or unpleasant habits. Hence a crocodile, which is master of its river system or swampland, is seen as a foul beast, whereas the lion is called "King of Beasts".

Like other members of the class Reptilia, crocodiles have a long and distinguished history. They are descended from prehistoric

reptiles called archosaurs—ancestral also to the dinosaurs, and somewhat like them in living pattern. The crocodiles have continued to occupy the same life style for 170 million years. There is a temptation to think that in evolution the new is always replacing the old. This is far from always being the case, and the crocodile group provides an excellent example of a group of animals which in far-back antiquity evolved a way of life that made them supreme in their chosen habitat and allowed them to remain masters of their environment throughout 170 million years. It must be remembered that, until the advent of shooting with modern automatic weapons, crocodiles could be seen in almost unbelievable numbers throughout tropical swamplands and river systems.

Like most reptiles, crocodiles do not thrive under cool conditions. For this reason they are restricted to the tropics, in Australia being found only in the north, occurring in Western Australia, the Northern Territory, and Queensland. In Western Australia they are restricted to the Kimberley Division. They occupy a similar portion of the "top end" of the Northern Territory, but in Queensland the estuarine species formerly ranged much further south along the coast, well into central Queensland. Human expansion and shooting have all but exterminated these more southerly populations.

All crocodiles are semi-aquatic, and show adaptations to their way of life. The eyes and nostrils (see the accompanying photos) are placed well up on top of the head so that the crocodile can swim or float with only the eyes and nostrils exposed. There is a fleshy flap at the back of the mouth which cuts off the throat so that crocodiles can open their mouths under water without drowning. The rear feet are webbed and the tail, the main organ of propulsion, is flattened laterally to make a powerful paddle. When swimming, all four limbs are folded back along the body. Crocodiles' jaws are well equipped with sharp teeth to hold the prey. This is particularly important with slippery prey such as fish, which forms an important part of the diet of all species at least during part of their life.

Life-cycle

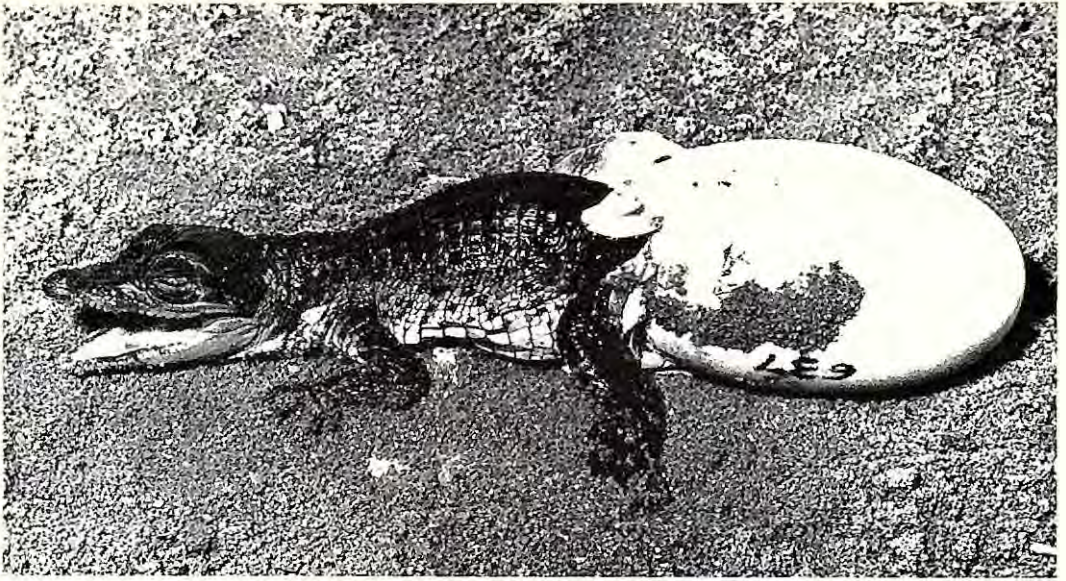
The life-cycle of crocodiles follows the classical dinosaur pattern. They begin life as eggs which have hard calcareous shells like those of birds. Not unnaturally there is considerable difference in egg size among the various species, but they approximate the size of goose eggs, though somewhat more elongated (see photo). The mother crocodile has to place the eggs somewhere where they will not run the risk of being flooded by rising water. Some crocodiles nest during high water levels, either in or immediately after the wet. They solve this problem by laying their eggs in nests which they construct in floating grass islands that rise and fall with the water (as is done by the Estuarine Crocodile). Others, of which the Australian freshwater species is an example, nest during the dry season, laying their eggs in sandbanks. The young of the latter species must emerge before the water-levels rise at the start of the next wet season. Emergence is usually timed so that the rising flood-waters serve to disperse the recently-hatched young, which would be extremely vulnerable if they were all cooped up in small dry-season pools. When they hatch, baby crocodiles are quite tiny, a total length, including the tail, of around 9 inches being usual, although, of course, there are species differences. They are extremely vulnerable to a whole host of predators, including many fish, birds, reptiles and mammals which larger crocodiles themselves eat. Here again we see the dinosaur pattern. A life-history beginning with small

eggs—even the largest crocodiles lay eggs which make an ostrich egg look enormous—and young which for some time are so small as to be virtually defenceless and must hide from their enemies, but which with growth eventually come to occupy a niche that no other species of animal can hope to challenge.

Parental care

Crocodiles have from time to time been stated to guard their eggs and even occasionally their young. For a long time this information was suspect and scientists thought that here was just another myth about crocodiles, especially since parental care is virtually unknown in reptiles. However, recent work, notably by H. B. Cott, a special adviser to the Governments of Uganda and Northern Rhodesia, has finally conclusively demonstrated that parental care does take place. The African crocodile *C. niloticus*, studied by Cott, not only guards the nest from egg-eating predators (as do many other species) but, according to Cott, plays a vital role in liberating the young from the nest and in guiding them to the nearest suitable water. When the young crocodiles are ready to leave the nest they call to the mother, who opens the nest. It appears that calling is also a key factor in synchronizing emergence by all the brood at the one time and in keeping them together with the mother. Cott has recently described "nurseries" in which the mother stays with the young, chasing away enemies until they are several months old.

Although juvenile crocodiles have many enemies, without man to disturb the balance crocodiles would always be numerous. This is because they are long-lived animals and require only a very low level of survival among their progeny to offset natural losses. Since they are master predators, losses will occur mainly from old age or fights with other crocodiles. It seems likely that crocodiles limit their numbers like other animal populations which have been studied and, indeed, as did man until he became a settled farmer. Crocodiles appear to do this by having "stations", or territories, each of which is occupied by an adult crocodile that will tend to be an old individual. Since crocodiles, like other reptiles, grow throughout life, old is synonymous with large. Let us take an example from the Australian estuarine



A New Guinea freshwater crocodile emerging from an egg in an incubator in Canberra, Australia.
[Photo: Author.]

species. Although females very rarely exceed 14 feet, males certainly grow to at least 20 feet. Sexual maturity is reached between 8 and 9 feet. Just imagine the result of an encounter in which a hopeful young male of 9 feet and weighing several hundred pounds tries to dislodge an old male of twice his length, probably ten times his weight, and with perhaps a century's experience in the art of killing opponents!

Crocodile society is ultra-conservative and is an old crocodile's world. While it is true that until recently we lived in an old man's world, the difference is that the young crocodiles are killed off without having a chance to breed, breeding being a prerogative of "station"-owning crocodiles. In human society the younger men, although they may have to wait for power, are able to produce progeny throughout this period. With crocodiles, evolution is largely in the hands of crocodiles which have been successful for long periods of time. A conservative situation like this will tend to result in little change—which is reflected in the group remaining similar throughout a long period of geological time.

There are many aspects of crocodiles which deserve mention, but space precludes more than two. Crocodiles are carnivores and as

they grow their diet changes from insects, tiny fish and frogs at birth, to larger fish, then other reptiles and birds, and, in large individuals, mammals usually come to make up a large part of the diet. (This was beautifully illustrated by Cott in a publication in 1961.) Crocodiles like fresh prey, and eat it at once. The idea that they keep food in underwater lairs until it is rotten is a myth. Crocodiles, incidentally, are not much interested in humans as food. This applies to large species well able to take a man. Even where contact is an everyday affair attacks are infrequent. Certainly the Estuarine Crocodile much prefers dogs or pigs to man. The Australian Freshwater Crocodile is a shy inoffensive little animal which will never attack humans unless attacked (wounded) first.

Conservation

I would like to finish this article with a plea for crocodile conservation. Those interested should read my 1969 article in *World Wildlife Year Book*. It would be tragic if such a fascinating group should be wiped out after such a long and proud history and before scientists have even had a chance to study them. Yet most species are threatened, and for some the only hope for the future lies in captive breeding studs. In

Australia the situation is not yet so critical—due particularly to the foresight of Western Australia, which protects both species. However, since Queensland refuses to take any action, poaching is rife as far away as Western Australia to sell skins in north Queensland. Incidentally, it would be quite possible to provide the commercial demand for crocodile leather from crocodile farms and leave the wild crocodiles to go their own way undisturbed as they have since Jurassic days.

By the time this article is in print Australia will have its first crocodile farms, run to benefit Aborigines, under my supervision, with financial backing from the Commonwealth Office of Aboriginal Affairs, apart from an attempt at Karumba which failed in the mid-1960's.

FURTHER READING

- “Report on the Crocodile Skin Trade in the Territory of Papua and New Guinea with Recommendations for the Future Development of the Industry”, by H. R. Bustard, special adviser to the Australian Commonwealth Government, July 1966 (cyclostyled).
- “The Current Status of Crocodiles in Western Australia with Recommendations for Conservation and Managed Exploitation”, by H. R. Bustard, special adviser to the Government of Western Australia, November 1969 (cyclostyled).
- “Scientific Results of an Inquiry into the Ecology and Economic Status of the Nile Crocodile (*Crocodylus niloticus*) in Uganda and Northern Rhodesia”, by H. B. Cott, special adviser to the Governments of Uganda and Northern Rhodesia, April 1961, *Transactions of the Zoological Society of London* 29: 211-342.
- “Tourists and Crocodiles in Uganda”, by H. B. Cott, special adviser to the Government of Uganda, December 1969, *Oryx* 10: 153-160.

SCHOLARLY BOOK ON SHARKS

THE LIFE OF SHARKS, by Paul Budker. Weidenfeld and Nicolson, London, 1971; 222 pp.; illustrated; \$11.90.

This excellent book, in *The World Naturalist* series, is not simply an English translation of Budker's earlier (1946) *La Vie des Requins*. Budker himself describes it as a complete revision, in which he set out “to graft new organs on to the old body.” This would seem to be an apt description of a work that still retains the character and flavour of the original account but is completely up-to-date in its information and coverage. The revision was carried out jointly by Budker and by Peter J. Whitehead, of the British Museum; the translation to English was by Whitehead.

The book begins with a chapter on classification, and continues from there with chapters on general form, anatomy, food and feeding habits, man-eaters, freshwater sharks, pilots and remoras, shark myths and legends, and fisheries and the utilization of sharks.

Budker's treatment of these wide-ranging topics is noteworthy for two main reasons—scholarship and enthusiasm. He presents us with a review that is a nicely measured amalgam of information from the ancients, such as Aristotle and Aldrovandi, to the authors of current research papers. His handling of this large source of fact, opinion, and fiction is not only masterly but balanced and artistic, and does much to display, on the one hand, the historical development of our present information and, on the other hand, the many fallacies which have pervaded sharklore.

As evidence of Budker's enthusiasm for his work I would cite the very appearance of this revision in its exemplary, up-to-date form—no mean task at any time but especially praiseworthy now because, for the last 30 years, Budker has been concerned chiefly with cetaceans rather than sharks. Enthusiasm and a keen interest in fostering shark research are also shown in Budker's frequent references to unsolved problems—as, for example, his discussions on the mechanism of tooth-shedding and fluctuations in liver weights.

The book is by no means lacking in minor flaws. Systematists might quarrel with parts of the classification, and there are some errors in scientific names and in facts. For example, the scientific names of *Cephaloscyllium* and *Dalatias* (p. 6) are misspelt; the Mako sharks, *Isurus glaucus* and *I. oxyrinchus*, are not from the Indo-Pacific and Atlantic respectively (p. 14) but occur in both oceans; there are two species of Bramble sharks (p. 20), *Echinorhinus brucus* and *E. cookei*; the lower teeth of *Hexanchus* (pp. 41, 51) do not form a pavement; and *Chlamydoselachus* (p. 43) has only six gill arches. Such errors are unfortunate, but they are not so numerous as to seriously detract from the obvious value of this book.

I believe that many people should and will find a place for *The Life of Sharks* on their bookshelves. Its appeal is broad, and its coverage will satisfy not only the discerning amateur naturalist and fisherman but also the professional biologist who wants an engaging but disciplined review of what sharks are and how they live their lives.—J. A. F. Garrick, Zoology Department, Victoria University of Wellington, New Zealand.

Rains of Fishes in Australia

By GILBERT P. WHITLEY
Honorary Associate, Australian Museum

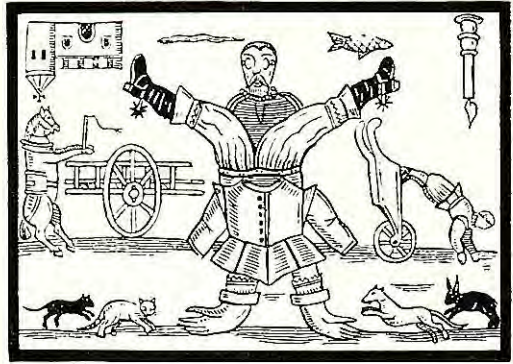
PREPOSTEROUS is the only adjective to apply to the subjects illustrated in a woodcut published in 1642 in John Taylor's *Mad Fashions, Od Fashions, all out of Fashion, or the Emblems of these distracted Times* (reproduced by Mason Jackson, *The Pictorial Press*, 1885, p. 76). Cromwellian England, in which everything was upside down, was the object of this Cavalier poet's satire: a man in the centre is dressed topsy-turvy, a candle is above its flame, the Church is overturned, the rabbit hunts the dog, and so on, until the accompanying text announces, "And Eeles and Gudgeons flie a mighty pace." That fishes should fly across the sky might have seemed the height of absurdity in the seventeenth century, yet that first of surrealist artists, Hieronymus Bosch (about A.D. 1450-1516), had earlier painted even more fanciful fishes flying through the air, and they were not the marine flying fishes either. (See G. P. Whitley, "Fishes in Flights of Fancy", *Australian Museum Magazine*, Vol. 7, No. 3, 1939, pp. 92-94).

Curiously enough, it seems at times that fishes (and other animals) can be transported, without man's aid, through the air, becoming deposited afar during rainstorms. Many such cases have been reported over the centuries from different parts of the world. The cleverest book on the subject is by Charles Fort, and is simply entitled *Lo!* It was published in 1931. The first known reference to a rain of fishes was in the third century A.D., in the Greek classic, *Deipnosophists*, and the earliest illustration was a woodcut printed by Olaus Magnus in 1555 (see illustration on page 157).

Indian legend

In monsoonal India there is a picturesque legend that waterspouts are celestial elephants' trunks which may suck up fishes and later spurt them forth in rain. The late Dr Sunder Lal Hora tells us (*Journal of the Asiatic Society of Bengal*, 29, 1933 (1934) p. 108) that Lord Indra is worshipped as the Hindu rain-god and that "the clouds are

His Boots and Spurs upon his Armes and Hands,
His Gloves upon his feet (whereon he stands)
The church o'turned (a lamentable show)
The Candlestick above, the light below,
The Coney hunts the Dogge, the Rat the Cat,
The Horse doth whip the Cart (I pray marke that)
The Wheelbarrow doth drive the man (Oh Base)
And Eeles and Gudgeons flie a mighty pace.



That "Eeles and Gudgeons flie a mighty pace" was regarded as a sign of the "distracted times" in Cromwellian England. [From John Taylor's *Mad Fashions, Od Fashions, all out of Fashion, or the Emblems of these distracted Times*, of 1642, reproduced in Mason Jackson's *The Pictorial Press*, 1885.]

believed to be Indra's elephants on which he rides about . . . One of these elephants . . . draws up water from the under-world and Indra seated on his elephant pours down the rain . . . The elephants are also believed to blow the wind out of their trunks." The similarity in the funnel-like form of a waterspout and that of the trunk of an elephant is very suggestive to the minds of the simple village folk. There is a more sophisticated exegesis of this legend in Angelo de Gubernatis's *Die Thiere in der indogermanischen Mythologie*, 1874.

There have been many reports of rains of fishes in Australia. Let us try to list here the different records—it has never been done before. (The list, which follows, also includes reports of other animals coming down in the rain).

| DATE OF OCCURRENCE | LOCATION | AUTHORITY |
|---|---|---|
| (?) May, 1879 .. | Thousands of "creek minnows" at Cressy, near Lake Corangamite, Victoria. | Melbourne <i>Argus</i> newspaper, 26th May, 1918; <i>Victorian Naturalist</i> , 35, 1918, p. 3. |
| 24th January, 1881 | Fish, Burrangong (near Young), New South Wales. | <i>Daily Telegraph</i> (Sydney), 26th July, 1933; Evesson, <i>Australian Meteorological Magazine</i> , 17 (3), September, 1969, p. 149. |
| January-February, 1887. | Fish near Walgett, New South Wales .. | <i>Sydney Mail</i> , 5th February, 1887, p. 301. |
| 21st September, 1888. | Fishes on road for a quarter-mile, Walgett, New South Wales. | <i>Daily Telegraph</i> , 26th July, 1933. |
| 21st September, 1888 (same storm as hit Walgett). | Fishes in tank, Gnalta Station, 100 miles northwest of Wilcannia and Darling River, New South Wales. | <i>Daily Telegraph</i> , 26th July, 1933. |
| 1898 | A 3-inch fish, hundreds of feet above river, after storm, Ipswich, Queensland. | Alexander Francis, 1935, <i>Then and Now</i> , p. 185. |
| 27th October, 1898 | Fishes along road, Goodooga, Cowra, New South Wales. | Commonwealth Bureau of Meteorology, file 30/0640. |
| 1901 | Gudgeon, <i>Philypnodon grandiceps</i> , Warwick, Queensland. | <i>Sydney Morning Herald</i> , 23rd August, 1901, and 7th January, 1902; Palmer, <i>Proceedings of Linnean Society of New South Wales</i> , 26, 1902, p. 515. |
| 1906 | Gudgeons, <i>Carassiops compressus</i> and <i>C. galii</i> , Killarney and Mildura Farm, Cooper's Plains, Queensland. | <i>Allgemeine Fischerei Zeitung</i> , 31, 1906, p. 203; Ogilby, <i>Proceedings of Royal Society of Queensland</i> , 20, 1906, (1907), p. 28. |
| 1907 | Gudgeon, <i>Mogurnda striata</i> , in thunderstorm, Victoria Park, Brisbane, Queensland. | Ogilby, <i>Proceedings Royal Society of Queensland</i> , 21, 1908, p. 12 as <i>Krefftius adspersus</i> ; Whitley, <i>Australian Museum Magazine</i> , 13, 1961, pp. 333-334. |
| February, 1909 .. | Small fishes rattling on tin roof during storm, Caloundra, Queensland. | T. Iredale, personal communication. |
| Year not known .. | Small whiting fell in storm. Roma, Queensland. | Haysom, <i>Queensland Fisheries Information Bulletin</i> , 16, 1959, p. 1 and T. C. Marshall, personal communication. |
| 12th November, 1913. | Small hardyheads [probably <i>Craterocephalus fluviatilis</i>] in tornado-type cloud, Quirindi, New South Wales. | Mares, <i>Sydney Morning Herald</i> , 1st August, 1918; McCulloch, <i>Australian Museum Magazine</i> , 2, 1925, p. 215. |
| 1918 | Numerous shrimps, <i>Paratya compressa</i> , near Singleton, New South Wales. | <i>Sydney Morning Herald</i> , 1st August, 1918; McNeill, <i>Australian Museum Magazine</i> , 1, (3), 1921, p. 88. |
| 1921 | Gudgeon, <i>Mogurnda australis</i> , Mullumbimby, Brunswick River, New South Wales. | Whitley, <i>Australian Museum Magazine</i> , 13, 1961, p. 335. Australian Museum registered No. IA.239. |
| About 1920 .. | Hundreds of Gudgeons, <i>Carassiops klunzingeri</i> , in streets, Gulargambone, New South Wales. | McCulloch, <i>Australian Museum Magazine</i> , 2, 1925, p. 217; Roughley, <i>Daily Telegraph</i> , 29th November, 1949. |
| 1923 or earlier .. | Fish, Benalla, Victoria | <i>Argus</i> newspaper, Melbourne, 22nd June, 1923. |
| 1925 | Fish, Grunter, <i>Madigania unicolor</i> , Murgoo, Murchison River, Western Australia. | Glauert, <i>Daily News</i> (Perth), 14th March, 1928, as <i>Therapon longulus</i> ; Whitley, <i>Transactions of Royal Society of South Australia</i> , 69, 1945, p. 11. Australian Museum registered No. IA.3605. |
| 1927 | Long marine worms in rain, St Jude's Church, Randwick, near Sydney, New South Wales. | <i>Sydney Mail</i> , 15th June, 1927, p. 18. |
| June, 1927.. .. | Various fishes and eels up to 15 inches long in tornado, Little Bay, near Sydney, New South Wales. | <i>Sydney Mail</i> , 15th June, 1927, p. 18. |
| 1st July, 1927 .. | Fishes, upper Swan Valley, Western Australia. | Glauert, <i>West Australian</i> newspaper, Perth, 20th July, 1927, and <i>Daily News</i> , Perth, 21st June, 1945. |
| 18th January, 1928 | Small crayfish in water-spout, Grenfell, New South Wales. | <i>Daily Telegraph</i> , Sydney, 26th July, 1933. |

- 12th May, 1930 .. Four-inch fishes in heavy rain, Bundamba, Ipswich district, Queensland. *Sydney Morning Herald*, 12th May, 1930; *Daily Pictorial*, 13th and 14th May, 1930.
- 12th May, 1930 .. Crabs supposed carried by rain, 50 miles from sea, Laidley, Toowoomba district, Queensland. *Sydney Morning Herald*, 12th May, 1930; *Daily Pictorial*, 13th May, 1930.
- Year not known .. Fish and frogs came down in heavy thunderstorm near Wiseman's Ferry, New South Wales. Armitage, *Sydney Morning Herald*, 6 December, 1947.
- 29th October, 1932 Hundreds of small "carp" on top of hill, Adelong, New South Wales. *Sydney Morning Herald*, 30th October, 1932, and 1935.
- 25th July, 1933 .. Pigmy Perch, *Nannoperca australis*, about 40 miles from the sea, Heyfield, Gippsland, Victoria. *Sun* newspaper, Sydney, 25th July, 1933; *Daily Telegraph*, 26th July, 1933.
- Year not known .. Gudgeon, *Carassius compressus*, Native Dog Creek, Bathurst district, New South Wales. Whitley, *Australian Museum Magazine*, 11 (5), 1954, p. 155.
- July, 1935 Sea birds dive after fish in mid-air during water-spout which hurled them in all directions, Southport Beach, Queensland. *Daily Telegraph*, 19th July, 1935.
- About November, 1938. Fishes over wide area, Mullumbimby, New South Wales. *Sydney Morning Herald*, 7th April, 1939, p. 10.
- 20th March, 1939 Thousands of 5-6 inch fishes in tornado, Byrock, 48 miles from Darling River, Nyngan, New South Wales. *Daily Telegraph*, 21st March, 1939; Brookes, *Angling and Gun Sport*, March 1939, p. 25; and Evesson, *loc. cit.*, 1969.
- 6th April, 1939 .. Thousands of frogs from rain on road, Ewingsdale, 25 miles from Lismore, New South Wales. *Sydney Morning Herald*, 7th April, 1939, p. 10.
- 1940 Mullet, 1½ inches long, in cabbage after shower, Brisbane, Queensland. *Sun* (Sydney), 15th May, 1940.
- Year not known .. Thousands of perch, half an inch to 1 inch long (also tiny frogs and water-beetles), Claraville, via Mitchell, Queensland. E. S. Campbell, personal communication, 1951.
- 13th January, 1941 Green eel, 12 inches long, Vacluse, near Sydney, New South Wales. Dr Curtin, personal communication.
- March, 1942 .. Small fishes in ponds after severe cyclone, Marble Bar, Western Australia. *Daily Telegraph* (Sydney), 29th March, 1942.
- February, 1944 .. Grunter, *Madigania unicolor*, near Prairie, Queensland. Edgar and Mack, *Salt*, 8 (8), 1944, pp. 20-21, and fig., as *Therapon unicolor*.
- 1944 Fall of frogs on roof, Coff's Harbour, New South Wales, also on naval vessel at sea, Australia. Morrison, *Wild Life*, 7, 1945, p. 219.
- 20th June, 1945 .. Four River Garfishes, *Reporhamphus regularis*, 3½-5 inches, Claremont, Western Australia. Glauert, *Daily News* (Perth), 20th and 21st June, 1945.
- 16th April, 1946 .. Two marine blennies, *Cyneichthys anolius*, 2 inches long, Erina Shire Depot, 100 feet above sea-level, Gosford, New South Wales. *Gosford Times*, 16th April, 1946. Australian Museum registered No. IB.I663.
- 16th April, 1947 .. Carp, nearly 3 inches long, on doorstep, after electrical storm, Fairfield, New South Wales. *Daily Telegraph*, 17th April, 1947.
- 23rd November, 1947 Perch on streets (but not on roofs or in tanks), Charleville, Queensland. *Aquatic Hobbyist* (Queensland Gold and Tropical Fish Society), 7th September, 1965; for possible explanation see Shipway, *North Queensland Naturalist*, 15, 1947, p. 10, and *Western Australian Naturalist*, 1, 1947, p. 47.
- 6th February, 1949 Small native perch, Cloncurry, Queensland. *Sydney Morning Herald*, 7th February, 1949.
- 27th November, 1949. Small fish from Hen and Chickens Bay, lifted 600 yards in hailstorm, Abbotsford, New South Wales. *Sun*, 28th November, 1949 (cartoon); *Daily Telegraph*, 29th November, 1949.
- 1951 or 1952 .. Hundreds of fishes, Wave Hill Station, Northern Territory. Brian Bertram, personal communication.
- August, 1952 .. Winkles (*Melanerita melanotragus*), Bel- field, New South Wales. "Nature Speaks" radio programme.

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| 1956 | Fishes up to half a pound in weight dropped by hundreds of pelicans, Forbes, New South Wales. | <i>Sydney Morning Herald</i> , 21st April, 1956, p. 4. |
| 1st April, 1959 | Fishes up to 5 inches long, Townsville airport, Queensland. (Crabs reported from there previously). | <i>Daily Telegraph</i> , 2nd April, 1959, p. 3; S. Stewart, <i>finchat</i> , May, 1959, p. 29. |
| 1959 | Small freshwater fishes, suburbs of Brisbane, Queensland. | Haysom, <i>Queensland Fisheries Information Bulletin</i> , 16, 1959, p. 1. |
| 17th July, 1959 | Hundreds of fishes, about 4 inches long, Lismore, New South Wales. | <i>Sydney Morning Herald</i> , 18th July, 1959, p. 1. |
| November, 1959 | A 9-inch whiting (<i>Sillago</i>) found in a puddle, Woollooware golf course, near Sydney, New South Wales. | <i>Sydney Morning Herald</i> , 17th November, 1959, p. 1. |
| 18th January, 1970 | Numbers of (introduced aquarium) fishes, <i>Tanichthys albonubes</i> , Dover Heights, Sydney, New South Wales. | <i>Daily Mirror</i> , 20th January, 1970, p. 13 (species identified at the Australian Museum). |
| 16th April, 1971 | Numerous Grunters (<i>Madigania unicolor</i>), 2-3 inches long, on airport at 3-6 a.m., after heavy rain, Hughenden, Queensland. | Mannie Scoffell, J.P. personal communication, April, 1971. <i>West Australian</i> , 17th April, 1971, and <i>Fishing News</i> (Brisbane), 30th April, 1971, p. 1 and photos. |

The above are the recorded cases. Perhaps there are more in obscure newspapers or publications; not every case is reported, and many are recalled after a lapse of years.

It is desirable that specimens of fishes and other animals fallen in rain should be preserved, preferably in museums, so that their exact species can be determined. (In the above list, specimens with numbers such as IA.239, 3773, etc., are preserved in the Australian Museum). The exact date, even time of day or night, should be noted, also the locality and weather. Thus an interesting time-pattern may emerge (we have not enough data yet to say if cycles exist) and in due course we may understand better this interesting phenomenon. We have begun to realize that birds, insects, and even some non-flying animals may be transported high in the air over very great distances. In some countries, fishes have come down embedded in ice.

I have not traced any rains of fishes in Tasmania or in New Zealand, but a 30-foot tidal wave near Gisborne, New Zealand, after an earthquake on 26th March, 1947, stranded thousands of fishes on beaches and streets there (*Sydney Morning Herald*, 27th March, 1947).

During heavy rainstorms, fishes such as the Spangled Grunter (*Madigania unicolor*) disperse widely over flooded country and are left behind in waterholes afterwards. These have also been seen swimming rapidly along in the water in cart-ruts (P. S. Wilson, *Independent* newspaper, Bowen, Queensland, 29th January, 1954, and Bruce Shipway,



The first illustration of a rain of fishes appeared in the Scandinavian *Historia de gentibus septentrionalibus* of Olaus Magnus, in 1555. [After Gudger, 1929.]

personal communication from A.I.F. commandos in the Second World War). Shipway had followed fishes, not 2 inches long, for a distance of over 10 miles at a speed of about 2 miles per hour along a wheel-track over what was normally spinifex desert at the head of the Gascoyne River, Western Australia. So it is likely that some reported



Principal vicinities in Australia from which rains of fishes have been reported, 1879-1971. [Map by Celia H. Tanner.]

"rains of fishes" had other causes, e.g., "dropped fish" like the mullet found in a cabbage in Brisbane in 1940, when the Sydney *Sun* newspaper observed that there should be a fortune for anybody who can get fish and potatoes to grow together! Others may be ascribed to heavy rains soaking soil and releasing living creatures which had been buried moist and dormant in aestivation. Dormant eggs may also hatch after heavy rainfall. A very few kinds of fishes can migrate overland for short distances.

Miscellaneous "rains"

Besides fishes, other animals have been reported as fallen from Australian skies. There are many stories of frogs, shrimps, and crabs so doing. Water-beetles are strong fliers in their own right. The first record in Australia of winkles (*Melanerita melanotragus*) apparently falling in heavy rain at Belfield, N.S.W., in August 1952, was announced on the radio programme "*Nature Speaks*". Rains of shells have been ascribed to England and North America, and even of "fossil hazel nuts" to Dublin, and turtles to Salonika; rains of "blood" and other substances have been regarded as of evil portent in many climes. Linnaeus reported furious worms descending in 1728 from the sky. So, to paraphrase the proverb, one man's meteorology is another man's poisson. Charles Fort (in his book *Lo!*) collected 294 records of showers of living things printed in the world's newspapers between 1800 and 1930. He found no falls of tadpoles, only frogs.

I have not myself seen any rains of fishes but, at Chinaman's Beach, near Sydney, years ago, saw how a sudden gust of wind whipped up the water from a small creek to such an extent that it stampeded a horse which was some yards away. The scene was over in a flash—it would have taken a Zen artist to depict it.

Meteorological aspects

It is interesting to try to correlate the meteorological data with the times when Australian fishes have imitated the fallen

angels, Shakespeare's quality of mercy, and Sinatra's pennies. This was seriously tackled in India by Sen (*Journal of the Asiatic Society of Bengal*, 29, 1933 (1934), No. 3, as a corollary to Hora's paper, *ibid.*, No. 1).

A former Divisional Commonwealth Meteorological Officer, the late D. J. Mares, said (*Sydney Morning Herald*, 1st August, 1918) that it was quite possible under unstable atmospheric conditions for local whirlwinds to develop which might lift portions of a water-surface on which they moved. He thought also that it was quite likely that small fishes and other small animals could be thus transported. In 1970, the Regional Director of the Commonwealth Bureau of Meteorology, Sydney, kindly investigated such data as I was able to submit to him, and he provided me with a copy of Mr D. T. Evesson's valuable paper, "Tornado Occurrences in New South Wales" (*Australian Meteorological Magazine*, 17 (3), September 1969, pp. 143-165), and also with cases of rains of fishes from the Bureau's files, for which I thank him. It is significant that, in at least five cases, rains of fishes were associated with tornado occurrences; on three other occasions severe storms were reported in the areas. It is possible that under these circumstances tornadoes or waterspouts were unobserved (e.g., out to sea or in uninhabited country).

We still have much to learn about these extraordinary occurrences.

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Queensland Trace Fossils Pose A 230 Million Years Old Problem

By ANNE WARREN

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IN their studies of extinct forms of life palaeontologists usually have to deal with specimens which have been distorted by millions of years of compression by overlying sediments. Often the animal concerned is squashed flat or disarticulated, and occasionally the only evidence of its existence is a stain between two sedimentary layers. Such conditions of preservation make it extremely difficult to reconstruct a lifelike three-dimensional animal from its fossil remains.

Fortunately palaeontologists are sometimes assisted by the presence of trace fossils in the sediments. Thus, a worm-like animal may leave a grazing trail, a burrow, or even a worm cast, which, when related to behaviour found in modern forms, gives a clue to the way of life of the animal concerned.

Traces of vertebrate fossils are usually in the form of footprints, sometimes with tail traces between them (a report on fossil footprints from Queensland, by Alan Bartholomai, appeared in *Australian Natural History* in March 1966). They can show the size of an animal's gait, whether it was quadrupedal or bipedal, and, if the latter, whether it held its body clear of the ground. Experienced ichnologists (those who study fossil footprints) classify footprints into genera and species, but these are species of *footprints*; as no animal has been preserved in the act of making a footprint it is not strictly correct to link a set of footprints with a known fossil. But it is certainly possible to tell the *kind* of animal responsible for most prints.

Recently some enigmatic trace fossils have been found in the Upper Permian Burngrove Formation north of Blackwater, in Queensland. These were first reported by Malone, Olgers, and Kirkgaard (1969) in their report on the geology of the Duaringa and St Lawrence (1:250,000 sheet areas, Queensland), but more recently further photographs of the trails were sent in by



Fig. 1.—These wavy broken lines are probably the tail trace of a large Permian amphibian.

Mr A. F. Skinner and Mr W. A. Hansen. Malone, Olgers, and Kirkgaard reported that abundant plant remains occur in some parts of the Burngrove Formation, which was probably deposited in quiet conditions in a shallow freshwater or brackish lake.

While footprints do occur in the area of shale which was exposed they do not appear

to form trackways, and by far the most prominent feature of the surface is a series of "wavy" broken lines.

One of these lines (fig. 1) was apparently made by the tail of one of the large fossil Amphibia which must have been abundant

in the Upper Permian, although it differs from traces claimed to have been made by other fossil amphibians in not having a regular series of footprints associated with it.

Two other traces are of particular interest, and both of these must have been made by an anguilliform (eel-shaped) animal. One (fig. 2) closely resembles trails made by modern snakes travelling with anguilliform motion; the other (fig. 3) is similar but shows no slithering at the bends, a feature shown by modern snakes and in fig. 2.

My problem is what *did* cause these trails? It is unlikely that such large and regular marks as these could have been made by an invertebrate animal, and of the vertebrates the only Upper Permian forms which may have moved in a snake-like or eel-like manner were the cyclostomes (lampreys and hagfishes), lungfish, and possibly a few survivors of the older lepospondylous amphibians; snakes and lizards are not known in the fossil record until the Upper Cretaceous, some 150 million years later. Modern cyclostomes are semiparasitic in habit, and a recent find from the Pennsylvanian Francis Creek Shale of Illinois, U.S.A., reported by Bardack and Zangerl (1968), differs little from them. It is to be expected that a lungfish (or fish) tail making such a deeply and cleanly incised trace as that seen in fig. 3 would do so with support from its paired fins, and the photograph shows no sign of prints of these.



Fig. 2 (above) and Fig. 3. —Particularly interesting tracks, which must have been made by eel-shaped animals.



Although lepospondylous amphibians have not been found above the Lower Permian, and none have been found in Australia, I am forced to conclude, on the basis of rather negative evidence, that a late surviving member of this group was responsible for the peculiar tracks in the Burngrove shales. Some of the lepospondyls were certainly anguilliform and were large enough to have made the tracks. It is to be hoped that a trip to Queensland planned for mid-1972 will

produce more concrete clues to the identity of the tracks, or even perhaps an Upper Permian lepospondyl.

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Persistent Sea-Foam Masses—A Problem Solved

By ROBERT E. BAIER

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An article by Elizabeth C. Pope, Curator of Worms and Echinoderms at the Australian Museum, in *The Australian Museum Magazine* (as *Australian Natural History* used to be called) in September 1952 referred to the curious nature of the great masses of foam which are often found drifted in from the sea onto local rocks and beaches. She pointed out that a most curious feature of these lather-like masses is the way in which they persist for relatively long periods, even when blown about by the wind.

It has recently been observed, and it continues to be the case, that in a large recreational inland lake in the northeastern United States, Lake Chautauqua, each August and September there is a similar gathering of very persistent foam masses along the windward shores. This gives the visual impression of thousands of washing machines having simultaneously flooded over. As Miss Pope pointed out, however, ordinary soap lathers soon revert to their original unlathered state.

When these persistent foams form, public interest is aroused and scientific and educational groups are asked for explanations as to how the foam is produced, why it lasts so long, etc. Miss Pope pointed out in 1952 that such questions could only bring the answer "We don't know", but that didn't prevent her from making guesses. She did point out, though, that her theories must be tested by physicists and chemists before one could have a notion as to whether they were correct or not. As she said, since the matter had little practical importance, little was done about it. My own recent report in the Proceedings of the 13th International Conference on Great Lakes Research is apparently the first analytical contribution to our knowledge on this subject since 1952.

After briefly discussing the properties of sea foam, Miss Pope volunteered, "One thinks immediately of some substance such as protein as being the type of chemical suitable for doing this". The most sensitive analytical method described in my report validates Miss Pope's conjecture almost completely. She further volunteered the observation that there were "certain substances in some of our algae which could possibly serve to 'hold' the foams once they had been produced". In fact, in Lake Chautauqua the proteinaceous material which did give rise to billowing heaps of foam along the windward shore had its origin in a large algae bloom. This was documented from spectral techniques which traced the source of this material from the algae, to spread surface films, to small bubble rafts and clusters, and finally through their concentration into large masses along the shore. An explanation of the phenomenon of foam formation volunteered to Miss Pope by another museum worker was that, during storms, large numbers of planktonic organisms were destroyed and the debris from these minute organisms lowered the water surface tension to allow it to foam and stabilized the froth once it was formed. Here again, the confirmation from the recent study in America is nearly perfect.

Miss Pope's closing paragraph was the following: "Is this the true explanation of how sea foam is made and blown ashore? At the moment we just do not know and it must remain still one of those fascinating, unsolved mysteries of the sea."

It is clear from my recent investigations that Miss Pope had remarkable foresight and was able to synthesize the correct explanation from the various, then known, scientific facts. Now, nearly two decades later, we have independent confirmation of her hypothesis from the use of experimental techniques which were themselves not even developed until the mid-1960's.

The Complexities of Simple Animals

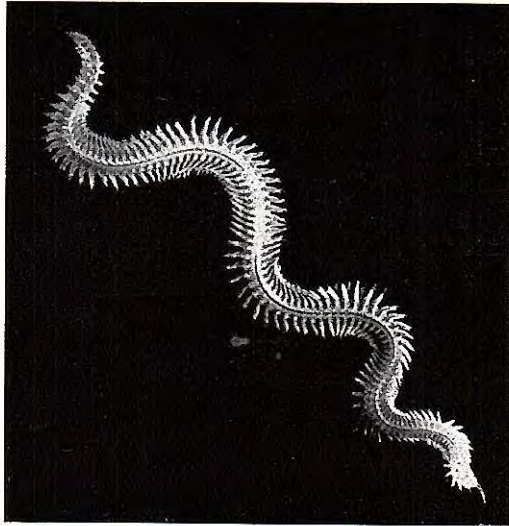
By D. W. GOLDING

Lecturer in Zoology, University of Newcastle upon Tyne, England, and Member of the Staff of the Dove Marine Laboratory at the University

ANYONE who acquires an interest in living organisms is soon confronted by a complexity in biological systems that tends to daunt even the least impressionable. Biological problems are usually posed by, and initially concerned with, higher vertebrates, and one approach to such a problem is to mount a "frontal attack" with an investigation of such an animal. An alternative procedure involves turning to lower animals for one's experimental material in the expectation that in them the fundamental properties of living matter will be more accessible to study. This article is a brief account of some investigations carried out into the hormonal control of growth and reproduction in the segmented bristle-worms (polychaete annelids).

Most polychaetes start their active life as an unsegmented larva, the trochophore. At the completion of the larval stage in the life-history, growth commences and consists of the addition of essentially similar body units, or segments. These are added to the body at the posterior end, so that the first segment is the oldest and the last is the youngest. With the increase in the total number of segments, their rate of production slows down, until at some stage in the life-history it ceases altogether, or almost so. Removal of part of the posterior of the animal is followed by regeneration—a rapid replacement of the lost segments. Such an organization would seem ideal for the study of the biology of growth, since it consists of the addition to the body of comparatively simple "building blocks" and since the extent can therefore be expressed in simple numerical terms. This is in contrast to the complexity of changes in form which are associated with growth in most other animals.

At a later stage in the life-cycle, many species of *Nereis*, one of the best-known polychaetes, undergo a fairly sudden and dramatic transformation or metamorphosis into the heteronereis, which is a sexually mature form adapted for active swimming and breeding. (The development of a winged



The polychaete *Nereis diversicolor*. Swimming involves the movement of locomotory waves along the body. [Photo: R. B. Clark.]

insect from the larva, or that of a frog from a tadpole, are comparable, better-known examples of the phenomenon of metamorphosis).

These two features of the biology of *Nereis*, namely growth (in particular, regenerative growth) and metamorphosis have been found to be controlled by hormones circulating in the body fluids. Early investigations showed that regeneration of lost posterior segments does not take place in the absence of the prostomium, or "head", of the animal. More precise experiments have demonstrated that a hormone originates from the brain (or tissue closely associated with it), which in *Nereis* is a small body of nervous tissue about half a millimeter in diameter, lying immediately beneath the eyes. After brain removal, the animal will continue to live for weeks or even months, but no proliferation of lost segments is possible. However, the brain is not exerting an influence on this process by way of its nervous connections with the rest of the body. This is demonstrated by removing the brain and

immediately implanting it into the coelom, or body cavity. Although the implanted brain makes no nervous connections with the body, its presence restores the ability of the specimen to regenerate. Alternatively, the brain of another animal can be used—it is just as effective as the one belonging to the specimen concerned. It is even possible to make transplants from one nereid species to another.

Implantation of a brain into a host specimen should not be thought of as an injection of a "dose" of hormone into the animal. The implant continues to live and secrete hormone activity. This was shown by locating the brain in the body of one host, into which it had been implanted some weeks



A host *Nereis*, into which a headless fragment has been grafted. The graft has regenerated segments under the influence of hormone secreted by the brain of the host. [Photo: Author.]

previously, removing it, and reimplanting it into a second host. Loss of segments was followed by regeneration in the second as in the first host animal. In one experiment, retrieval and transplantation of the brain were repeated every 3 to 4 weeks for about 7 months. At the end of this time, the brains were secreting hormone as actively as at the beginning. Of interest is the fact that the animals from which they originated initially would have matured and died long before this time. In other words, the tissue appears to be potentially "immortal" if maintained in young host animals.

The stimulus to regenerative growth

provided by the brain hormone can be demonstrated by yet another procedure. This is the grafting or parabiosis technique. It is possible to make a slit in the body wall of one animal—the host—and to stitch into this a headless length of another animal—the graft. There is no immune response in these animals and the body does not reject or attack tissues of another individual of the same species. (This is, of course, in contrast to the situation in vertebrates, the "immune response" of which is the bane of every transplant surgeon). The wound between host and graft quickly heals, the blood systems and body cavities of the two join up. In some cases, continuity of the intestine is even achieved. Only the nervous systems remain distinct and separate—a fact that is shown by the tendency of the host to devour the graft from off its back if its jaws are not trimmed!

In this situation the graft has no brain of its own. However, when posterior segments are amputated from it, regeneration ensues due to the influence of the hormone originating from the brain of the host animal, which reaches the tail end of the graft through the shared circulatory system. Of interest is the fact that regeneration is possible if the brainless graft is stitched into an intact (i.e., non-regenerating) host, just as it is possible when a regenerating host is used. The brain hormone is present in each case.

The action of the brain hormone on metamorphosis and reproduction is also interesting. The effect is in contrast to that on regenerative growth in that it holds back or inhibits these processes. As a result, removal of the brain from an immature animal is quickly followed by the commencement of metamorphosis to form the heteronereis and the production of mature eggs or sperms.

The hormonal control of growth and development seems to be a very economical one. In the immature animal, the brain hormone stimulates growth of the body but prevents the onset of sexual maturity. Later, when the animal is full-grown, hormone secretion stops, with the result that the animal becomes mature. The presence or absence of one hormone, then, acts as timekeeper for the progress of the life-cycle. It ensures that growth and reproduction do not occur together but that these two processes, which

make great demands on the resources of the organism, occur one after another and therefore do not compete.

While carrying out these experiments, it was noticed that the number of segments proliferated by a regenerating *Nereis* depends on the number lost. Removal of a large number of segments leads to the production of many segments, while removal of a small number results in the regeneration of only a few segments. In other words, regenerative growth continues until the original number of segments has been replaced, approximately. Clearly, growth-control mechanisms are at work here. One suggested mechanism would involve the control of the total number of segments by circulating hormones or other agents. In this case, regeneration of many segments would be due to a high hormone concentration. An alternative mechanism would depend upon purely local factors—the growth potentiality of the growing region. This question was investigated by means of the grafting technique.

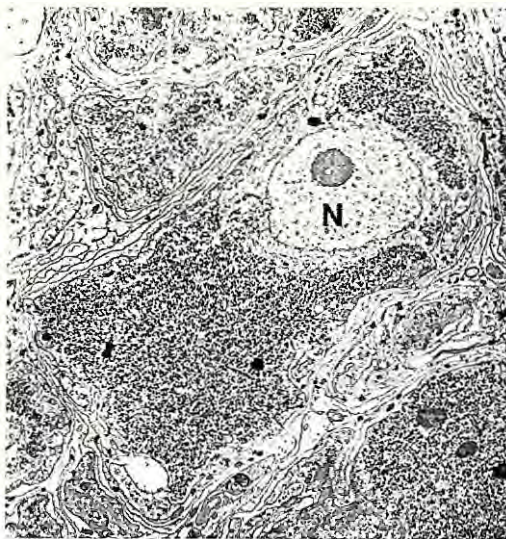
A number of hosts with their respective grafts were divided into two groups. Each animal in the first group was subjected to the removal of many segments from the host, but few from the graft. The host proceeded to regenerate many segments; the graft produced only a few, despite the continuity between the blood system of host and graft. The operation on each member of the second group was a “mirror image” of that carried out on animals of the first—many segments were amputated from the graft, few from the host. The results were comparable in that the grafts regenerated many segments, while the hosts produced few, despite the fact that, in each case, the host and graft were regenerating under the influence of the same hormonal stimulus.

It appears that although the brain hormone is indispensable for growth, it is not responsible for growth control. This does not depend on circulating but on purely local factors of unknown nature, which together result in the inherent growth potentiality of the region responsible for segment proliferation.

Information concerning the ability of the brain to secrete hormones has recently been obtained. Originally, it was assumed that this function was performed by specialized nerve cells called neurosecretory cells. The

central nervous systems of most animals contain such glandular neurones, and certainly polychaetes are no exception. The cytoplasm of these cells is packed with masses of secretory material, and, with the aid of the electron microscope, this can be seen to consist of great numbers of “elementary neurosecretory granules”, each approximately one ten-thousandth of a millimetre in diameter. The granules are produced within the nerve cell body and are carried down the nerve fibres in the active flow of cytoplasm that is a characteristic of all nerve cells. In most polychaetes bundles of these nerve fibres travel to the base of the brain, but in a minority they are directed upwards to its roof. In either case, they form swollen bulbous endings in contact with the sheath of connective tissue which encloses the brain. In many animals, there is yet another component beneath the brain. This consists of sheets of cells which, when viewed with the electron microscope, have an appearance strongly suggestive of glandular function, and it has been called the “infracerebral gland”.

Despite the fact that these are among the lowliest animals in which an endocrine (i.e., hormone-secreting) system has been adequately described, its complexities are remarkable. The nerve fibres appear to be



Electron micrograph of a neurosecretory cell in the brain of *Nereis*. Note the nucleus, N, and the large number of minute secretory granules. Magnification, x 6,000. [Photo: Author.]

of several different types and presumably release different secretions (there are as many as five types, in some groups of animals). The infracerebral gland consists of two or more different types of cell. Furthermore, it is not known whether the hormone or hormones affecting growth and maturity originate from the nerve fibres, from the gland cells (in which case they are presumably controlled by the nerve fibres) or from both, although these questions are under investigation.

In introducing this article, I pointed out that many investigators turn to lower animals in the expectation of finding comparatively simple biological systems which will be accessible to study. In many cases, this leads

to significant advances in our knowledge of the fundamental properties of living materials. More frequently, one encounters a complexity and "sophistication" as profound, in its way, as that characteristic of higher animals. However, in either case, it is rare for the investigator to remain insensitive to the fascination of these "simple" organisms.

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BOOK REVIEWS

AUSTRALIA'S WILDFLOWERS, by Michael Morcombe; Lansdowne Press, Melbourne; 1970; \$4.95.

This book is the latest in the series flowing from Morcombe's authorship which serve as the vehicle for his magnificent photography and drawings. These indeed are almost unrivalled, for few other naturalists have developed photographic technique to this degree, or, if they have, are equally talented as botanical artists. His previous *Australia's Western Wildflowers* will be remembered. The present work covers the whole continent in like vein, dividing it into six natural regions, each of which is dealt with in turn. For each region a brief account of the flora is given by a well-known professional botanist, and there is a list of National Parks, a liberal sprinkling of black and white botanical drawings by the author, and a series of colour plates of representative species. The end result is a truly magnificent picture-book.

Quite certainly picture-books have their place, and fill certain roles, one of which is to make money for the author and publisher. One requirement that they rarely satisfy is the needs of the serious student. Morcombe's *Australia's Western Wildflowers* included much that was praiseworthy in this regard, with dissertations on pollination, for example, and photographs of small animals and birds visiting flowers. The latest book, with its greater geographical coverage, has no space for such digressions. Where all flora picture-books fail is in sheer inability to illustrate a sufficiently wide range of species. This book has 180 colour plates and illustrates about 1½ per cent of the flora of Australia. *Flowers and Plants of Victoria*, by Cochrane, Fuhrer, Rotherham, and Willis (1968) made a conscious attempt at coverage of a smaller area with its 500 plates. Probably none has been so successful as Gardner's classic, *Wildflowers of Western Australia*, in which at least one illustration

is systematically provided for each botanical family in turn.

However, there is no desire to denigrate a book which is unquestionably outstanding in its own field of artistic expression and which does contribute to the number of published illustrations of Australian species.—J. S. Beard, *Director and Chief Botanist, Royal Botanic Gardens, Sydney*.

VOICES OF THE AUSTRALIAN BUSH. Twenty-six pages, with L.P. record inside the front cover. By Harold Pollock, 1970. The Jacaranda Press, Milton, Queensland. Price, \$2.95.

This little book and 7-inch L.P. 45 r.p.m. record give a useful selection of 30 bird calls.

Side 1.—The calls here are mainly of forest birds, and consist of the Wedge-tailed Eagle, Whistling Eagle, Satin Bower Bird, Great Bower Bird, Green Catbird, Spotted Catbird, Albert Lyrebird, Brown Pigeon, Golden Whistler, Buff-breasted Pitta, Yellow Figbird, Eastern Roseola, Crimson Roseola, Yellow-tailed Black Cockatoo, and Sulphur-crested Cockatoo.

Side 2.—Here the birds chosen are usually associated with swamps or close to water. They are the Willy Wagtail, Brown Honeyeater, Pallid Cuckoo, Coucal, Rainbow Bird, Grey-crowned Babbler, Spur-winged Plover, Australian Pelican, Pelican chick in nest, Pelican chick that has just started to walk, Cape Barren Goose, Magpie Goose, White-headed Stilt, Black Swan, and Reed Warbler.

In the text a coloured photo of each species is given, with 200 or 300 words describing some of the habits of the bird and where and how the recording was made. There is a final note on how Mr Pollock makes his recordings and the equipment he uses.

This book is recommended as very good value for \$2.95.—H. J. de S. Disney, *Curator of Birds, Australian Museum*.



Avicennia mangroves on the shores of Western Port Bay, Victoria. [Photo: Author.]

Mangroves on the Australian Coast

By E. C. F. BIRD

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MANGROVES are plant communities that grow on tidal shores in estuaries, inlets and embayments, and in the lee of offshore islands and coral reefs on the Australian coast. They occupy sites that are normally protected from strong wave action, and are usually found growing on muddy foreshores, where they extend out towards mid-tide level. Accumulation of sediment within mangrove swamps builds up the surface, and confines the ebb and flow of tides to intricately branching creek systems.

Textbook accounts which imply that mangroves are confined to our tropical coasts are misleading, for they extend a long way south of the Tropic of Capricorn. They fringe estuaries and inlets along the coasts of southern Queensland and New South Wales, and reach their southernmost limit in Corner Inlet, on the Victorian coast at latitude 38° 55' S. Mangroves also occur in Gulf St

Vincent and Spencer Gulf, South Australia, and have been reported from sites near Streaky Bay in South Australia and at Bunbury and Carnarvon on the coast of Western Australia.

Another textbook misconception is that mangroves extend almost continuously along the northern coast of Australia. In fact, our northern coast is predominantly sandy, with sectors of cliffed and rocky shore, and here, as elsewhere, mangroves are confined to sites sheltered from strong wave action, such as the inner shores of the branching tidal inlet at Port Darwin.

The White Mangrove

The most widely distributed mangrove species in Australia is the White Mangrove (*Avicennia marina*), the only one that extends on to our southern coasts. On the east coast it is joined by the River Mangrove (*Aegiceras*

The southern part of Corner Inlet, Victoria, where mangroves (arrowed) reach their southernmost limit.
[Photo: Author.]



corniculatum) in estuaries in New South Wales north of latitude 35°, and towards the Queensland border by other mangrove species—*Rhizophora stylosa*, *Bruguiera gymnorhiza*, and *Ceriops tagal*. The number of species increases northward in Queensland to the humid tropical sector between Ingham and Cairns, where there are more than a dozen, arranged in five distinct zones parallel to the shoreline (W. Macnae, 1966). The seaward fringe is here usually dominated either by *Avicennia marina* or another species, *Sonneratia alba*, backed by successive zones dominated by Black Mangroves (*Rhizophora* species), then Red Mangroves (*Bruguiera* species), then Grey Mangroves (*Ceriops* species), with *Avicennia marina* occurring again near the landward margin and *Aegiceras corniculatum* common in the vicinity of fresh water (see photo on page 170).

Mangrove swamps attain their greatest diversity and luxuriance in the humid tropical sector, especially near Innisfail, where they are backed by tropical rainforest, and on the east coast of the Cape York peninsula (W. T. Jones, 1971). Along the northern coast there are comparatively few species. *Rhizophora mucronata* and *Avicennia marina* are present in sheltered embayments and inlets on the northwest coast, the latter extending to Carnarvon and Bunbury on the west coast, and on to the outlying Houtman Abrolhos islands (J. Sauer, 1965).

On the drier sectors of the tropical coast mangroves are often confined to the seaward

fringe and creek margins of broad coastal plains where other vegetation is sparse or absent, because of intense desiccation and high salinity in the dry season. These features are seen on the Fitzroy delta near Rockhampton, Queensland, and on the alluvial plains on the other Fitzroy River, which opens into King Sound in the north of Western Australia. Outside the tropics mangroves generally form the seaward fringe of salt marsh communities, which in Victoria show zones of *Salicornia* and *Arthrocnemum* species, then *Juncus maritimus* and *Stipa teretifolia*, backed by scrub vegetation, generally the Swamp Paper-bark (*Melaleuca ericifolia*).

In Victorian estuaries the mangroves (*Avicennia marina*) show signs of being close to their climatic limit. They rarely grow as tall as in warmer latitudes, the typical community being scrub less than 6 feet high; they are locally killed off by occasional frosts, and where the mangrove fringe has been removed they revive slowly, if at all. In Corner Inlet and Western Port Bay erosion has developed on shoreline sectors where the mangrove fringe has disappeared as the result, directly or indirectly, of man's activities. Mangroves which used to border parts of Port Phillip Bay have also disappeared, probably as the result of pollution from the ports of Melbourne and Geelong.

Dispersal of seed by water

The spread of mangroves around the Australian coast is the result of water-borne dispersal of seed material. *Avicennia marina*, for example, produces viviparous seeds,

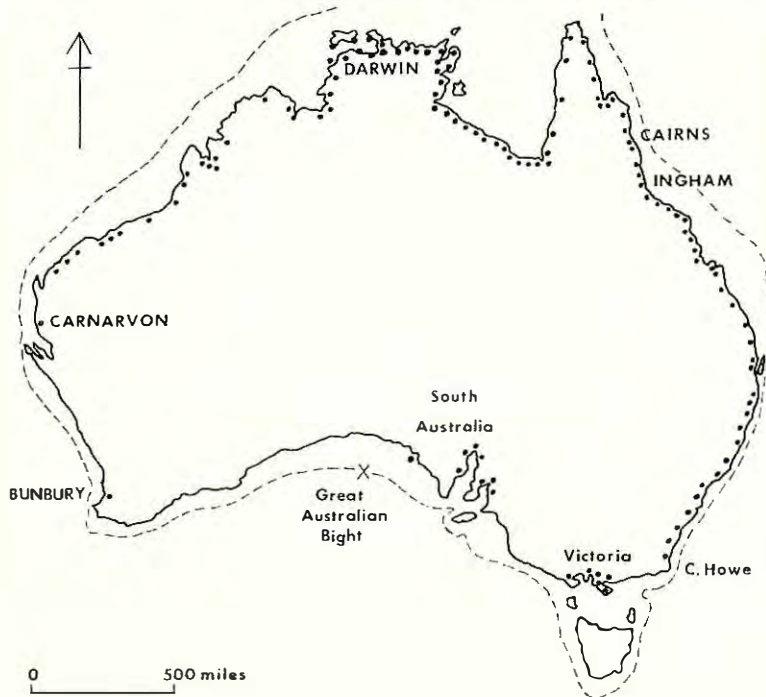
which germinate before dropping from the plant. Many of these seedlings take root in nearby mud, but those that fall during high tide may float away and be dispersed by waves and currents. They can survive for several days, and may be carried some distance. The writer has picked up viable *Avicennia* seedlings from drift debris on the beach near Lakes Entrance in Victoria, more than 80 miles from the nearest possible parent tree, in Corner Inlet to the southwest. If such seedlings became stranded on a more suitable sheltered site they could take root and grow, and eventually establish a new mangrove community.

On the southern coast of Australia, *Avicennia marina* is found only on the coast east of the Great Australian Bight. Even then, it is missing from apparently suitable sites at the mouth of the Murray in South Australia, at the entrance to the Gippsland Lakes in Victoria, and in a number of smaller inlets on the Victorian coast. Many of these sites are of limited extent, linked to the sea by way of narrow and variable entrances that are sometimes completely sealed off by sand deposition, and it may be simply a matter of chance that *Avicennia* has failed to establish within them.

Explanation of distribution

The presence of mangroves on the southern coast of Australia requires explanation. The existing patterns of predominant drift in coastal waters around Australia are unfavourable for the supply of *Avicennia* seedlings, either from east or west coast sites, to the southern coast. There is a southward ocean current off the New South Wales coast, but near the shore, where waves (and the long-shore currents produced by wave action) are the chief agent of coastal drifting, the predominant drift is from south to north. On the west coast, ocean currents alternate, but wave-generated drift is also from south to north. The predominant drift along the southern coast is from west to east. It is true that predominant drift is occasionally reversed, so that *Avicennia* seedlings from estuaries in Queensland or New South Wales could be carried south beyond Cape Howe during a spell of northeasterly wind and wave action. If easterly winds then persisted, the seedlings could pass through Bass Strait to reach coastal waters off Victoria and South Australia, and finally arrive at the sites which have proved suitable for mangrove establishment, but the chances of all this happening within the period of viability of a mangrove

The distribution of mangroves on the Australian coast, shown by dots. The pecked line indicates the approximate position of the shoreline about 20,000 years ago, and X marks the hypothetical location of *Avicennia* on that shoreline.



Mangrove zonation on the shores of Cairns Bay, north Queensland. *Avicennia* dominates the outer (paler) zone and *Rhizophora* the next (darker) zone, while other mangrove species are farther inland. [Photo: Author.]



seedling appear remote. Similarly, mangrove seedlings originating on the west coast would have had to travel great distances southward to Cape Leeuwin, thence eastward through the Great Australian Bight to reach their present South Australian and Victorian sites.

Aware of this, W. Macnae (1966) concluded that the mangroves on the southern coast of Australia must be relict features, established under past conditions when the seas were warmer than they are today, and when patterns of drifting in coastal waters were more favourable for the supply of *Avicennia* to southern shores. He noted evidence that sea temperatures were higher during late Tertiary and early Pleistocene times (at least 2 million years ago) and suggested that mangroves were then able to spread to Australia's southern coast and form communities from which the present *Avicennia marina* stands in Victoria and South Australia are descendants. This is an attractive hypothesis, but it fails to take account of the fluctuations of climate and sea-level that have occurred during the past 2 million years, through Pleistocene and Recent (or Holocene, the final 10,000 years) times. The distribution of *Avicennia* must be explained in terms of coastal evolution, acknowledging that there have been many changes in the outline of the coast of southern Australia since the early Pleistocene.

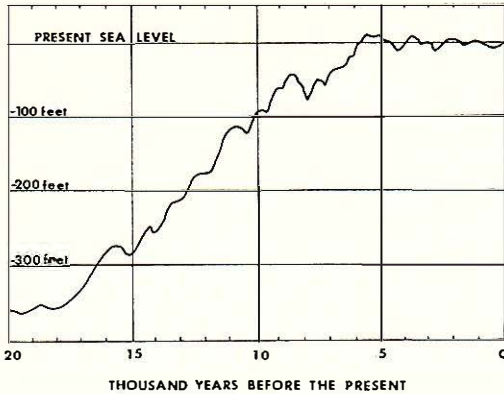
The sea has remained at, or within ± 10 feet of, its present level during the past 6,000 years, but before this there were major fluctuations in sea-level, and the shore sites which now carry mangrove swamps were

alternately above and below present sea-level. Details of Pleistocene fluctuations of the world's oceans remain controversial, but it is generally agreed that about 20,000 years ago, during the last major cold phase of the Pleistocene epoch, the sea stood at least 300 feet below its present level. The Australian continent then had an enlarged outline (see map), with Tasmania attached to the mainland (E. C. F. Bird, 1968). Mangroves must then have occupied sites on a shoreline that is now deeply submerged off the present coast, and as the climate was cooler they could not have extended as far south as they do now.

Sea-level rise

The world-wide sea-level rise that took place between 20,000 and 6,000 years ago (see the graph on the opposite page) must have been accompanied by shifts in the distribution of mangroves as the shoreline migrated towards its present position. The existing distribution of *Avicennia* should therefore be considered as a sequel to the late Pleistocene and Holocene phases of (1) low sea-level and cooler climate, (2) rising sea-level with climate becoming milder, and (3) relatively stable sea-level and existing climate. The distribution of mangroves during the warmer late Tertiary or early Pleistocene phases is thus of little relevance to the problem of explaining their present pattern.

Did mangroves survive anywhere on Australia's southern coast during the late Pleistocene low sea-level phase? The shoreline then retreated southwards, and the sea



Graph showing world-wide sea-level fluctuations during the past 20,000 years, compiled from various sources.

became cooler. In southeastern Australia the low sea-level shoreline ran well south of the present southernmost mangrove limit, and as the sea was cooler it is unlikely that any mangroves survived here. Farther west, however, where the sea withdrew from the South Australian gulfs and the Nullarbor coast to a position out in the Great Australian Bight in latitude 33° to 34° S., it is possible that *Avicennia marina* persisted on some favourable shoreline site. If it did, it could have provided a source of seedlings to initiate mangrove communities on suitable sites along the transgressing shoreline as sea-level subsequently rose, and eventually to establish *Avicennia* in the estuaries and inlets where it is now found. The fact that these sites lie east of the Great Australian Bight is consistent with the predominant west-to-east drift in waters along the southern coast, and by the time the sea reached its present level it would have become sufficiently warm for *Avicennia* to extend south as far as its Victorian sites.

Possibility of warmer climate

One other possibility should be borne in mind. The climate of southern Australia may briefly have been warmer than it is now just after the sea reached its present level. Studies of past and present distributions of plants and animals, of soil phenomena, of sediment sequences, and of landform evolution in Australia during Holocene times have sometimes indicated this possibility (E. D. Gill, 1955), but more work is needed to establish the details of climatic history.

If there *has* been a warmer phase, it may have been accompanied by modifications in the pattern of drifting in coastal waters, possibly facilitating the transportation of *Avicennia* seedlings from east or west coast sites to the southern coast. In this connection it would be useful to investigate the salt marshes of northern Tasmania for stratigraphic evidence of a warmer Holocene phase when mangroves may have extended south beyond their present limits. In view of the great distances that mangrove seedlings would have had to travel in order to reach the southern coastline, the hypothesis that mangroves persisted on part of the late Pleistocene low sea-level shoreline in the Great Australian Bight as a nucleus for subsequent dispersal to present sites in South Australia and Victoria seems the more likely.

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 Jones, W. T., 1971: "The Field Identification and Distribution of Mangroves in Eastern Australia", *Queensland Naturalist*, 20: 35-51.
 Macnae, W., 1966: "Mangroves in Eastern and Southern Australia", *Australian Journal of Botany*, 14: 67-104.

BOOK REVIEW

TREES OF AUSTRALIA, by H. Oakman, Jacaranda Press, 1970. Price, \$1.95.

This interesting little book is a pocket-size edition (4 in by 5½ in) in the Jacaranda Colour Guides series, and illustrates 60 different Australian native trees. This is admittedly a relatively small number, but all picture books have to fall short of completeness and the author explains that as far as possible he has made a representative selection "from the various plant families, the useful or ornamental and the rare trees that grow in the different regions of this continent". The descriptive matter for each, given on the opposite page to the colour plate, includes habitat, size, botanical data, timber, and general notes. The colour reproduction of the plates is variable, from mediocre to excellent, although the originals all seem to have been very good, and carefully chosen. The author has followed no set pattern, which gives an interesting variety to the book. He illustrates sometimes the whole tree, sometimes its trunk, sometimes its flowers or fruit, depending on which provides the most readily recognizable or characteristic feature. The book will be appreciated above all for its plates.—J. S. Beard, Director and Chief Botanist, Royal Botanic Gardens, Sydney.

SEA URCHIN THAT CARRIES ITS YOUNG

By ALAN J. DARTNALL

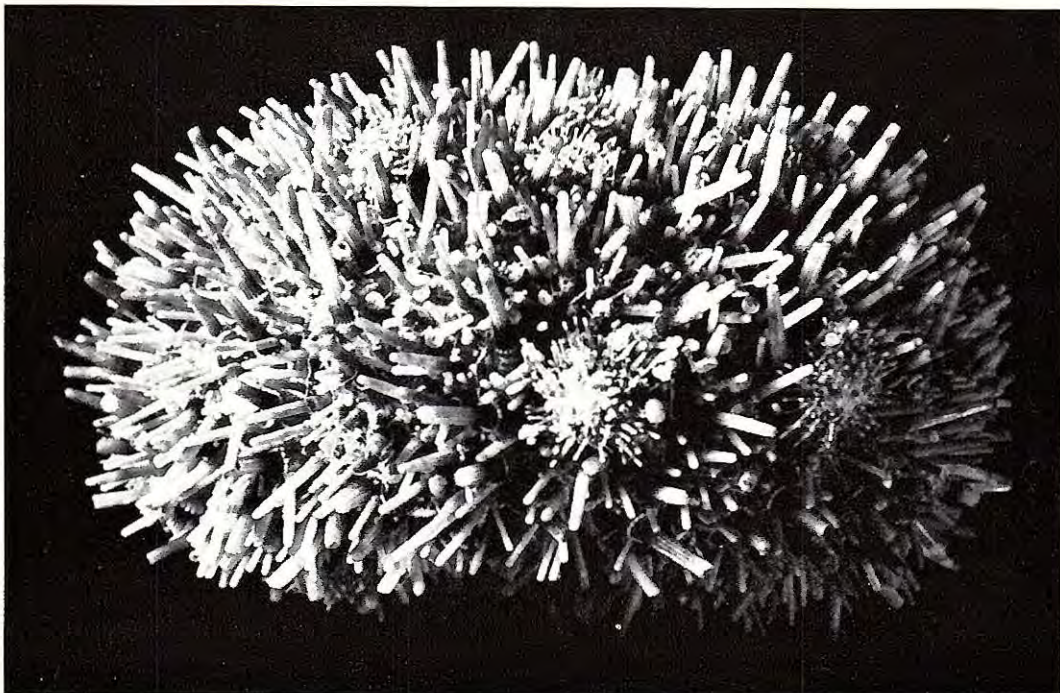
Curator of Invertebrate Zoology, Tasmanian Museum, Hobart

MOST echinoderms (the sea stars, sea urchins, and their allies) breed by releasing eggs and sperm into the water around them. The larvae which develop after fertilization spend some time swimming and feeding in the plankton, and then settle to the bottom and metamorphose into the adult form.

Some other echinoderms, however, forego this free-swimming larval stage and retain their young within or upon the body of the adult. Care of the young in this way is termed brooding. A general account of breeding and brood-protection in echinoderms can be found in an article by Dr D. L. Pawson in the December 1968 issue of *Australian Natural History*.

The sea urchin illustrated here, carrying seventeen young amongst its spines, is unusual because only one other urchin of this kind has been reported to brood its young. The present specimen was collected, by the author, from under a stone at low-tide level at Maria Island, off the east coast of Tasmania.

The brooding habit of this animal had been noticed before. In fact, Emeritus Professor V. V. Hickman had shown a lantern slide of the animal to a meeting of the Royal Society of Tasmania in 1960—the occasion on which he was presented with the Clive Lord Memorial Medal in recognition of his contributions to zoology. Professor Hickman had more specimens of the urchin in his collections, which he placed in my care.



A side view of the sea urchin *Pachycentrotus* carrying its young among its spines. The adult is about 21 millimetres (about seven-eighths of an inch) in diameter and 11 millimetres in height. The young range in size from about 1 to 3 millimetres in diameter. Altogether, seventeen young urchins are being carried. [Photo: C. V. Turner.]

We now know that the urchin belongs to a genus called *Pachycentrotus*, which is found only in southern Australia, including Tasmania, and which contains one named species, *Pachycentrotus australiae*. The Tasmanian brooding urchin, however, appears distinct from *P. australiae*, and will be described and formally named in another place. It does not attain the size of *P. australiae*, and there are differences in the pattern of the skeleton and the colours of both test and spines. The brooding urchin appears to be found only in southeastern Tasmania.

The distribution of this sea urchin has interesting implications. Work by Miss E. C. Pope, of the Australian Museum, and Miss I. Bennett, of the University of Sydney, has shown that the shore fauna of Tasmania belongs to a marine faunal region called the Maugean. The presence of this region has sometimes been denied in the past because the faunal patterns of the Maugean widely overlap the marine faunas of South Australia, New South Wales, and Victoria. Recent studies on echinoderms in Tasmania have shown that a small endemic element does exist which is especially noticeable in southeastern Tasmania. The brooding *Pachycentrotus* probably belongs to this Maugean faunal unit, and more intensive collecting to determine the limits of its distribution will probably enable this to be determined.

There is another interesting fact about brooding echinoderms in southeastern Tasmania. A small sea star, *Patriella vivipara*, goes one better than the sea urchin and incubates its young inside the body of the parent. It appears that some factor has favoured direct development (without free-swimming larvae) of some echinoderms in Tasmania, in contrast to their relatives in the remainder of southeastern Australia, whose young spend a period as planktonic larvae before metamorphosing into the adult form. Brooding is more common among the echinoderms of polar regions and the depths of the sea, and it has been suggested that low temperature may be a direct cause of this method of reproduction. As no Tasmanian waters reach the "cold" category, this may not be all the story. Dr Fu-Shiang Chia (*Marine Pollution Bulletin*, May 1970) has argued that the brooding habit may be an adaptation resulting from the small size of

the animals which only produce a few large eggs. In order to compete with larger animals producing more eggs the smaller animals ensure that more of their young survive by brooding and protecting their eggs and young. The factors which have caused some Tasmanian echinoderms to brood remain to be found. As the animals appear to be restricted to the Maugean fauna mentioned above, we can only observe, at this stage, that this reproductive habit has evolved in response to the particular conditions of a Tasmanian marine climate.

FURTHER READING

Physiology of Echinodermata, edited by R. A. Booloootian. John Wiley, New York, 1966.

Echinoderms, by D. Nichols. Hutchinson, London, 1962 (revised 1966).

Sections on echinoderms and zoogeography in *Australian Sea Shores*, by W. J. Dakin, I. Bennett, and E. C. Pope (Angus and Robertson, Sydney, 1952, revised 1966) and *Australian Sea Shores in Colour*, by K. Gillett and J. Yaldwyn (Reed, Sydney, 1969).

BOOK REVIEW

AUSTRALIAN SHELLS, by B. R. Wilson and K. Gillett. Reed, Sydney, 1971, 168 pp., \$12.95.

SEASHELLS OF AUSTRALIA, by W. Deas. Rigby, Sydney, 1971, 32 pp., \$2.25.

Despite a similarity in the titles of these two books their contents and quality of presentation differ considerably. One book is designed as a shell collector's manual and the other as an introduction to the world of molluscs that is opened to the scuba diver. Both rely heavily on sumptuous colour photographs of excellent quality.

Australian Shells has a carefully written and accurate text, including a well-rounded introduction and descriptions of, and information on, the 600 species illustrated. A few gastropod families popular with shell collectors have been treated comprehensively, but the remainder of the gastropods have been given a cursory coverage. No molluscs other than marine prosobranch gastropods have been included, this making the title rather misleading (although partly corrected by the subtitle). It is also rather unfortunate that this title is the same as that of Joyce Allan's well-known book. This book will be extremely popular with shell collectors and will give delight to amateur naturalists of all kinds with its fine photographs of living molluscs.

Seashells of Australia is a smaller book, the only text being a foreword and brief captions to the plates. Errors are frequent and the usefulness of the book can be questioned. The book deals mostly with the usual well-known collector's species and includes a few examples of classes other than the gastropods.—W. F. Ponder, Curator of Molluscs, Australian Museum.

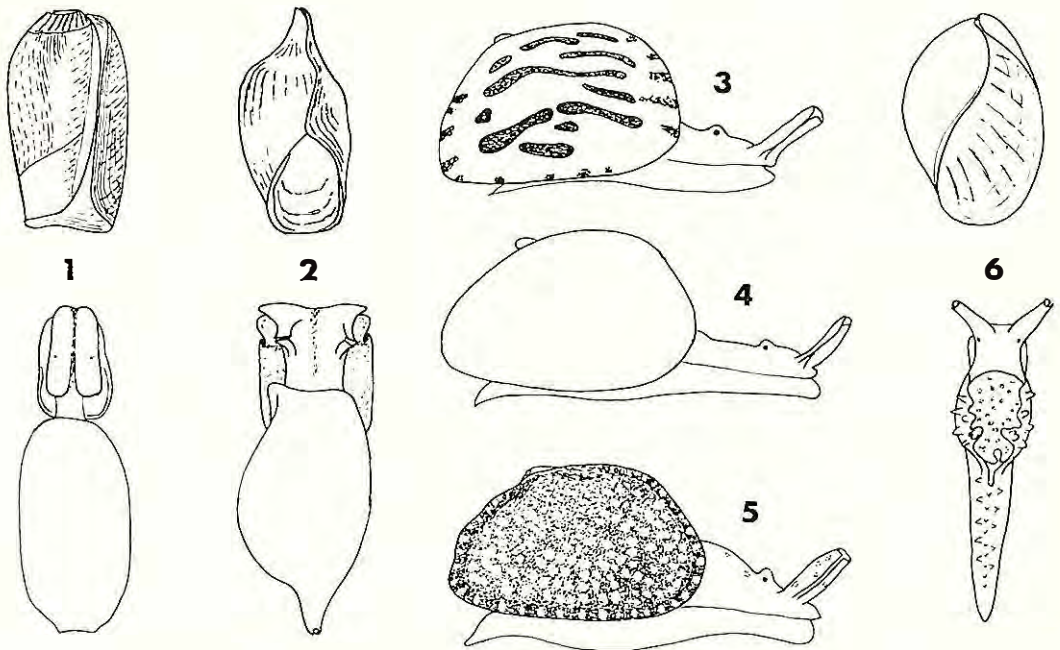
A Guide to the Ascoglossa or Sap-Sucking Sea-Slugs of Australia

By ROBERT BURN

Honorary Associate, National Museum of Victoria and Western Australian Museum

THE 600-700 opisthobranch molluscs or sea-slugs of the Australian coastline include many specialized or otherwise peculiar forms. Loosely speaking, they are divided into two groups, carnivores and herbivores. The larger group by far is that of the carnivorous species, among which are the bubble-shells that eat foraminifera, polychaete worms and smaller bivalve molluscs; the dorids that eat sponges and ascidians; the eolids and dendronotids that eat hydroids and anemones, and the arminids that eat sea-pens and polyzoans. The smaller group of herbivorous species includes only the grazing umbrella-shell (*Umbraculum*) and the sea-hares (*Aplysia*, *Dolabella*, etc.), and one very specialized group of algal sap-suckers that all belong to the order Ascoglossa.

These sap-suckers are very selective in their choice of food, confining themselves exclusively to the green seaweeds of the phylum Chlorophyta. In Australian seas the genera most commonly utilized for food are *Caulerpa*, *Codium*, *Enteromorpha*, and *Halimeda*. Many ascoglossan species have adapted themselves intimately to a life solely concentrating on one or two species of algae for nourishment. Not only have they adapted themselves in this way, but also they have adopted the pigment of the green algae to provide their own body pigment, by storage of the pigment in the multitudinous fine branches of the digestive system in the body walls. In this way, most ascoglossans are decisively cryptic and find further protection from what predators they might



Figs 1-6.—1. *Cylindrobulla fischeri* A. Adams and Angas, Cottlesloc, Western Australia. 2. *Volvatella* cf. *vigourouxi* (Montrouzier), Proserpine, Queensland. 3. *Edentellina typica* Gatliff and Gabriel, Point Lonsdale, Victoria. 4. *Tamanovalva babai* Burn, Torquay, Vic. 5. *Midorigai australis* Burn, Torquay, Vic. 6. *Oxynoe viridis* (Pease), Torquay, Vic. [Drawings by the author.]

have by hiding among the fronds of their food-host. They are also difficult to discover and collect for research purposes, owing to their "homochromy", elusive nature, and small size.

Because of this complete dependence upon their food-host, the ascoglossans have evolved a rather uniform method of obtaining their food. The head is provided with either a pair of rhinophores (sensory tentacles) or a pair of lobes. The anterior of the foot is complexly muscular, and forms a sinus over which the lateral corners of the foot close pincer-fashion. The combined application of the rhinophores or lobes and the foot-corners forms a vacuum-like seal of the mouth-parts to the thallus of the algae. The muscular pharynx, with the radular tooth-in-use projecting into the anterior aperture, is pushed forward to touch the thallus, and, by rocking the pharynx up and down, the radular tooth pierces and slits the thallus skin. The action of withdrawal of the pharynx sucks the juice from the thallus. The juice is then pumped into the alimentary tract by means of either a pump action of the pharynx or by a modified muscular pouch on the dorsal side of the pharynx.

The radula or ribbon of teeth in itself is a peculiar organ and gives rise to the ordinal name Ascoglossa. The teeth lie in a continuous single row in which the older or outgrown teeth are retained, either in a spiral or a jumbled heap, in a ventral ascus (pouch or sac) of the pharynx. In most other opisthobranchs, the older teeth are discarded from the radular membrane and passed out of the body in the faeces. The blade-like tooth is very distinctive, and in combination with anatomical features, can be used in the identification of genera and a few species.

As always, there are exceptions to the general rule. One European species varies its diet by piercing and entering the egg-ribbon of an eolid opisthobranch and sucking out the minute eggs. Another species, from western Canada, eats the eggs within the egg mass of an aglajid opisthobranch. Whereas the first species has a normal radula, the second has a degenerate radula with only a few ill-formed teeth.

Reproductively, the Ascoglossa are similar to all other opisthobranchs with an hermaphrodite genital system. This provides nuances upon which generic and specific

differences are based, primarily whether there are one or two female apertures beside the male organ. The latter is often armed at the tip with a hollow cuticular stylet that acts as a hypodermic needle for the transference of sperm from one animal to its partner. Some species with one female aperture (the oviduct) have a blind second "aperture" (the vagina), in reality a seminal receptacle just within the body-wall into which the male organ with its stylet is plunged during copulation.

Classification

Systematically the major division of the Ascoglossa is very simple. The shell-bearing species, Oxynoacea, are held to be more primitive than the naked or shell-less Elysiacea. All families of the shelled species are represented in Australian seas; in common they have a mantle cavity within the protection of the shell. The shells of all genera except *Julia* are very thin and fragile, and their shapes are decisive for family and generic determinations only. In *Julia*, the shell is hard and glossy.

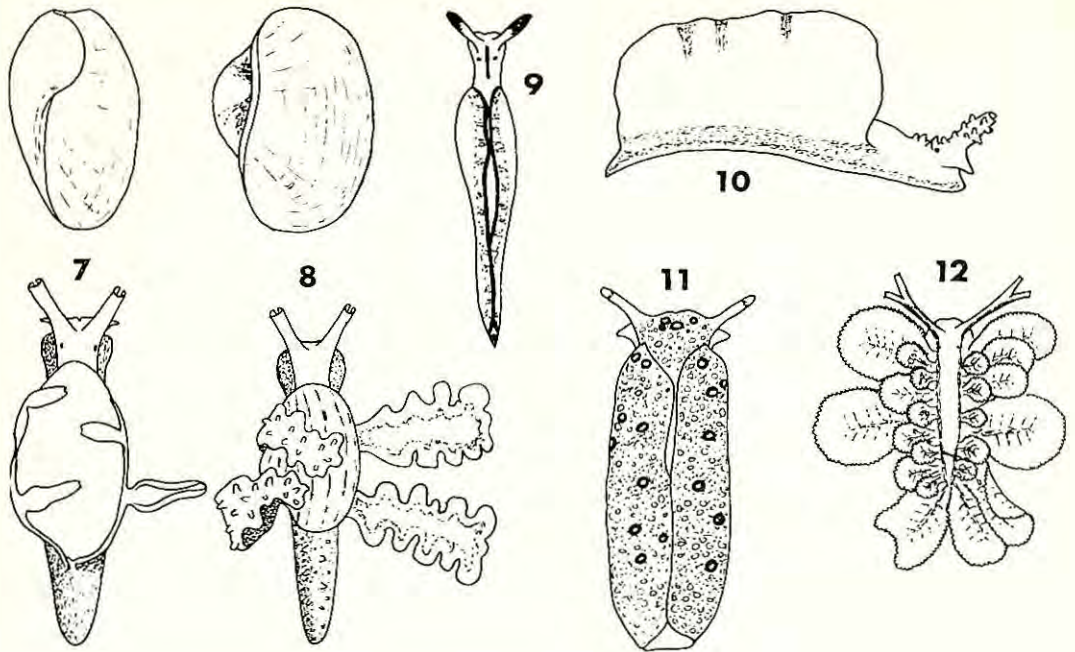
The naked Elysiacea have either simple parapodial lobes or rows of branchial papillae (called cerata) along each side of the body, or rarely a simple smooth body without appendages. Not all families of this suborder occur in Australian seas.

Taxonomically, the Ascoglossa is a very difficult group. Many genera and species have been inadequately described, more often than not without study of the important features of the anatomy. In the case of shelled species, names have been given to dried and distorted beach material.

Nearly fifty species of Ascoglossa are presently known to the writer from Australia. A good number are new records and some appear to be new species, clearly indicating that the fauna is not at all well known. This guide is intended, therefore, to facilitate the recognition of animals to generic level at least and to promote study of the order as a whole.

Oxynoacea

The most primitive of the shelled ascoglossans is the small genus *Cylindrobulla*, represented by one widespread species, *C. fischeri* (fig. 1), in southern and eastern Australia, and a single record of a second



Figs 7-12.—7. *Lophopleurella wilsoni* (Tate), Torquay, Vic. 8. *Lobiger viridis* (Pease), Norfolk Island. 9. *Elysia australis* (Quoy and Gaimard), Minnie Waters, New South Wales. 10. *Elysia Italimedae* Macnae, Minnie Waters, N.S.W. 11. *Plakobranchus ocellatus* van Hasselt, Orpheus Island, Queensland. 12. *Polybranchia* species, Long Reef, N.S.W. [Drawings by the author.]

species from Queensland. A cylindrical shell with oblique striations at the shoulder contains the bulk of the cream animal, only the small bipartite head and oval foot projecting clear of the shell. Most records refer to dead specimens, but at Cottesloe, Western Australia, numbers of living specimens can generally be found burrowing among the sand-covered root system of *Caulerpa geminata* (formerly *sedoides*) growing at and near the edge of the rock platform. It shares this habitat with other burrowing opisthobranchs, such as *Acteocina*, *Aglaja*, and *Chelidonura*.

Like the above, *Volvatella* (fig. 2) has a primitive-style large shell into which the small head and foot can be withdrawn. The shell is greatly swollen in the middle and tapers sharply to a terminal spout. The animal varies from white to orange in colour, and has lobe-like pointed tentacles on the head. Though various species have been reported from Australia, it is only very recently that living specimens have been taken. Like *Cylindrobulla*, the white species of *Volvatella* burrow among the roots of

Caulerpa. Orange species seem to prefer a more open mode of life, possibly feeding on epiphytic green algae.

Bivalved gastropods

The analogy of the bivalved shell of the Bertheliniidae with the shells of the Bivalva created the greatest interest when living specimens were first discovered in Japan in 1959 and Australia in 1960. In a short space of time, living specimens were collected in all parts of the Indo-Pacific and the Caribbean. Australia is rich in species, five of which are named and another half-dozen await description.

The animals of the bivalved gastropods differ in no real way from the animals of other shelled ascoglossans. The peculiar form of the shell commences, once the free-swimming veliger settles, as an anterior and posterior notch in the rim of an otherwise normal embryonic shell. The shell thus develops as two lateral plates, the right one of which fractures lengthways near the embryonic shell to form a false "hinge".

The periostracum thickens over the fracture to create a ligament, and, as the shell grows, very simple hinge teeth develop. The animal can be completely withdrawn into the shell.

The three Victorian species are all thin-shelled, less than 5 millimetres long and easily distinguished by colour pattern. *Edentellina typica* (fig. 3) is pale green with black stripes within the shell-mantle. *Tamanovalva babai* (fig. 4) is green all over and the embryonic shell is large and upright. *Midorigai australis* (fig. 5) is dark green with white spots in the shell-mantle. They are respectively found eating *Caulerpa brownii*, *C. geminata* and *C. scalpelliformis*, and *C. simpliciuscula*.

Reduced shells

Three genera have rather simple reduced shells that offer scant protection to the ample animals. *Lobiger* (fig. 8), as yet not collected from the Australian mainland, has a large flat shell similar in shape to a single valve of a bivalve. The animal has a short broad tail and four large knobby parapodial lobes that fold over the shell. Bright blue-green lines are present within the shell-mantle of

the species *L. viridis*, and the parapodial lobes are marked with green and pink on the inner smooth face.

Oxynoe viridis (fig. 6) is a common Indo-West Pacific species with a rounded bulla-form shell, short parapodia lying on the shell, and a long thick tail. Blue ocelli or eyes mark the shell-mantle. It has been found in all States and on many species of *Caulerpa*. The very rare *Lophopleurella wilsoni* (fig. 7) is restricted to a few miles of the central Victorian coastline. The shell is like *Oxynoe* but more elongate, the animal like *Lobiger* but with smaller smooth parapodial lobes.

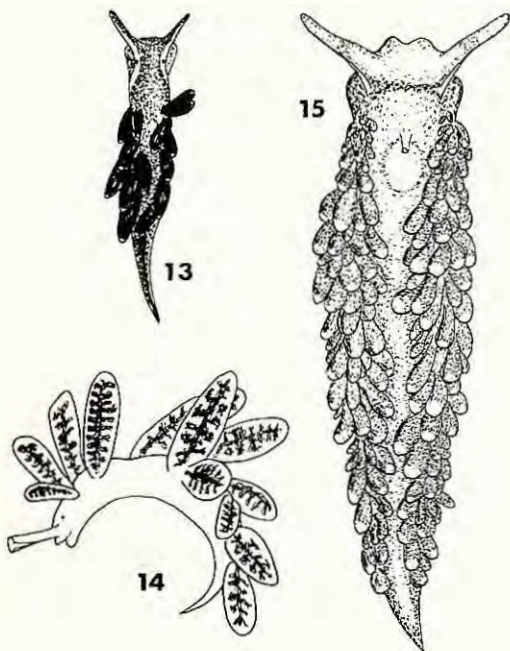
Elysiacea

The family Elysiidae comprises all those species with a parapodial lobe along each side of the animal. Only the genera *Elysia* and *Plakobranchus* occur in Australia. The best-known species is *Elysia australia* (fig. 9), which ranges from southern Queensland southwards to south Western Australia. Its green coloration, with black rhinophores, a black stripe on the head, and black margins to the parapodia, make it difficult to find, even though it occurs in large numbers in high rock pools, where it grazes on *Enteromorpha*.

The widespread tropical species *E. marginata* is up to 100 millimetres long, green in colour with the parapodial margins black and red or yellow. *E. furvacauda* from Victoria is brownish, *E. maoria* from New Zealand and southeastern Australia is green with red flecks and tubercled skin, *E. caerulea* from the Great Barrier Reef is deep blue with red parapodial margins, and *E. halimeda* (fig. 10) from South Africa, Japan, and New South Wales is pale green with tubercled rhinophores. *Plakobranchus ocellatus* (fig. 11) from tropical seas is a broad species that folds the parapodia flatly over the dorsum; it is spotted all over with blue and brown "eyes".

Eolidiform species

Two types of eolidiform species occur in Australia. The first has large, flat, leaf-like cerata that hide the greater part of the animal, and bifurcate or forked rhinophores. These belong to the family Polybranchidae (fig. 12). *Cyerce nigricans* is a large, predominantly black species with orange spots on the cerata,



Figs 13-15.—13. *Ercolania* species, Point Lonsdale, Vic. 14. *Hermaea* species, Torquay, Vic. 15. *Aplysiopsis* cf. *smaragclina* (Baba), Flinders, Vic. [Drawings by the author.]

and the sole of the foot transversely divided into two sections. *Polybranchia orientalis* has a greenish-orange, red or yellow body and often colourless serrated edged cerata. It is particularly common along the Great Barrier Reef. In southern waters, the brown and pink bodied *P. pallens*, with blue-flecked cerata, occurs but uncommonly.

The remaining Australian eolidiform species belong to the family Stiligeridae, with cylindrical or club-shaped cerata. Species of *Stiliger* have been found on the algae *Codium*; the small dark-green *S. fralila* lives in southern Queensland. The genus *Ercolania* has one common species on the mudflats of the mouth of the Brisbane River, and another (fig. 13) is even more common at times on the rock platform at Point Lonsdale, Victoria. Both species are darkest brown or black, with a small number of short cerata and pointed rhinophores, while a second Victorian species is green and pink in colour. One species of the genus *Hermaea* (fig. 14) is present in Victoria; its white body and pink or red cerata and rolled rhinophores allow easy recognition.

Also, there are two species of *Aplysiopsis* which can only be distinguished from other eolidiform species by the peculiar shape and denticulation of the radular teeth. *A. nigra* is small and black; *A. smaragdina* (fig. 15) is up to 75 millimetres long and green in colour with a transverse white bar on the head, and the cerata are shaped like light globes. Both species were originally described from Japan; in Australia the former is found at Long Reef, New South Wales, and the latter throughout southeastern Australia.

Finally, mention must be made of a genus of European ascoglossans. *Limapontia* lack both cerata and tentacle-like rhinophores, but in every other way they most closely resemble the *Ercolania* and *Stiliger* eolidiform genera.

FURTHER READING

- Burn, R., 1966: "The opisthobranchs of a Caulerpan microfauna from Fiji". *Proceedings of the Malacological Society of London*, 37: 45-65.
- Burn, R., 1966: "Opisthobranchia, Port Phillip Survey 1957-63". *Memoirs of the National Museum of Victoria*, 27: 265-288.
- Pruvot-Fol, A., 1954: "Mollusques opisthobranches". *Faune de France*, 58.

IMPORTANT BOOK ON MELANESIA

MELANESIA: A GEOGRAPHICAL INTERPRETATION OF AN ISLAND WORLD, by H. C. Brookfield, with Doreen Hart. Methuen & Co. Ltd, London, 1971. 1x + 464 pages. \$17.80.

The geographical region of Melanesia stretches across several thousand miles of ocean, and includes thousands of islands which range in size from small atolls only a few acres in area to the vast island of New Guinea. This variation in land mass is matched by the diversity of environments and the cultural adaptations to them. To compound the difficulties of the geographer who would synthesize the data from this region, the quality and quantity of information for each island or island group are extremely variable. Nevertheless, Brookfield and Hart have tackled these problems with great success to produce this first-ever study of the economic geography of Melanesia.

The main text is divided into two sections, preceded by a 60-page introduction which presents essential background data on conventions used, maps available, geo-political units, and some basic statistics. Part I of the main text, titled "Ecology", outlines the ecological base for human settlement in the region, the traditional subsistence activities of "old" Melanesia, and the cash-income activities of farming and mining introduced through European colonization. Of particular interest in this section are the discussion of Melanesian agriculture in terms of ranked intensity systems, and an hypothesis relating demographic variation, agricultural technique, and ecology in a dynamic equilibrium model. Part II, "Location and Scale", continues the theme of change through development in the economic and social spheres. New economic activities are dislocating the traditional patterns of resource exploitation and redistribution without totally destroying them, giving rise to a "dual economy" of commercial and peasant systems. The interaction and conflict between these systems is considered at length, especially in terms of organization and communication. The main text concludes with a survey of the urbanization processes current in every major island group, and some comments on the "in-between" nature of Melanesian society and its economy, neither wholly traditional nor fully "developed".

The pitfalls of generalization are self-evident, and the authors maintain a fine balance between detail and generality. The text is lucid, well-documented, and intelligently illustrated with photographs. The book is not designed as a standard text-book from which facts and figures can be gleaned by those reluctant to refer to original sources. Rather, it stands as an overview of economic change to be read by all who are seriously interested in the progress of these colonial and ex-colonial territories. As such, it is a major contribution to the entire field of geography.—J. Specht, Assistant Curator of Anthropology, Australian Museum.

BOOK ON NATIVE MAMMALS OF AUSTRALIA REVIEWED

A GUIDE TO THE NATIVE MAMMALS OF AUSTRALIA, by W. D. L. Ride, with drawings by Ella Fry; Oxford University Press (Melbourne, London, Wellington, New York), 1970; 249 pages, 62 plates, 1 colour plate of a numbat on the dust jacket; \$7.50.

This critically conceived and executed guide to the native mammals of Australia is a book worthy of the zoologically exciting and varied assemblage of mammals on this island-continent. Basically, this book is a reflection of the renewed interest in the study of native animals and plants that has swept Australia since the end of the Second World War. When the reviewer first visited Australia in 1948 the study of mammalogy, with rare exceptions, was at a cyclic bottom. The 1950's brought the formation of the Australian Mammal Society (1958), the expansion of the work of the CSIRO Wildlife Survey Section (now a Division) to include studies on native fauna, and the rise of a whole new generation of enthusiastic field observers and well-trained zoologists with a wide spectrum of interests. One of the most cosmopolitan in outlook of these was the author of this long-awaited guide, whose fresh approach to the problems of mammalian taxonomy, to the organization of natural history museums, and to the need for preservation of the environment will have lasting effects on Australian thinking and planning.

This is no run-of-the-mill guide to the mammals of a given region, of which there are too many examples on library shelves. This book conveys the excitement of a continent-wide marsupial radiation, of monotreme egglayers whose prehistory is still guesswork, and of stepping-stone "invasions" of bats and rodents from the distant mainland of Asia. The lay reader and the professional can both profit from reading and studying this handsome volume. One of the most delightful features of the book is the series of brief essays about the history, composition, and naming of the Australian mammal fauna, the habitats these mammals occupy, the devastating effect of man and his introduced mammals on the native fauna and flora, the semantics of words dealing with numbers of mammals (including lists of mammals now rare or whose status is changing), and the profound need for thoughtful action at many levels of government that will help preserve natural communities throughout Australia.

The main body of the book discusses the 228 species of Australian mammals. These are divided into 55 groups of species on the premise that any native mammal can be readily recognized as belonging to one or another of these groups. For example, the five gliders known to the continent are discussed as a group. For the layman this makes more sense than having to look for gliders in three separate possum categories, as one would have to do if the mammals were in strict taxonomic

order. The thylacine and the numbat, among others, stand alone in groups of their own. On the other hand, the macropodids are divided into nine groups ranging from the "great kangaroos" to the rock-wallabies. The reviewer has used this book for many weeks now, and can vouch for the simplicity and ease of reference. One further feature of this group system is the provision of a plate which shows at a glance the external form of the group members. Too often reviewers are prone to overlook the principles on which an author constructs his book, and expound their own ideas about how the book should have been written and illustrated. Users of books also fall into this trap, so I strongly recommend that the reader pay particular attention to pages 36 and 37, where the author lays down the ground rules for using his guide most efficiently.

This book could easily have been several times its present size if Dr Ride had chosen to include even part of the voluminous anecdotal material on Australian mammals. Instead, he has chosen to provide an excellent list of suggestions for further reading, in appendix one. For the student and professional users of this guide, appendix two consists of a list of species each of which is accompanied by one or more bibliographical references to morphological descriptions of both external features and skulls and teeth. This section, with its up-to-date scientific names, is of great value, since it reflects current taxonomic thinking and usage among Australian mammalogists.

The monochrome drawings by Ella Fry serve three important functions basic to the plan of this guide: they enable the user to recognize at a glance specific physical features of the mammals of a given group; they freeze the animal in one or more characteristic poses (how vividly I remember my first sight of a tuar in the wild—posture and shape, not colour, were imprinted on my memory!); and they give a vignette of the habitat in which the mammal is found. Months of painstaking observations of living mammals went into these drawings. It was my privilege to see living *Tarsipes* in a terrarium in Mrs Fry's home. Of course, not all of the species represented could be drawn from life. But there is a refreshing candour about this phase of the work. Appendix three details whether or not the drawings are based on living individuals or photographs. As would be expected, many of the more successful drawings are those based on close observation of living animals. I agree wholeheartedly with the author in his decision to illustrate his guide in monochrome. This brings the price of the book within the reach of every interested observer, and there is a crying need in Australia for the widest possible distribution of this book. Fortunately, in Australia basic interest in nature is extraordinarily widespread compared to other countries. Since most mammals in Australia are nocturnal, glimpses of individuals

at dusk or by torchlight minimize the value of colour as an aid to identification.

I have no intention of nit-picking for errors; this is a foolish exercise in reviewing a book of such manifestly high standards. No guide ever written has been free of error. Subsequent editions will certainly see these errors corrected. Readers are only too pleased to point out mistakes to authors, and writers worth their salt are only too glad to receive corrections.

I predict that this elegant book, with its delightfully fresh approach to the review of the mammals of a whole continent, will become the constant companion of new and old naturalists alike for years to come. Let it be a source of strength to those dedicated Australians who would save what is left of their homeland from over-exploitation.—*Hobart M. Van Deusen, Archbold Expeditions, American Museum of Natural History, New York.*

MEET OUR CONTRIBUTORS . . .

ROBERT E. BAIER, head of the Chemical Sciences Section, Cornell Aeronautical Laboratory, of Cornell University, U.S.A., is a Ph.D. in Biophysics of the State University of New York at Buffalo and a Bachelor of Engineering Science in Physics of Cleveland State University, U.S.A. Dr Baier is responsible for interdisciplinary research in surface chemistry and environmental chemistry, extending to problems of biological adhesion and water and air quality control. He received a national award of the American Chemical Society in 1971 for technical excellence in the organic coatings and plastics fields.

E. C. F. BIRD, Reader in Geography at the University of Melbourne, is a graduate of the University of London, where he trained in geography, geology, and ecology. He came to Australia in 1957 as a Research Scholar at the Australian National University, and completed a doctoral thesis on the Gippsland Lakes, Victoria, in 1959. Subsequently he held positions at King's College London, University College London, and the School of General Studies in Canberra, and in 1966 was appointed to his present post at the University of Melbourne. His main interests are in coastal studies, on which he has published a textbook and more than fifty papers, and in the problems of environmental conservation.

ROBERT BURN, a carpenter by trade, is an amateur marine zoologist, and specializes in the systematics of the opisthobranch molluscs. He has collected extensively along the southern and eastern coastlines from southern Queensland to south Western Australia, and has written a number of papers on the Australian fauna. His appointments include honorary associate of the National Museum of Victoria and the Western Australian Museum, chairman of the Victorian branch of the Malacological Society of Australia, and editor of the society's journal.

H. ROBERT BUSTARD is a population ecologist working at the Research School of Biological Sciences of the Australian National University. His particular field of interest is reptiles, and he is engaged on long-term studies of geckos and sea turtles as well as being interested in crocodiles. Dr Bustard has strong interests in conservation, and is a member of the International Union for the Conservation of Nature and Natural Resources

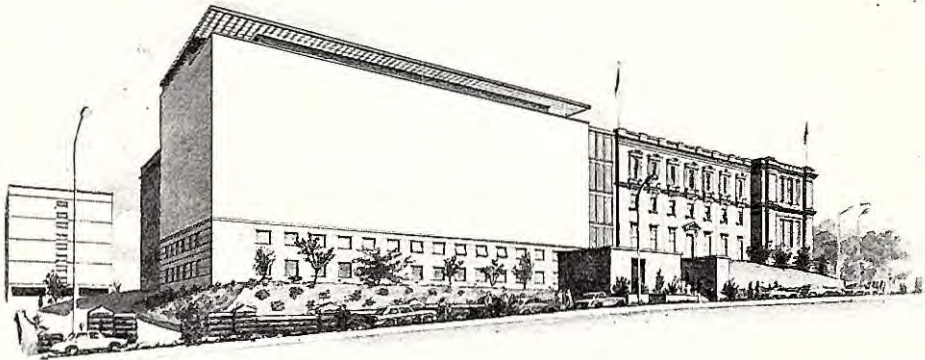
(Sea Turtle Group) and secretary of the Union's Crocodile Specialist Group. He has played an important role in the conservation of Australian reptiles.

ALAN J. DARTNALL gained his degree in zoology from the University of Durham, England. He was employed in museums in Sunderland and Newcastle upon Tyne, England, and became Curator of Invertebrate Zoology at the Tasmanian Museum, Hobart, six years ago. He is particularly interested in the taxonomy and zoogeography of echinoderms, and was recently granted an M.Sc. by the University of Tasmania for some aspects of his work on this subject.

D. W. GOLDING, Ph.D., Lecturer in Zoology at the University of Newcastle upon Tyne, England, is also a member of the staff of the Dove Marine Laboratory at the University. As a research fellow at the Universities of Bristol, California and Cambridge, he worked on the cytology and electron microscopy of neuroendocrine systems.

ANNE WARREN was an undergraduate at the University of Sydney and went on to Cambridge, England, to work for her Ph.D. in vertebrate palaeontology. This involved a study of capitosaurid labyrinthodonts (Amphibia) from Tanzania, and prompted her on her return to Australia in 1967 to look for labyrinthodonts in the Australian Permo-Trias. In 1969 a Lower Triassic fauna was located in south-central Queensland, and since then she has been working on the fauna's several labyrinthodont species.

GILBERT P. WHITLEY, an Honorary Associate of the Australian Museum, was formerly the Museum's Curator of Fishes. He was Assistant to the late A. R. McCulloch, Zoologist in Charge of Fishes at the Museum, in 1925, when the latter wrote an article on "Raining Fishes" for *The Australian Museum Magazine*, the forerunner of *Australian Natural History*. Mr Whitley has also discussed rains of fishes with the late American bibliographer, E. W. Gudger, and the former Director of the Zoological Survey of India, Sunder Lal Hora, both of whom had thoroughly documented such occurrences in overseas countries. In his article in this issue he has assembled the Australian occurrences for the first time.



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