AUSTRALIAN NATURAL HISTORY

PUBLISHED BY

THE AUSTRALIAN MUSEUM
SYDNEY

SEPTEMBER 15, 1966

VOL. 15, No. 7

PRICE, THIRTY CENTS

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

CONTENTS

● **FRONT COVER: A Spiny or Crocodile Skink (*Tribolonotus gracilis*) from Karkar Island, off the coast of north-east New Guinea. This bizarre, six-inch lizard is dark brown on the back and sides and bright yellow, with patches of orange, underneath. It has a bright orange ring around each eye, and there is often a light yellow band around its body just in front of the forelimbs. The vertical rear wall of the skull is very distinctive. The photo is by Harold G. Cogger, whose article, "Expedition to Karkar Island", appears on page 212.**

VOL. 15, No. 7 SEPTEMBER 15, 1966

GIFT SUBSCRIPTIONS

to

"Australian Natural History"

The order form below is to enable readers to send "AUSTRALIAN NATURAL HISTORY" to friends as a Christmas gift.

If the form is filled in, and this page torn out along the perforation and sent to the Government Printer, your friends will be informed by letter that the magazine is being sent to them as a Christmas gift, with your good wishes.

To: *The Government Printer, Harris Street, Ultimo, N.S.W.*

Please enrol as a subscriber to "AUSTRALIAN NATURAL HISTORY"

for one year (4 issues) @ $1.40 posted

for..................issues @ 35c per issue posted

(cross out line not required)

the person whose name appears below:

Name of person to whom copies are to be sent:

Mr
Mrs ....
Miss

Address of person to whom copies are to be sent: ....

....

Name and address of sender:..

....

Additional names and addresses should be sent on a separate sheet of paper.

Please send the appropriate payment with the order form. Postal orders and cheques should be made payable to THE GOVERNMENT PRINTING OFFICE and exchange added to country and interstate cheques.

All Christmas Gift Subscriptions will start with the December, 1966, issue.

AUSTRALIAN NATURAL HISTORY

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

Editor: F. H. Talbot, M.Sc., Ph.D. Annual Subscription, Posted, $1.40

VOL. 15, NO. 7 SEPTEMBER 15, 1966

Sink or Swim—Some Consequences of Buoyancy in Fish

By G. H. SATCHELL
Professor of Biology, School of Biological Sciences, University of Sydney

SYDNEY is justly proud of its oceanarium, Marineland, at Manly. There you can see more than 100 species of fish and observe how they swim and breathe and feed. There you can share in the spontaneous and corporate delight in the spectacle that ripples and shimmers through every window. Fish, it seems, arouse a greater public enthusiasm than any other class of animals. Those of us who believe that deepening the public awareness and understanding of biological science is not only worthwhile in itself but is necessary if this heritage is to continue to be with us, should look carefully at Marineland. It plays a significant and unique role in biological education in New South Wales.

The visitor to Marineland can well be pardoned if he feels himself to be overwhelmed by the variety of species and the multitude of facts about them that he encounters in the course of a morning's visit. Science is not a set of facts but a way of giving unity and intelligibility to what we observe around us. This article attempts to show that there exists a framework of ideas into which very many of these facts and observations can be fitted so that our understanding, and indeed our recollection, of them is enhanced.

The eye of even the most casual observer tends to distinguish between two great natural groups of fish. Our attention is arrested by the great Whaler Sharks with their ceaseless menacing swimming. At another window, we are delighted with the many kinds of small bony fish which execute the most intricate and precise movements. They can hover and dart and swim backwards; the delicacy of their ballet seems the very opposite of menacing. What information do we need to have that will give unity and intelligibility to these casual observations?

Sharks and rays

Our train of thought starts, it may seem, at a rather remote station. It is the observation that the specific gravity of most tissues is more than 1 and lies between 1·02 and 1·08. So a still fish will sink to the bottom unless it possesses some way of

Fig. 1. Tiger Sharks, showing the typical shark form of the tail and pectoral fins.

preventing this. Sharks and rays and their allies have only one method of raising themselves off the bottom: it depends upon the upthrust that results when an inclined plane is moved through the water. It is the same physical principle that lifts the aeroplane into the air and keeps the water skier up as he is pulled along by the boat. The long tapering muscular body of a shark is the power unit that serves to move the tail from side to side. This propels it through the water in the same way as does a single oar when it is sculled over the stern of a boat. The lateral surfaces of the body assist the tail in providing this forward thrust. When we look closely at the tail (fig. 1), we see that the spinal column stiffens the upper part of it, but that there is a flexible membraneous lower lobe. This bends as it is pressed against the water, so that it is converted into an inclined plane. It is no longer vertical but bent sideways. The side-to-side movements thus push water downwards and tend to lift up the tail end of the animal. The tail-flap acting alone would make the fish nose-dive to the bottom. Its effects are compensated by the pair of fins at the front. These, the pectoral fins, are like great paravanes set on the sides of the fish at a slight angle so that the leading edge is higher than the trailing edge. As long as the shark is driven through the water by its power unit of a tail, it will receive a lifting force at the front from the pectoral fins. The smoothly inclined underside of the snout offers an additional surface that provides lift. The shark is thus lifted up at both ends and so can stay off the bottom as long as it swims forwards. Moreover, the paravane-like pectoral fins provide the shark with a very delicate control of its level in the water. Small movements of elevation or deflection will force the shark up or down. If it stops swimming, it promptly sinks to the bottom.

It is not surprising that many of the shark's relatives, such as skates and rays, have adopted a bottom-living habit. The huge stingrays in the aquarium are an example. Bottom-living fish mostly have a flattened form, and in the stingray this has been achieved by the enormous expansion of the pectoral fins. No longer does the tail fin act like the sculling oar of a boat to drive the fish through the water. The muscular edge of the pectoral fin now undergoes a sinuous undulation (fig. 2), each wave of movement passing from the front to the back of the fin. Each undulation can be thought of as an inclined plane that is moving backwards through the water, and thus forcing the ray forwards. The hind part of its body tends to hang down and tilt up the flattened forward part, providing some upthrust, but the ray can also alter the angle of its huge pectoral fins relative to the rest of its body, and thus steer itself up and down. Again, as with the shark, it sinks to the bottom if it does not swim forward.

Neutral buoyancy

Some time around 300 million years ago, in the middle of the period known as the Devonian, new types of fish began to appear in which the skeleton was lightly constructed and entirely bony. But a further and more far-reaching change was that paired sacs from the gut developed that were filled with air. Subsequently in the course of evolution, one sac was lost and in some lines the single remaining one lost its connection with the gut. But whatever its precise relations, the air sac enabled the specific gravity of the animal as a whole to be reduced to the point that the fish could float with neutral buoyancy. When a shark dies its corpse is to be found on the bottom of the tank. When a bony fish dies, it floats on the surface. The over-riding importance of forward progression to prevent sinking to the bottom was gone. Locomotion could now be much more precisely controlled. With neutral buoyancy it was possible to swim in any direction, forwards, up or down—even backwards if this was an advantage. No longer did the tail need to have a flexible lower lobe, since the tail had not to provide lift. The tails of bony fish are symmetrical around their central axis. Compare the tail of a trevally with that of a shark. The pectoral fins need no longer be limited to lift-producing paravanes—they could be delicate fan-like structures for rowing or steering. This neutral buoyancy of a fish with a swim bladder helps us to understand the enormous variety of form in the bony fish. Many are relatively unspecialized and still use their now symmetrical tails and trunk surfaces as their power unit. We see this in the trevally (fig. 3). But the pectoral fins are now specialized to serve as braking and steering devices. When one of these fish wishes to pull up, the pectoral fins are simply thrust out and held on either side of the body, where they exert a powerful drag on the animal's locomotion. Their stiffened front edge and angle of insertion would tend to make the fish shoot upwards every time it slowed. To counteract this, the hind, or pelvic, fins have moved far forwards. They are set in with a downward-facing tilt so that they counter any tendency to rise when stopping. The co-ordination of all these fins is remarkable. We can speculate that along with these improvements in fin design went an increasing complexity of the control mechanisms in the brain. Ordered efficient swimming movements are of value not only in economizing energy; turbulent clumsy movements attract predators. If new fish are introduced into the tank at Marineland during the daytime, they dash wildly around the unfamiliar surroundings and are promptly attacked and eaten. This can be avoided by introducing them at night, as they have settled down to a more tranquil type of swimming by the following morning.

Other bony fish have abandoned the tail as a power unit altogether. The parrot fish and sea-horses propel themselves by undulating movements of the dorsal fin, which is much extended. This structure served, in the sharks, to prevent roll when turning, but has come to have a quite different function in these fish. The tail fin now acts only as a rudder. The Old Wife shows us another type of swimming. The fish rows itself along by its pectoral fins, using one more than the other to steer.

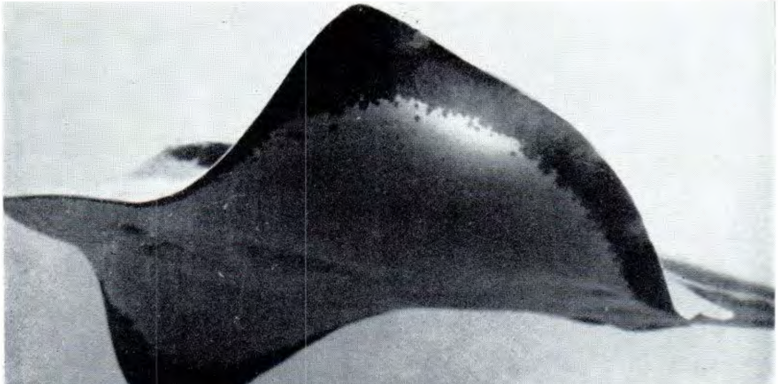
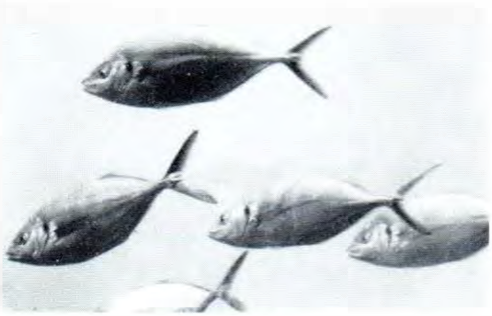
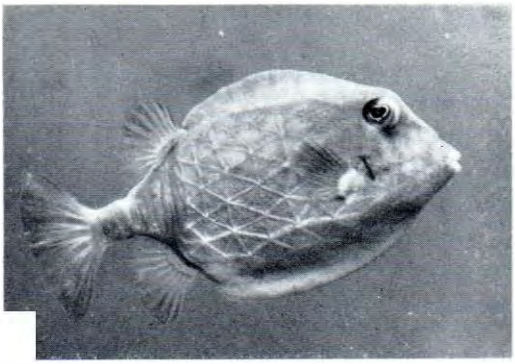


Fig. 2. The Stingray (*Dasyatis brevicaudatus*) swims slowly past a window at Marineland, revealing the gill slits on its under surface.



Above. Fig. 3: Trevally (*Usacaranx georgianus*), with the symmetrical tail that characterizes bony fish. Below. Fig. 4: The Humpty Dumpty (*Anoplocapros gibbosus*) flickers its eye in our direction as it passes.



The Humpty Dumpty (fig. 4) and the globe fish propel themselves by a propeller-like action of the dorsal and anal fins. As the globe fish often cruises slowly along close to the windows at Marineland, its curious fin movements can easily be observed.

These sophisticated means of locomotion have enabled some of the bony fish to adopt feeding habits that involve great delicacy of manoeuvre. In Marineland, one can watch the Old Wives swimming below one of the gropers and nipping bits of detritus and parasites off the skin of the belly. Other fish of this type live amongst coral. The John Dory furtively stalks the smaller fish and catches them with a sudden thrust of its protrusible jaws. Such a way of life would be impossible for a shark even if it were scaled down to size, as it would have to maintain a steady forward progression to keep afloat. It is the neutral buoyancy that the swim bladder provides which is the starting point of all this diversification.

Respiration

The sharks and their relatives have capitalized on their compulsory swimming to make economies in the field of respiration. Fish, like other animals, must have a continuous supply of oxygen. They obtain this in solution from the sea-water which they pump over their gills. Each gill is a cluster of blood-filled filaments. The water normally enters via the mouth, and is expelled from the gill slits, or from under a bony cover called the operculum. If you look at the Port Jackson Shark in Marineland you will see the five pairs of gill slits opening to expel the water and closing as fresh water enters the mouth. This action occurs about sixty times a minute. The actively swimming Whaler and Nurse Sharks do not have to pump the water in and out. As they cruise forward they need only to open their mouths slightly and the water is forced over their gills and out of their gill slits. These can be seen to be normally kept open by the outgoing current of water (fig. 5). The bottom-living stingrays face a different problem If they pulled the water in through their mouths they might inhale sand. They have a pair of openings on the upper surface called spiracles and the water enters through these. The spiracles are guarded by an efficient pair of valves, and as these great fish move slowly by the windows you can see the valves opening and closing. The gill slits open on the ventral surface (fig. 2), so the ray sits on a cushion of its own exhaled water like the more modern sort of vacuum cleaner. As soon as the ventral surface makes contact with the sea floor, a reflex causes the mouth to close. Once the stingray lifts off the bottom its mouth opens to admit water just as does the mouth of the Port Jackson Shark.

Bony fish do not have separate gill slits, the delicate gills all being housed in one cavity. The flap that covers this over may open widely behind as in the trevally or sweep, or it may be reduced to a small tubular opening as in the Humpty Dumpty (fig. 4).

Vision

Fish have well-developed eyes organized on much the same plan as our own. But living in water has its particular difficulties. Much of the optical power of our eye comes not

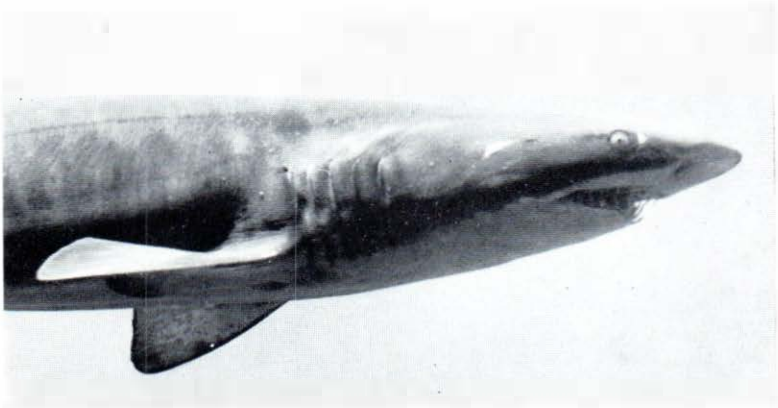


Fig. 5. The Nurse Shark (*Carcharias arenarius*) swims past with its mouth and gill-slits open, allowing the water to stream through.

from the lens but from the curved outer surface of the eye called the cornea. In a fish, the cornea is in contact with water and has much the same refractive index as water. So all of the optical power of the eye has to reside in the lens. This has a very high refractive index and is spherical. As the cornea cannot be counted on to bend light rays from ahead of, and behind, the fish so that they will pass into the eye, it is necessary for the lens to shoulder this task. Thus the lens protrudes through the pupil and sticks out beyond the sides of the body. As it is transparent we do not readily notice this, but it can be easily seen if we look at the globe fish from in front (fig. 6). This protrusion of the spherical lens beyond the margin of the body gives each eye 180° of vision and the two together 360°. It is particularly well developed in the smaller slow-moving fish, but is less obvious in the fast-swimming ones. In these it tends to be suppressed in the interests of streamlining.

The movements of the eyes are also quite different in the sharks and the bony fish, and again this relates to the different types of swimming. In the sharks, the side-to-side movement of the tail tends to make the head swing from side to side also. A picture of an object falling on the retina at the back of the eye would thus tend to be shifted from side to side. For an object to be accurately perceived it must be held stationary on the retina. This is achieved by a compensatory movement of the eyes. As the head swings towards the left, the left eye moves forwards and the right eye backwards. These side-to-side eye movements are quite automatic and are reflexly controlled. In a still shark they can be made to occur by passively bending the tail. These compensatory eye movements of sharks are particularly well shown in the whalers in Marineland.

In the bony fish that swim with their pectoral or dorsal fins, the head is not thrown from side-to-side in this way. The eye muscles are freed from the necessity of continuously taking part in reflex movements, and can now assist the fish in the delicate and precise location of food and other objects. Their eyes can shift and rotate in a most lively manner, particularly well seen in the leatherjackets. The sudden flick and roll of the eye that these little fish exhibit (fig. 4), give us the impression that they are looking at us and explain something of their popularity with visitors. The eyes of the two sides can be moved independently and this ability to inspect a 360° field at will is no doubt of great value to these fish.

The eyes of sharks and their allies are more

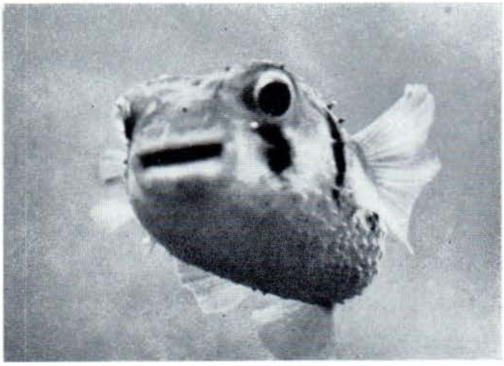


Fig. 6. A globe fish, showing the protuberant lens of the eye on the left of the photo.

likely to be abraded by passing objects than are those of the bony fish with their more precisely controlled body movements. Shark eyes possess protective eyelids, but those of bony fish do not. Moreover, different species of sharks have developed different eye protective reflexes that are set off if any object touches an area of the snout that lies in front of the eye. The Spiny Dogfish flicks its eye rapidly backwards, burying the transparent cornea in the orbit (fig. 7). The School Shark has a beautiful nictitating membrane that flicks up from below (fig. 8). The Carpet Sharks have upper and lower eyelids, but it is the lower one that closes up onto the upper one when the cornea is threatened. These three species use quite different mechanisms to achieve the same end.

Fig. 7 (above): The Spiny Dogfish's (*Squalus acanthias*) reflex action to protect its eyes after its snout in front of them has been touched is to flick them backwards. Fig. 8 (below): The nictitating membrane of the School Shark (*Carcharinus australis*) moving upwards in response to a touch on the snout.

Changes in skin

Lastly, there are certain changes in the skin that became possible when the tail ceased to be used as the main power unit. The skin of a shark needs to be flexible and smooth since the whole trunk undergoes sinuous movements that culminate in the tail swing. But when swimming is accomplished by the dorsal or pectoral fins the skin can become leathery or horny, or studded with spines, and thus serve an additional protective function. In the globe fish the body can be inflated so that the bony spines stick out. This is achieved by gulping sea-water into a sac that leads off the stomach. In the leatherjackets there is a single sharp spine above the eye. In the pig fish the dorsal fin has its rays extended as sharp spines, and this is erected into a spiny crest if the animal is alarmed. Moreover, some species use the swim bladder as a sound-producing organ. Pig fish have a special muscle that moves the swim bladder and causes it to emit a booming-thumping noise. They let off a burst of these sounds if attacked, and perhaps the noise serves to warn off intending predators. In others, the teeth in the pharynx cause the swim bladder to resonate when they grind against each other, and this sound serves to bring the fish together when feeding. The combination of leathery skin, spines and sound production is not a fortuitous one and no doubt serves a protective function.

Most of the points discussed can be observed in any oceanarium. Most of the illustrations in this article are photographs shot through Marineland's observation windows. They are offered to the interested layman in the hope that they will enhance the interest of his next visit.

I would like to thank Mr R. J. Oldfield, Mr B. T. Lester, and Dr Elizabeth Batham, who took the photographs, and Mr Geoff Goadby, of Marineland, for his courteous assistance.

A typical hunting canoe at Malaita, Solomon Islands.

PORPOISES AND PORPOISE HUNTING IN MALAITA

By W. H. DAWBIN
Senior Lecturer in Zoology, School of Biological Sciences, University of Sydney

MALAITA, in the south-eastern portion of the Solomon Islands, is the most heavily populated island in the Protectorate, but in many ways the mode of life of its people has been changed least by European contact. In many localities, locally made shell or tooth money is still in more general use than European coins, while paper money is often not recognized as valid currency. Even where European currency is used there is one major negotiation in which the exchange of necklaces of porpoise teeth is still an essential part of the transaction. This is in the payment of bride price where goods to the value of approximately $A50 must be given by the prospective husband and his relatives to those of the prospective bride before marriage amongst Malaitans is possible.

Formerly, through an unknown but probably very long period, the necessary teeth were obtained through widely spaced porpoise hunts carried out by the salt-water people, mainly from the Lau Lagoon off the north-eastern coast of Malaita. The capture of single schools of porpoises at intervals of probably some years between each appears to have been the practice up till 1964. A single school could contain between 100 and 600 adult animals each with approximately 150 usable teeth valued at 5c each, so that six to seven porpoises would provide the 1,000 teeth required for a necklace valued at $A50. Most of the so-called porpoises are beaked forms which should strictly be called dolphins but, as the local residents universally refer to them and some other small whales as porpoises, this term is used often in the present account.

In 1964, for reasons that are still not completely clear, the scale of hunting increased enormously and became a regular occupation during a large part of the year, resulting in catches of several thousand animals per year since that time. Curiously, this seems to have had no deflationary effect on the value of the teeth obtained. In the first expansion, salt-water people from Lau Lagoon used Bita'ama harbour, where they were sheltered from the south-east trade winds from April to September, after which they transferred to sites along the north-eastern side of the island as protection from the north-east monsoons. In 1965, three groups set up simultaneously and for the first time recruited bush people to the crews. The bush people, originally inexperienced in canoes, are very strongly built from the constant exercise of walking to and from their remote hill villages and, under the guidance of salt-water people in charge, they proved to have great stamina for long sustained paddling during extended hunts. All groups were to some extent under the sponsorship and guidance of a Malaitan minister from one of the local missions which received twenty teeth from each porpoise captured. Former pagan sacrifices and rituals in the preliminaries to the hunting to propitiate "devil sharks" were replaced or modified by services to bless the hunters, their canoes and the instruments they use to drive the porpoises.

Study of porpoises and hunters

Following on valuable information and help from Mr J. L. Pepys-Cockerell, former District Officer of North Malaita, the University of Sydney provided funds for me to study the porpoises and their hunters. During this work I stayed at Bita'ama village, where the local hunters followed traditional methods with the greatest success. They were intrigued that a solitary European should, for the first time, come to stay for a month in their village and despite language barriers they finally allowed me to take part in all stages of their hunting.

There are thirty-one hunters in the local group living together in a communal palm-leaf shelter away from their families during the season. Nearby they have another shelter for the ten hunting canoes, of which nine carry three paddlers each and the tenth carries four. The canoes are made to a traditional design on Santa Ysabel Island, where axe-trimmed planks are lashed together by cord and the joints are sealed by resin from local trees. All have very high stern pillars which are richly decorated by coloured tassels and streamers. A collection of small wood carvings is placed immediately in front of the pillar. The carvings and decorations are distinctive for each canoe. Outriggers for extra stability are not used either for these plank canoes or dugouts anywhere in the area, so a good deal of practice and experience are needed to keep them stable in anything but flat calm. The pointed paddles, often inlaid with shell, are of local design. Beside the canoe shelter there is a pile of rounded stones each weighing several pounds. These are collected from a creek bed in the mountains some distance to the south. They appear to be of a volcanic glass related to or identical with chalcedony. Several of them are placed in each canoe before the start of the hunt and they are the main instrument used for driving porpoises towards shore.

Hunting methods

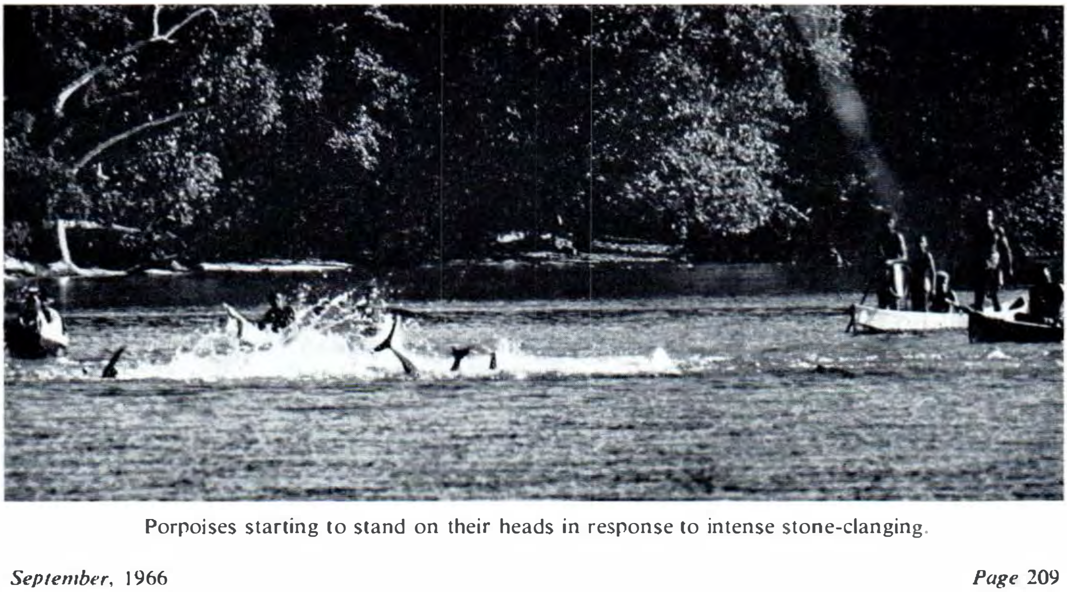
On six mornings a week, unless the weather is too rough, or the crews are still dealing with a previous catch, the crews launch their canoes at the first light of dawn and set off in line until outside the harbour entrance. From here they fan into a broad front gradually increasing the distance between canoes until they are about half a mile apart. By this time they are some miles out to sea and cruising may continue until they are seven to ten miles from land, with canoes ranging some five miles from one end of the fan to the other. As soon as a crew sights porpoises they raise a flag on a long pole, signalling to the other crews to close in towards the school. As the canoes approach, the centre paddler in each lays down his paddle, takes a large stone in each hand, then reaches over the side and clangs them violently together under water. The particular quality of the sound and percussion effects is intensely disturbing to most of the local species of porpoise. Some schools will not cross between two noise-making canoes spaced half a mile apart. The combined effect of the fleet of canoes gradually closing in is like an invisible net made of sound waves only. By appropriate manoeuvring, two or more sub-schools may be brought together into a single large group and then herded towards shore in the direction of the harbour mouth at Bita'ama. Once the school is moving satisfactorily in the right direction, flags on long poles are raised on all canoes to warn watchers ashore that a landing can be expected in the next few hours.

Throughout the season, some of the natives from hill villages as far as four or five hours' stiff walk from Bita'ama harbour, set off before dawn each morning with betel nut and stick tobacco as their only sustenance to wait on the harbour shores on the off-chance of a catch during the day. They join others who come from more coastal huts and villages to form a waiting throng which may build up to 600 or 800 people sitting under trees at the forest fringe around the head of the harbour. As soon as word reaches them that flags are up they quickly arrange themselves at vantage points on banks behind a small beach at the top of the harbour. Meanwhile, in a successful drive, porpoises can soon be seen leaping clear of the water and swimming rapidly ahead of the canoes converging in from their seaward side. The harbour acts as a funnel leading to a blind cul-de-sac, in front of the beach. By the time the first porpoises have reached this point and commenced attempts to return to sea, the canoes have closed in as a tight barrier behind them and the rate of stone clanging is increased to deter escapes. A few hundred yards from the beach, with porpoises between them and shore, the canoes stop and the stone clanging reaches a crescendo while the chief hunter stands up watching the school closely and the throng ashore waits tense and silent. The porpoises mill about frantically until some of those in shallows of three or four feet of water suddenly plunge vertically and bury part of their heads in the softish sandy mud bottom. Here they remain with tails oscillating above the surface, and others then join them in the same position. This strange performance, previously unrecorded, is described by the natives as "burying their ears from the sound". When the chief hunter judges that the porpoises will no longer attempt to escape to sea he calls and arm-signals to crews and shore throngs.

Throngs rush for porpoises

Crew members leap overboard and hundreds from shore dash into the sea, shouting and waving. The double onrush is a most disturbing sight. All are attempting to grab a porpoise each. By this time the animals react as if stunned, and the natives, by grabbing beak, fin or flipper can escort them passively, without struggle, towards shore. Within minutes there may be hundreds lined up along the beach where ownership is confirmed (or disputed!).

Beaks are tied and some animals are transferred to canoes for carriage to coastal villages, while others are trussed to poles for shoulder cartage to villages in the mountains behind. Over 200 carcases can be dispersed



Porpoises starting to stand on their heads in response to intense stone-clanging.

Porpoises being lined along the beach.

from the beach within an hour of landing, giving very little time for biological examination of the catch.

At the villages the tooth-bearing rostrum or beak of each porpoise is cut off separately and cooked carefully to free the teeth, which are the main objective of the catch. As much meat as can be used locally is transferred to earth ovens for slow steam cooking. Some of the meat packed in large bamboos, sealed off and roasted will keep for about a week. However, as each animal weighs about 200 pounds there is normally far more meat than can be used and wastage is great. This is especially the case if catches occur at intervals of a few days apart. There is, of course, no power supply, let alone refrigeration, whilst the heavy rainfall and high humidity militate against sun drying or smoking for preservation. Experiments on salting or other cheap means of preservation are urgently needed to reduce the tremendous waste of meat in a locality which is very deficient in animal protein at other seasons.

Little-known dolphins

The first catch I observed contained 212 adult animals, but in the grand melee I was able to obtain only six heads and these cost $5 each to include the value of the teeth. These, plus a series of photos, measurements and sex records of thirty other animals were sufficient to show that the school was composed of one of the little-known tropical groups of long-snouted dolphins of the genus *Stenella*. It was obviously desirable to organize much more extensive collections despite the speed at which the carcases are dispersed.

Through great help from L. Liolea and other elders, I obtained the assistance of I. Oloifana and other local lads to train in collecting data and material. In addition, we walked to villages over a wide radius to work out a schedule so that gonads and basic measurements could be taken quickly on the beach and heads be removed later at villages without the destruction caused by chopping off the beaks. After cooking, the owners were to extract teeth from the intact skulls for themselves and save me a single tooth for age determination from the growth rings they show in section. The heads could then be brought back to me at a much smaller price. We gave a numbered label to each

Colour variation in six heads of *Stenella* of *attenuata-frontalis*. The main variation, in the colour of lips and snouts, can clearly be seen.

owner and from it could relate the cooked skull to the length, sex and other data obtained on the beach.

Through this schedule we obtained a further fifty skulls, gonads from 120 carcases, and twelve foetuses, together with measurements and other material. These, with the teeth samples, should give useful data on the age composition, stages of maturity and breeding cycle of the local stock. The twelve embryos and a formalin-preserved calf are being X-rayed for rib counts, the number of vertebrae and other structures which, with the skulls, should show something of the variability to be found in a single group. Examination so far shows that stock belongs to the *S. attenuata-frontalis* group, described previously under a number of names from the tropical east Atlantic Ocean, and recently from Japan. There is great uncertainty as to the number of species involved in this little-known complex and very little is known about their general biology. The range of variability in one locality should help to shed some light on these problems.

During one hunt I noted, but could not identify, a school of long-beaked dolphins that responded differently to the clanging stones and eventually escaped. The hunters told me it was a species that is much more difficult to catch, although they had beached one school of 700 in 1964. The hunters also claim that there is a third species of beaked dolphin caught occasionally, but we so far have no material to confirm this.

Need for study of sound emissions

In several villages we found parts of skulls and jaws sufficiently intact to identify as Risso's Dolphin (*Grampus griseus*), which was also driven by stones and caught in a school of thirty in 1964. Its few teeth make it of little value to the hunters. It is clearly highly desirable not only to gather material on the two or three other species but to record their underwater sound emissions as well as behaviour in response to stones for the light it might shed on aspects of communication between individuals or their use of sonar in echo location of shallows and shores.

Finally, there is the problem of the size of local stocks and whether the increased catching rate is liable to cause depletion. Daily recording of the numbers sighted per canoe-day's effort has been commenced. This, together with a record of any consistent changes in age structure of the schools, should make some start at stock assessment possible. Much depends on whether the schools near Malaita are part of those from a large or restricted region. In an attempt to answer this I have requested sample catches from other parts of the Solomon Islands and Papua-New Guinea. To my surprise the first three captured near Rabaul are clearly a very distinct species from those forming the main catch at Bita'ama. Whether they are the same as one of those unaccounted for at Malaita is still yet to be seen.

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

Approaching Karkar Island from the south.

Expedition to Karkar Island

By HAROLD G. COGGER
Curator of Reptiles and Amphibians, Australian Museum

I HAD just completed nearly four months' work in various parts of Papua and New Guinea (see *Australian Natural History*, Vol. 14, No. 11, September, 1964, page 363) and was to return home within a few days. Looking out from my hotel across the waters of Madang Harbour I could see through the haze a distant island whose single peak disappeared into the clouds. At the time it seemed to epitomize for me all the exotic and tropical appeal of New Guinea and I decided then and there that I would return to visit that island.

At the time this intention was prompted simply by the island's somewhat romantic appearance (and no doubt influenced by the comfortable surroundings from which I was viewing it!), but on my return to Sydney a more prosaic look at my maps convinced me that the island might indeed have much to offer the biologist. And so two years later, in September, 1965, I returned.

The island was Karkar Island, known until earlier this century as Dampier Island, a dormant volcano about 40 miles north of Madang. It is separated from the mainland of New Guinea by Isumrud Strait, a stretch of water about 10 miles wide. Although the island is only about 14 miles in diameter its highest point is more than 6,000 feet above sea-level and, despite its small size, its rich volcanic soil supports a native population of more than 15,000.

Island's biological interest

What is the principal interest of such an island to a biologist? Karkar Island is one of a series of volcanoes off the north coast of New Guinea which have risen from the sea floor in relatively recent geological time. Although the strait separating Karkar Island from the mainland is narrow, it is about 2,500 feet in depth and the evidence suggests that since its formation the island has always been separated from the mainland by sea. This means that the fauna and flora of the island can have arrived there only by crossing the sea-barrier formed by Isumrud Strait. There are many ways in which the strait could be crossed—seeds might float across or arrive in the droppings of birds; insects and seeds might arrive on the wind; large mammals or reptiles might even be able to swim to the island. But for most reptiles, and certainly for frogs (which are quickly killed by immersion in sea-water), "rafting" is the most likely means of colonizing such an island. From the rivers of the north coast of New Guinea, including the great Ramu and Sepik, vast quantities of debris spill out into the sea. The flow from these rivers is so great that many miles out from their mouths water taken from the sea is fresh. Strong currents in this region will move floating vegetation, much of which may carry small animals, long distances in a short time. It is probably from such drifting "Noah's Arks" that Karkar Island has obtained most of its reptiles and frogs.

Once an animal becomes established on such an island it may continue to evolve under a very different set of influences from those acting on its parent population. The effects of these changed and changing conditions—such as those of environment and competing species—are often reflected in changes in the animals themselves, and it is for this reason that isolated island communities are of such interest to the biologist, often providing him with an uncluttered picture of evolution at work. Such communities will often also tell him much about the relative powers of dispersal of various animal species.

Drought

Despite its large population much of Karkar Island remains unoccupied. Villages and plantations dot the coast, where the original forest has been largely replaced by copra plantations and gardens. But as only one or two villages occur above 1,000 feet the higher parts of the island are clothed in rich, primary rain forest.

Nearly two months were spent on Karkar collecting and studying its reptiles and frogs, at a time when, in common with the mainland opposite, the coastal parts were experiencing one of their worst droughts in living memory. During my first week on the island I was joined by Mr R. D. Mackay, of the Port Moresby Museum. From the Administration Centre at Miak, on the north-western coast, we were taken by Landrover to the village of Mom, several miles from the coast at an altitude of about 800 feet. The village was dry and dusty as a result of the drought, and we sat in the shade of a hut drinking coconut milk while one of the huge garamut drums—a hollow log with a slot in one side and at one end the carved and painted effigy of a boar's head—was beaten to summon the young men of the village. These arrived, and soon we were moving along a steep track leading to the central crater. We eventually set up a camp at the junction of two stream beds, each consisting of a solid base of convoluted and pock-marked lava.

We soon learned that this camp, at an altitude of nearly 3,000 feet, was not experiencing the coastal drought, and several hours each day were spent sheltering from torrential downpours. But at night, the streams were alive with breeding frogs, which were easily located by their calls.

Volcano's crater

From this camp we visited the volcano's crater, whose sheer but forest-clothed walls fall as much as 1,000 feet from its rim to the crater floor below. The floor of the crater is about two miles across and consists of large areas of bare, solidified lava with pockets of stunted vegetation. From it rises Mt Uluman, a cone whose peak extends above the level of the crater rim. To the uninitiated the idea of sitting on a dormant volcano is rather like sitting on an unprimed bomb—knowing that it won't go off doesn't diminish one's awareness of its potential explosive power!

Karkar Island probably first rose above the surface of the sea in late Pleistocene times, i.e., within the last 250,000 years. In recent times it is known to have had several major eruptions, possibly of catastrophic proportions, between 900 B.C. and A.D. 1200. Vulcanologists have documented eruptions of minor extent in 1642, 1700, 1830, 1885 and 1895.

Looking into the volcanic crater of Karkar Island. The steep walls of the crater are up to 1,000 feet high and are richly clothed in forest. The crater floor consists of stunted vegetation and large areas of bare, convoluted and tumbled lava. The cone of Mount Uluman is seen rising from the crater floor in the foreground at right.

It was planned to spend one or two days in Mom village on our way back to the coast, but the village people had collected such large numbers of reptiles during our absence that, after buying specimens for a couple of hours, we could no longer cope with the numbers coming in.

Only one other mountain area was visited and this was the village of Gamog, on the slopes of Mt Kanagioi. Gamog, at 1,200 feet, is believed to be the highest village on the island. From my house in the village I had a magnificent view of Isumrud Strait and the mainland opposite. The forest above Gamog proved to be rich in reptiles, though at the time of my visit was too dry to produce many frogs.

As the reptiles and frogs collected on these mountain camps proved to be essentially the same as those collected on the coast, most of the remaining time on the island was spent collecting in the coastal villages and plantations, where help was plentiful and collecting successful.

Possibly because of the general dryness, one of the best collecting sites was under the piles of rotting coconut husks which are scattered everywhere through the copra plantations. Once the copra, or coconut "meat", is removed from the husks the latter are left to rot and form a shady, moist environment in which frogs, lizards and snakes abound.

Snakes and lizards

Two dangerous snakes are found on Karkar—the Death Adder (*Acanthophis antarcticus*) well known to Australians, and the Small-eyed Snake (*Micropechis ikaheka*). The latter is much feared by the native peoples of Karkar, and with good reason. It is a relatively savage snake, which, though sometimes active during the day, is largely nocturnal. As the local people often move about at night barefoot, and without a light, the risk of being bitten is relatively high; the venom is very potent and the snake attains a length of more than 7 feet. It is usually cream to light-brown or pink above, with irregular dark cross-bands and scattered dark scales, while the belly is cream. The bands are more prominent in the young and tend to disappear with age. Adults are known locally as "white snakes".

Another snake found commonly in the plantations is the Ground Boa (*Enygrus*

A ranid frog, *Platymantis papuensis*, from Karkar Island. This species is widely distributed in New Guinea in a great variety of habitats.

asper), a harmless snake whose heavily built, viper-like body gives it a false appearance of aggressiveness. It is slow-moving and inoffensive.

Of the lizards, the most conspicuous are the sun-loving skinks, of which Karkar has a rich variety. Wherever one walks various species scamper from underfoot. Some, like the 3-inch *Emoia baudinii*, have tails coloured a vivid iridescent blue. An arboreal skink, *Dasia smaragdina*, grows to about 10 inches in length and is shiny emerald green.

Probably the most bizarre of all lizards on the island is the Spiny Skink (*Tribolonotus gracilis*). Its extraordinary appearance can be seen from the photograph on the front cover. Although it appears to be nowhere common on the mainland, about 200 were found on Karkar in the course of a few weeks.

All told, more than 1,000 specimens of about thirty species of reptiles and four species of frogs were obtained on this expedition. Its success was due largely to the assistance given so freely by the Administration of Papua and New Guinea and by the people of Karkar Island. The work was supported by a grant from the Science and Industry Endowment Fund of C.S.I.R.O. How effectively the results obtained will help us to understand the problems posed earlier in this article will depend on studies now being carried out at the Australian Museum.

[*The photos in this article are by the author.*]

BOOK REVIEW

"SHARKS". By Dr J. A. F. Garrick. A. H. and A. W. Reed Pty Ltd. Price: $1.15.

"Sharks", by Dr J. A. F. Garrick, is designed for "young people", but in spite of its slight size (32 pages), it is full of accurate, up-to-date information, and has plates of some 40 species of sharks. We are told something of their feeding, including the man-eating propensities of the few that give the group a bad name (a fraction of the 250 known species). Questions such as how a shark solves the constant battle to keep from sinking to the bottom without a swim bladder, whether sharks have a sense of smell, by what means they find a damaged fish, how old they grow, and how they reproduce, are discussed, albeit briefly, and we are given what answers are known.

Dr Garrick is a world expert in his field, and he has, in the simplest language, given us a booklet with the answers to some of the curious layman's questions.

It is an excellent dollar's worth, which both young and old will find useful.

His reference to Mr G. P. Whitley's 1940 book on sharks for further reading is rather pointless, as this book has been out of print for many years. Let us hope that it will not be long before Dr Garrick enlarges his booklet to give us a much-needed handbook of the sharks of New Zealand and Australia.

METAMORPHOSIS OF A CICADA

3

4

2

1

The series of illustrations on this and the opposite page show the rapidly occurring changes that take place when an immature cicada (nymph) emerges from its burrow in the soil and assumes the adult form. After hatching from the egg the nymph spends several years below the surface of the soil, where it feeds on the sap of tree-roots. When fully grown it burrows to the surface (fig. 1) and makes its way on to a tree trunk (fig. 2). Clinging firmly to the bark, it becomes immobile for a time. The thick cuticle has a weak line along the middle of the back, and pressure from within causes this to burst. The insect struggles gradually from its old skin through this opening until it hangs free, except for the tip of the abdomen by which it remains attached (fig. 3). It is necessary for it to remain in this position for a time until its new cuticle has hardened sufficiently for the next stage. The insect then stretches forwards, and, grasping its old skin with its legs, pulls itself free (fig. 4). At this stage its body is extremely soft and any disturbance may prove fatal. Tree-crickets (family Gryllacrididae) and other predators frequently attack the helpless cicadas at this stage. The insect now begins to expand its wings, which hang limply, moving with every breeze until hardened (fig. 5). Within about an hour the cicada can usually ascend to the treetop (fig. 6), where it feeds by piercing the branches and sucking the sap. The normal adult coloration may not be assumed until the following day in many species. The species illustrated here is the Double-drummer (*Thopha saccata*), a large chestnut and black species fairly common in the bush near Sydney. It was photographed at about 9 a.m. in late November—an interesting fact, as most species of cicadas emerge in the evenings. Adult cicadas appear in early summer and few survive for more than a month or so. There is evidence that a few individuals of the Bladder Cicada (*Cystosoma saundersi*) survive till the following spring in

(*Continued on opposite page*)

5

6

northern New South Wales. The male cicada has a pair of sound-producing organs in the abdomen. Despite the large number of cicada species in Australia (nearly 200) there has been a negligible amount of study of their songs, habits and life-cycles. Even the status of some of the recorded species remains to be worked out, and no authoritative review of the family has been published—D. K. McAlpine. [Photos: Howard Hughes.]

INSECTS COLLECTED

During May and June Mr David K. McAlpine, Assistant Curator of Insects at the Australian Museum, spent two weeks at the Claudie River, Cape York Peninsula, collecting insects for the Museum. Although several entomologists have collected butterflies and moths in the area, the other insects there are very little known. The specimens collected during the visit include several New Guinea genera, not previously known in Australia, and many species of flies, wasps and other insects new to the Museum collection. In view of the richness of the insect fauna, more prolonged study of this far northern locality seems desirable.

ORNITHOLOGICAL CONGRESS

Mr H. J. de S. Disney, Curator of Birds at the Australian Museum, recently visited research centres in England, on the Continent, and in the United States. He attended the 14th International Ornithological Congress at Oxford from 24th-30th July and read a paper on Australian honeyeaters.

MUSEUM ASSOCIATE

The former Director of the Australian Museum, Dr J. W. Evans, has been appointed an Honorary Associate of the Museum.

ART OF THE TELEFOLMIN AREA, NEW GUINEA

By BARRY CRAIG
Senior Research Assistant, Economics, Macquarie University, Sydney

PASSING through the village on my way home from the Telefolmin primary school where I was head teacher in 1962-65, I noticed for the first time a boat-shaped plank, with a rather crude and dingy-looking design cut on it, fastened at the doorway of a house. It was about 9 feet high, 2 feet wide and a couple of inches thick, and had a hatchway cut into its lower end. Placed so that the hatchway coincided with the tiny entrance to the house, it served as an attempt to decorate the house and place it a cut above its neighbours . . . . . But no, I was wrong, for upon closer examination I discovered that most of the village houses had one of these curious boards. Now that I was aware of them, I saw that some were rather better-kept than others and that not all had been allowed to weather to such a disgraceful state as the one I first noticed.

On successive days I consciously took note of these things and when in other villages kept my eyes open for them. After some time I began to see regularities in the many designs and found that certain of them predominated in a couple of the villages. Later, I discovered that war-shields carried similar carved and painted designs.

My curiosity thoroughly aroused, I was ready for the suggestion, while I was on leave in Sydney, of the then Assistant Curator of Anthropology at the Australian Museum, Mr D. Miles, that a collection of art forms and general material culture from Telefolmin would be a useful supplement to the collection he was to make in the Sepik District late in 1964.

The resultant collection of 300 artefacts, including three houseboards and two war-shields, supplements a collection of seventy-five items presented to the Australian Museum by Flight-Lieutenant S. Campbell in 1937. This latter collection includes three very fine shields.

A Telefolmin houseboard in situ. Note the spirals, which are a feature of this particular design. The rhomb motif is at the centre. (The little boy is wearing only a net-bag covered with cockatoo feathers, which, though mainly a decoration, serves to keep his back warm).

It is a striking fact that, although the Telefolmin were first contacted almost twenty years before much of the three-quarter million people of the Highlands of Australian New Guinea were discovered, they remain little changed at any but the most superficial level. This contrasts with the rapid developments in most Highland communities, which not only have roads, schools and hospitals, but also a few large European towns, one of which was rejected as a site for the Territory's first University only in favour of Port Moresby; many of the people grow coffee and other crops for cash income, and Local Government Councils have been organized.

First contact with the Telefolmin was made in 1914, when Thurnwald and a small party of native carriers left behind the major part of the German Expedition in which they were participating, and followed the Sepik River to discover that its source was not in Dutch New Guinea, where it was thought to lie, but near the border with Papua, in a large open valley. This valley was populated by people of rather short stature whose main activities, when not gardening or looking after pigs, seemed to centre upon warfare with certain of their neighbours, and trade with the remainder. The men were distinguished by rather long gourd penis sheaths, the women by tiny reed aprons worn fore-and-aft.

Thirteen years after Thurnwald's brief visit, two Australian patrol officers and a party of shivering native carriers stood at the high bleak southern rim of the same open valley and knew that they had overcome the major barrier in their journey from the Fly to the Sepik. Karius and Champion completed the first crossing of New Guinea after several months of gruelling patrol that succeeded without the benefit of air support.

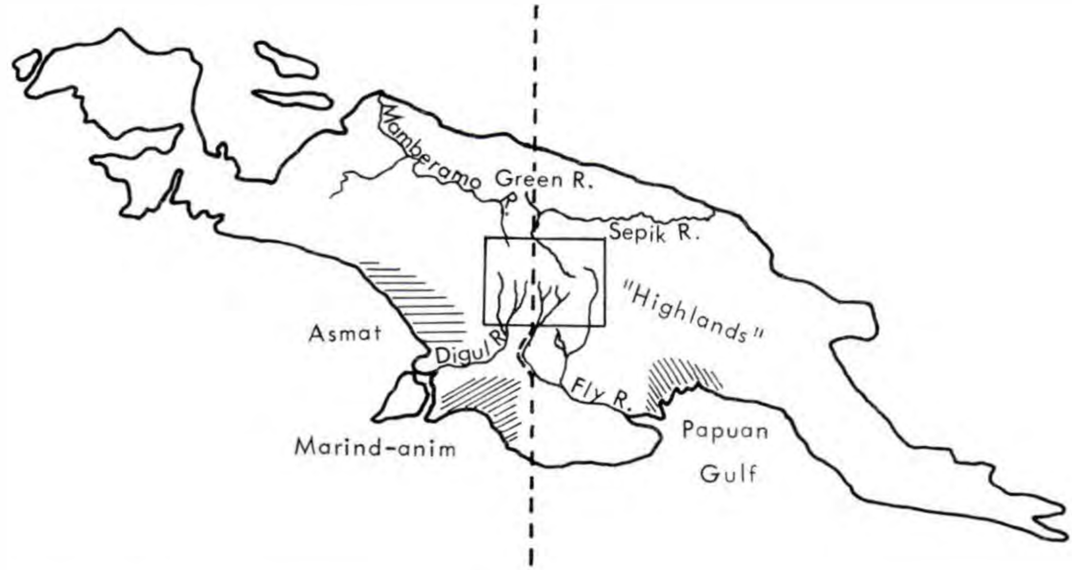
Campbell participated in a prospecting venture and air support was his particular task. A ground party walked in from the Fly River, supplied by airdrops, and built an airstrip which became the basis of the present 4,000-foot runway at Telefolmin. No doubt the collection presented by Campbell was flown out by his aeroplane, which made the first landing in 1936.

How the houseboards are made

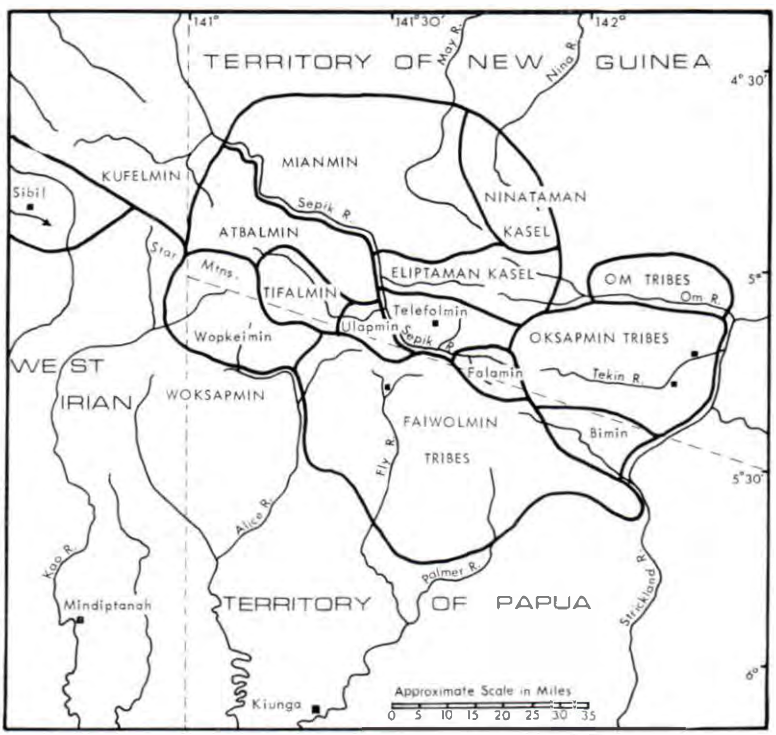
Fifty years after the first European entered the lives of these people, I was beginning to ask questions about the houseboards and war-shields. How were they made? What did the designs mean? Where did the art style originate?

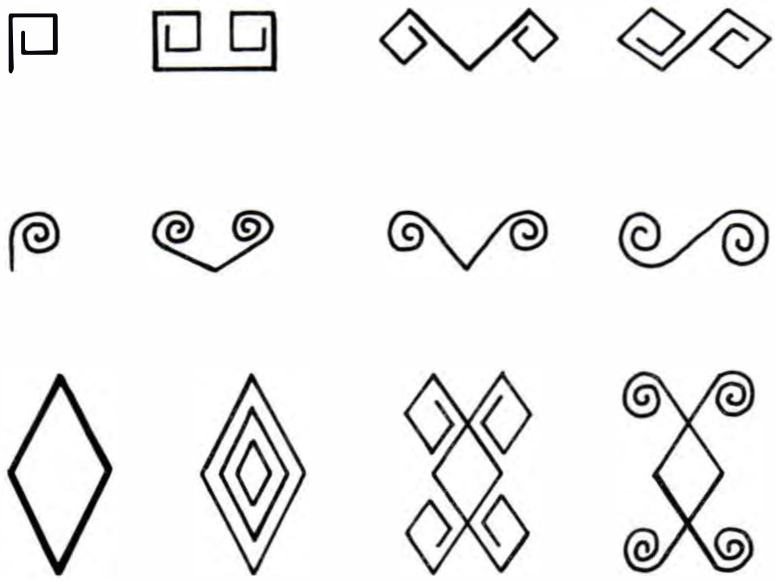
The same range of designs occurs on both houseboards and war-shields and the technique for carving these designs is the same in both cases. First, the artisan prepares a plank: he fells a tree, cuts out a

Three houseboards collected for the Australian Museum. The one at left was part of a spirit-house facade near Olsobip Patrol Post (Faiwolmin people). Note the definite key motifs and the choice of a rectangular hole to match the design. The Telefolmin board (centre) does not preserve the key motif faithfully, but distorts it into a rough spiral in most instances. The rhomb in the centre of this board is barely identifiable as such. The board at right is also Telefolmin. Here the spiral motif is used, and the rhomb is the central device of a figure with four limbs, variously reported as human or crocodile. [Photo: C. V. Turner.]



Above: New Guinea, with the Mountain Ok area shown in the square. Below: Detail of the area in the square, showing the Mountain Ok tribes and their neighbours. The boundaries are approximate only. [Map after A. Healey.]





Some Telefolmin design elements. Top, the "key" motif. Centre, the spiral motif. Below, the rhomb motif (two figures at left) and (right) two combinations of motifs.

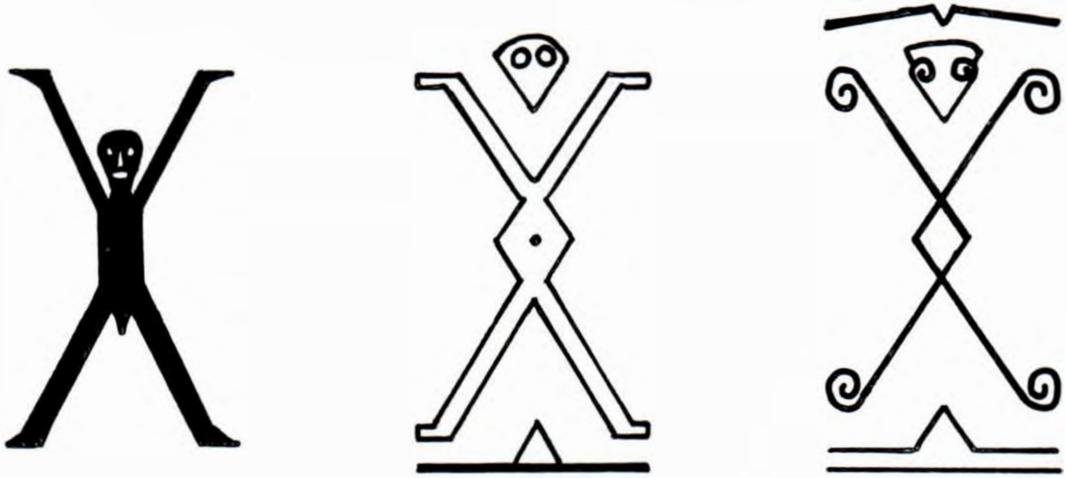
suitable length and splits this. Then he works at chopping out a plank from one of the half-logs, which must then be trimmed to its required shape and smoothness. All this was traditionally done with stone adzes only and must have required an enormous expenditure of time and effort.

Having completed the board to his satisfaction, the artisan then takes a piece of charcoal and marks out a design on the flat surface. Using an axe or sharp knife (traditionally small hand-held blades and flakes of stone, and cassowary-bone gouges) he cuts along both sides of every black line, and proceeds to chip out the areas between the black lines to a depth of about a quarter of an inch, leaving the design in relief. The raised lines are then repainted black and the lower areas red and white according to the inclinations of the artisan.

And who are the artisans? I found that any man who was prepared to spend the time and energy could make a houseboard. Most men apparently find that once is enough. Only a few among them make more than one article and these men come closest to constituting a class of artisans in Telefolmin society. They acquire a reputation as fine artisans and may be contracted to produce a houseboard in return for pork, or assist in the execution of the design for a small consideration. However, no man is likely to be involved in the production of more than a dozen boards in his lifetime. There were only eighty houseboards and a handful of shields in the entire valley in 1964, and each board may last upwards of sixty years. Skill as an artisan therefore never takes one far in Telefolmin society. The most important qualities are those pertinent to the everyday business of living, such as industrious gardening, raising pigs successfully, killing one's enemies and getting lots of people into one's debt.

Meaning of designs

My frequent inquiries as to the meaning of each design always brought forth the rather impatient response: "Nothing!". Then one day I happened to point to a particular part of the design and did not gesture vaguely at the whole thing as I usually did, and was astounded by a positive answer: "This part represents the tracks of a snake; this part the abdomen of a spider; that part the beak of a cassowary; etc.". If the designs ever had a total meaning or representation then this has been lost to memory long ago. Although the design itself is a fully-integrated and total thing, it has no total meaning. Instead, one finds that meaning is given to it piecemeal, according to the similarities of the design elements to certain naturalistic phenomena in the environment.



It is postulated that the two anthropomorphic designs at right are based on a human figure as at left.

The war-shield, incised and painted as described, is known to exist as far north as Green River, a tributary of the Sepik River; and as far south as the southern coastal tribes. The Papuan Gulf also yields examples of the technique, and among the Asmat of south-western New Guinea a similar but finer style is to be found.

The houseboard is known to occur among the Telefolmin, their sub-tribe the Eliptaman kasel, the Falamin and the Ulapmin, and, in conjunction with other boards to make up a complete decorative facade, among the Tifalmin and Faiwolmin tribes, as shown in an accompanying photo. The facade, without the main houseboard, exists among the Oksapmin to the east and the Wopkeimin to the west, and is also reported from some areas of south and south-west New Guinea.

The spirit-house facade at Brolemavip, Tifalmin. The spirals in these designs are little more than hooks. The rhomb appears frequently.

The question now is whether the artefacts and the art styles displayed on them are products of the mountain cultures which have been passed on to the coastal areas, or vice versa. War-shields and facades with incised and painted designs occur in both mountain and lowland areas, but the houseboard is apparently peculiar to the Telefolmin area. As for the art style, it is the design elements which give us the clues as to its origin, as shown in accompanying diagrams.

A glance at the plates confirms that three design elements predominate in the Telefolmin area: the rhomb, the spiral and the zig-zag. The rhomb occurs mostly at the centre of the design, often denoting "belly" or "navel". The spirals (sometimes done in rectangular fashion and calling to mind the Chinese "key" motif) are arranged symmetrically about the centre, often interpreted as "limbs": the zig-zag occurs as a border on each side of the design.

The rhomb, spiral (or "key") and zig-zag occur in many areas of New Guinea; but in conjunction with one another, with the technique of carving as described, and with the particular artefacts under discussion, their distribution is restricted to the area between Green River and the south coast of New Guinea, with strong affinities apparent with the Asmat area on the one hand and the Papuan Gulf on the other.

Transmission of art styles

Whilst it is uncertain whether any mechanism existed for the transmission of art styles and artefacts between the Telefolmin and the Papuan Gulf areas, it is not difficult to discover a mechanism which operates to transmit articles and ideas between the south coast and the central mountains and almost certainly as readily from the south-west coast.

Extensive trade takes place between the Telefolmin and their neighbours to the south. The presence at Telefolmin of a number of steel axes of Dutch or German origin, said to have been traded in from the south, is sufficient evidence for the mechanism being operative to at least as far south as Tanahmerah, possibly even to Merauke near the coast. This is not surprising, for Dr Alan Healey has established that the Ok family of languages, some ten to fifteen languages spoken by about 50,000 people,

These shields are (left to right) from the Asmat (south-western New Guinea), Telefolmin and Papuan Gulf areas. In the Asmat shield the arrangement of hooks around tiny central rhombs recalls Telefolmin and Tifalmin designs Asmat carving is finer and deeper than that of the Telefolmin and Papuan Gulf areas, and often includes quite recognizable human and animal figures. The Telefolmin shield shown serves to protect its bearer and bowmen in single file behind him. In close combat it may be used to batter and pin down an enemy. The design on it is closely related to that on one of the Telefolmin houseboards illustrated, but the rhomb has been distorted. The shield at right, half the size of the other two, is slung from the left shoulder so that the left arm, resting in the slot, is free to hold the bow. The design on this shield is remarkably like that on the Telefolmin shield. [Photos: C. V. Turner.]

and of which the Telefolmin language is a member, extends to the tribes in south New Guinea speaking the Marind-Kuni family of languages.

Wirz has written a great deal about the Marind-anim tribe and includes a description of carved and painted boards which are fastened above the doorways of houses. He gives illustrations which demonstrate remarkable similarity between the art styles of the Marind-anim and the Telefolmin. There can be little doubt that the influence has been direct. Other similarities between artefacts from both areas support this.

To determine in which direction the influence travelled we must resort to current hypotheses of the origin of Melanesian art styles. Heine-Gelderne derives the origin of all Oceanic styles from areas outside the south seas, principally from China via Indonesia.

It is widely accepted that the art of the earliest Papuan population is extremely old but persists in certain areas of New Guinea, particularly the southern and some mountain regions. This style is characterized by designs painted or incised on flat surfaces, and by the production of wicker work masks. The design elements are typically geometrical and repetitive.

Whether Telefolmin art is geometric and repetitive design is a matter of opinion. However, the use of rhomb and spiral or "key" in conjunction is an art style that is considered to be characteristic of the so-called Dong-Son style which was introduced from Indo-China into Indonesia in the latter half of the first millennium B.C. The south coast of New Guinea is in direct line of eastward-bound Indonesian seafarers. Although the fierce attitude of the Papuans to strangers would deter the Indonesians from making regular visits, contacts would almost certainly have been made and it would be extraordinary indeed if such contacts did not leave their mark in the sphere of art. That it most certainly has, and that these influences have been carried by trade into the interior of New Guinea, is therefore hardly to be doubted.

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

Eastern Rosellas inside a trap. [Photo: J. Le Gay Brereton.]

The Language of the Eastern Rosella

By J. LE GAY BRERETON, Associate Professor of Zoology, University of New England, N.S.W., and R. W. PIDGEON, Research Assistant, Zoology Department, University of New England

MOST heterosexual animals communicate with each other. This is necessary because, being heterosexual, they must have some means of co-ordinating the behaviour of the male and the female so that sperm can be produced at the right time and in the right place to fertilize eggs. Where fertilization is external, as in most fish, the two sexes do not need to come very close together, but where fertilization is internal the male and female must be in contact with each other. In some species bodily contact occurs even in the non-breeding season, for example, Red-back Parrot, Wood-Swallow, *Antechinus* Marsupial Mouse, isopods. In others, bodily contact is confined to copulation and suckling or rearing young and is very abbreviated, and the individuals do not meet during the rest of the year.

From what has been said one can easily see that those species which have much co-ordination of individuals with individuals will require a more complex signalling system than those in which the individuals live isolated lives and rarely meet. But we need to be careful here, for some animals are driven or drawn together by the environment. Any co-ordination derived from this is signalled by the environment and not by the individuals of the population. While such simple systems may illustrate the way in which more complex systems develop, we shall not consider them here, but will concentrate on those systems in which the individuals co-ordinate their behaviour with each other by their own language.

In man the language is largely vocal, but visual signalling also occurs. Facial expression and gesticulations as well as general posture convey or help to convey information. Chemical communication is not strongly developed in man, but it is in many other mammals.

An Eastern Rosella at a trap entrance. [Photo: J. Le Gay Brereton.]

Catalogue of calls

Now that we have seen that communication between individuals is not peculiar to man, but widespread in the rest of the animal kingdom, we may take a closer look at the language of one species, the Australian parrot *Platycercus eximius*, known as the Eastern Rosella. It is a species which, like man, communicates more by visual and vocal than by chemical means. As in man, many signals involve a combination of visual and vocal activity. Chiefly for lack of space we shall omit consideration of visual components and purely visual signals. Nevertheless, in learning a language it is necessary to be aware of the whole signal.

Our own procedure in attempting to understand the meaning of the vocalizations of the Eastern Rosella was to assemble a catalogue or list of all the recognizably distinct calls. We collected some calls on tape, using transistorized tape recorders pre-amplified several hundred times and augmented by parabolic reflectors. However, many calls can be heard by ear which are too faint or distorted to be useful on tape. Samples of all calls were then turned into audio-spectrograms in order to obtain a more objective test of their discreteness. [An audio-spectrogram is a kind of chart which shows sounds in graphical form. The frequencies of a call are shown on the vertical axis, while time (about 2 seconds) is shown on the horizontal axis. The amplitude, or loudness, of each frequency is indicated by the darkness of the line on the graph.] When the calls were known by ear and could be distinguished, it was possible to go into the field to record the number of times each call was heard, and, if possible, the circumstances in which it occurred. This is the chief method so far used to attempt to understand the meaning of the call. Such a method approximates that used by an illiterate person attempting to learn a foreign language. It is an interesting problem in itself how to achieve this kind of knowledge. Other methods are to observe the result of playback, and to attempt some sort of analysis comparable with cracking an enemy's code. At the present stage of these investigations the method adopted appears to be the most practical and useful. Further experience with this and related species may help to substantiate the hypotheses so far put forward as to the meaning of the calls.

Of the twenty-four calls, only thirteen appear to have any function. Most of the others appear to be corrupted versions of meaningful calls. The meaningful calls fall into three major categories: warning and distress calls, aggression calls, location and intention calls. The location and intention calls illustrate well aberrations and variations in meaningful calls. All of the calls of this group are relatively pure low-amplitude calls with a piping quality, hence they are also called piping calls. The commonest occurs as three piping notes closely spaced. The typical context of this call is a situation where one or several of a group are separated by alighting in different trees after a group flight. After landing one often hears the three-note piping call (labelled 3p). Soon after this two or more birds sometimes leave their respective trees on another leg of their flight. However, other combinations of this piping note may be heard under the same circumstances. After about 140 hours of collecting over a span of 15 months the number of times each type of call was heard was obtained, and yielded the following data: 2p, 252; 3p, 653; 4p, 144: 5p, 20; xp, 96. At present we have no reason to suppose that 2p, 4p, 5p and xp are different to 3p. It is, however, possible that these differences do have meaning: they may, for example, represent individual differences which allow other individuals to know who is calling, or they may represent age or sex groups, or have other subtle connotations which we shall not know until our command of the language improves.

250 birds marked

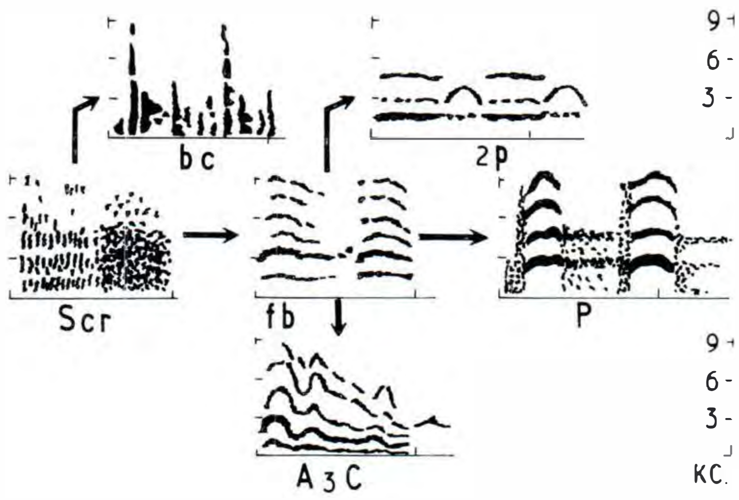
The above example of differences in frequencies also serves to show how some information about the meaning of calls is obtained in this way. Such guesses are further improved by obtaining the rate of call for each signal in succeeding months of the year. These differences can then be correlated with major changes in behaviour at the time the calls occur. The study of calls is all done on a marked population of about 250 individuals. They are retrapped at least once a month. The traps serve as feeding centres during the rest of the time, and hiding places are established near these feeding centres in order to observe and hear individuals.

Let us look at one call whose changes in frequency can be correlated with seasonal changes in behaviour. "Pinging" becomes most frequent in autumn, falls somewhat in winter and rises in early spring. From direct observation we believe that "pinging" (P), a loud pure two-syllable call which is very familiar and frequently heard, means "danger, fly this way". It thus conveys two messages—warning, and group co-ordination as a response to danger. Our tentative interpretation of this change in frequency (not audio-frequency, but occurrence) involves our knowledge of the population life-cycle, and a brief description must now be given.

Life-cycle

Eastern Rosellas are extremely sedentary animals. Of the 766 captures during 1965, 706 were recaptures. Moreover, individuals show a preference for one of the five traps in the 800 acres used for the study. During autumn, winter, and early spring they move in small groups of about eight individuals, amalgamating into larger groups of up to seventy-five when food is highly localized. However, in spring, aggression calls and posturing, and occasionally ritualized fighting, occur more and more commonly and gradually the population disperses, so that Eastern Rosellas become very rare where they were very numerous. Pairs breed in places where nest-holes occur, and on the whole each nest is fairly well separated from others. When the fledglings appear they are very vocal, giving only one vocalization, the food-begging call (fb). The fb call differentiates into three other calls later, and this will be discussed shortly. At about the time the juveniles become competent to give the P call, and when the adults and immatures commence to moult into their new flight and body plumage, the groups of older and new birds with their parents move back to their former area and commence to roost in larger groups at the winter roosting sites.

Having given this sketch of the life-cycle, we can return to the question of the change in frequency of "pinging" (P). As the groups



An audio-spectrogram showing Eastern Rosella calls in graphical form. [Drawn by R. Pidgeon.]

return to their non-breeding area, "pinging" increases. This is presumably both the result of the new capacity to "ping" of the juveniles, and the drawing of the group back to the non-breeding area by the adults. "Pinging" remains at fairly high levels throughout the winter and rises to a new peak in early spring shortly before the groups disperse for breeding.

Further examples of the correlation of calls with population activities may be deduced for piping and aggression calls. Piping remains about the same throughout the year, while aggression calls rise in autumn as the immatures rejoin the adults and their young and in spring when adult pairs begin to increase the pair distance as the breeding season advances.

It is by the use of all these methods that one comes to have some understanding of the signals given, and of the type and degree of co-ordination existing in such a society as this. It is as well to point out the dangers of this sort of investigation. It is obvious that the reasoning is likely to be circular. We are ignorant both of the meaning of the calls and of the exact details of the population life-cycle. Each advance in one direction leads to new insight and new techniques in the other. The tests of the correctness of these hypotheses lie in prediction, experimentation, and general congruence of observation and hypothesis. As facts grow in number and the experience with the population increases, the adequacy of the theory is tested. Familiarity with a phenomenon can lead to a level of insight so deep that judgement about the phenomenon has the degree of infallibility found in an individual's capacity to recognize his close friends. However, the ultimate proof lies in prediction arising out of deductions from the hypothesis.

Origin of calls

Another interesting aspect of the study of vocal communication is that of the origin of the different calls. We may be concerned with this at two levels: first there is the development of the calls in the maturing individual (ontogeny), and second there is the evolutionary development (phylogeny) of these calls in this species. We do not know a great deal about the evolution of the calls of the Eastern Rosella, and methods of studying this are not very exact. Of necessity, the hypothesis must result from a study of contemporary events. One way is to adopt the hypothesis of Haecke, who claimed that "ontogeny recapitulates phylogeny". This concept is a dangerous one, for it is known to be only partially true at best; nevertheless, no clue can be neglected. Secondly, the examination of distantly and more closely related parrots may indicate what has happened and how it happened, especially when the population life-cycles are compared. In the third place, a knowledge of the climatic and geological changes in the Tertiary, Pleistocene, and Recent history of Australia may give some idea of what the Australian fauna has had to meet and what adaptations were necessary. This kind of research requires a wide knowledge of many fields and a lot of induction; it is very speculative and the researcher has to take great care that he does not come to believe entirely his theories, for when this happens he selects facts to fit the theories, and rejects those that do not fit, unconsciously. The work with parrots shows some interesting evolutionary trends: the least social have the least complex systems of calls, while the species in the middle zone of sociality has the richest array of calls. At the moment no species are quite as well known as the Eastern Rosella and thus much care is required. Furthermore, as mentioned earlier, methods of communicating other than by vocalization need to be considered. Not only must the degree of sociality and co-ordination be considered, but the degree of canalization of behaviour by the environment can do much to control and regulate individuals, and once strong social bonds are developed successive socialization may lead to reduced social complexity.

The squawking call

As for the ontogeny of calls, the nestling is capable of only one call, the squawk (sq). This call is given also by adults when caught by a predator, and is very similar for all parrots. When the young bird leaves the nest-hole it is capable of the food-begging call. About two weeks after leaving the nest, the field observer can detect changes in this call towards "pinging", piping, and aggression calls. The path of development of these calls is shown in the accompanying audio-spectrogram. You will see from the sound spectrogram of squawking how this call could be modified to give the triumph call, clicking (bc), and food-begging (fb). By modification of the mechanical apparatus and by modulation, one can easily envisage piping and aggression calls developing. However, until we know much more about how sounds are made and how they can be modulated we shall not be sure that this is the correct interpretation.

The study of communication in the Eastern Rosella is only one part of a general study of the population ecology and evolution of the Australian parrots. By studying the biology of a number of key species in Australia intensely, and of all the others more superficially, a good deal will be learned about the way social behaviour evolved, and about its functional significance. Clearly a full understanding is impossible by confining work to Australian forms. It will be necessary to study New Guinea species, as well as those in the East Indies. The trail leads through the east to Africa, while related forms exist in South America, indicating either a faunal exchange through the Antarctic Continent, or via the Bering Straight and North America. A number of colleagues are engaged in this work and related studies at the University of New England, and we believe that we shall ultimately have a better idea of how and why these species have changed, and also, indirectly, of how and why our own species and the primates have evolved.

MUSEUM APPOINTMENT

Mr D. J. G. Griffin has been appointed Assistant Curator in the Department of Crustacea and Coelenterata at the Australian Museum. He graduated Master of Science at Victoria University of Wellington, New Zealand, in 1962. Since then he has been a Teaching Fellow and later a Temporary Lecturer at the University of Tasmania, where he has been working on the ecology and behaviour of shore crabs.

Mr Griffin has published extensively on the spider crabs of Australia and New Zealand and will be continuing with similar work at the Museum, as well as assuming responsibility for the collections of annelid worms and bryozoan lace-corals.

REVIEW

AUSTRALIAN BIRD CALLS. Recorded by Frank Cusak and Redvers J. Eddy, and distributed throughout Australia by W. and G. Distributing Co. Pty Ltd. Cat. No. WG-B-2493. Price, $5.25.

The recordings on this disc are well done, clear and very even. On each side are calls of 15 different birds: on side one, birds of the open grassland and light timber, birds of the mountain forests, and birds of the dry interior and scrublands; on side two, birds of the open forest. There are no typical rainforest birds. All the recordings have been made in Victoria or the Northern Territory.

The expert and novice alike will find the recording very valuable and interesting. However, the novice will discover that not all the calls given are those most generally heard. The call of the Spiny-cheeked Honeyeater (*Acanthogenys rufogularis*) was recorded in the Northern Territory and is not one of those usually heard in western New South Wales. Also, there appear to be too many Bell Miners (*Manorina melanophrys*) present, as the calls sound continuous and one does not hear the single individual "tinks" of each bird which make up the bell sound.

The mimicking of the Lyre Bird (*Menura superba*) is good, but no territorial call is given.

The "Dick-dick, the devil" call of the Crested Bellbird (*Oreoica gutturalis*) is very true and will evoke many happy memories of out-west, but for most people it is too prolonged.

The text on the back of the cover should be read, as it explains where and when the individual recordings were made and helps to answer the criticism that these are not the only calls made by these birds, or are not their typical calls.

Despite the reviewer's opinion that most of the calls are too prolonged, so that one tends to get bored, this collection of calls is a valuable addition to the recordings of Australian bird songs—*H. J. de S. Disney*.

PACIFIC SCIENCE CONGRESS

The Curator of Molluscs at the Australian Museum, Dr D. F. McMichael, attended the 11th Pacific Science Congress, held in Tokyo from 22nd August to 10th September. The congresses are held every four years in the countries bordering the Pacific. Dr McMichael participated in two of the symposia held at the congress, including one dealing with marine national parks.

BUSHFIRES PROBLEM

The Australian Museum's Director, Dr F. H. Talbot, Curator of Molluscs, Dr D. F. McMichael, and Curator of Birds, Mr H. J. de S. Disney, attended a seminar on the Problem of Bushfires in Public Lands, organized by the National Trust, at Leura. The seminar showed the urgent need for research by biologists on the effects of bushfires on fauna, especially invertebrates and ground-dwelling vertebrates.

The Natural History of the "Cane Toad" in Queensland

By J. R. STRAUGHAN
Zoology Department, University College of Townsville, Queensland

THE so-called "cane toad", *Bufo marinus*, was introduced to Queensland in 1935 to combat the beetle *Dermolepida albohirtum*, which caused heavy damage to sugar cane crops, particularly north of Ingham. Although this species is a native of tropical America, stocks were imported from Hawaii, where it had been previously introduced and proved highly successful in controlling a similar cane pest. Toads were initially released in the Cairns-Innisfail area and became so quickly established that, two years later, transfers to the Ingham, Ayr, Mackay, and Bundaberg-Isis sugar-producing areas were commenced.

The "cane toad" has since spread by natural dispersal and the fortuitous assistance of man throughout coastal Queensland north of Brisbane. Apart from this continuous area of occupation, there are isolated populations in southern Queensland and northern New South Wales, at least as far south as Coff's Harbour. Today, this species is a familiar sight on summer nights along roads and in home gardens throughout this area.

The "cane toad". [Photo: Stanley Breeden.]

Varied habitats

All habitats, from dense rain forests of the high rainfall areas near the coast to dry savannah woodland of Queensland's cattle country, have been successfully colonized. Even the "Wallum" of southern Queensland, characterized by very acid waters, supports a large population of toads. The felling of trees and conservation of water in earth dams by man have partially ameliorated the environment in drier regions by providing shelter and breeding sites. Although equipped with strong shovel-shaped metatarsal tubercles, the toad does not dig deep burrows, but shelters during dry months in shallow dugouts under logs, piles of debris, etc., where it remains relatively moist. Almost any waterhole, transient pool, ditch, or sluggish creek backwater will be occupied by breeding toads during summer. Although preference is shown for the shallows, the presence of aquatic vegetation, grasses, or weeds, and whether the bottom is clear, covered with rocks or dead vegetation, has no effect on choice of breeding site.

Mating calls

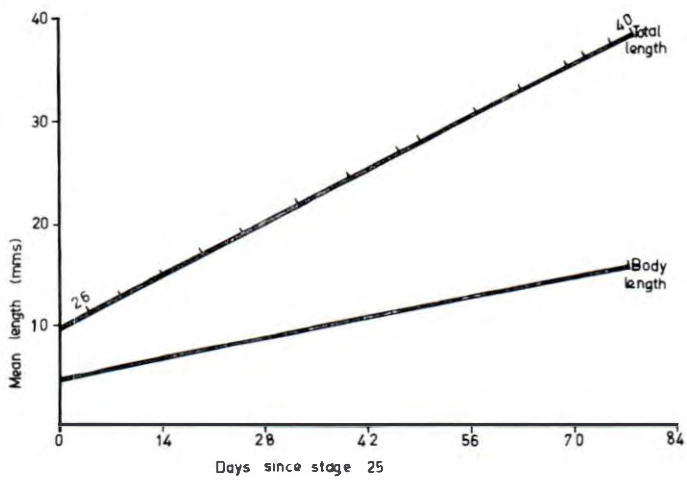
Males take up calling-stations around the edges of breeding sites, usually with the hind limbs and portion of the body submerged in shallow water. The first mating calls may be heard as early as mid-August on nights when the air temperature is only 59° F. These are the calls of a few individuals, which only occur when the day temperatures have soared above 75° F, and do not represent the true start of breeding for the species. Mass emergence and formation of large choruses of breeding males occur after the first summer storms, usually in September in southern Queensland. Water temperatures above 78° F are necessary for the establishment of breeding choruses, so that the date of commencement of breeding varies from year to year. Few females enter these early choruses and it is not till January that breeding reaches a peak. Densities of calling males during the breeding peak may reach 12 individuals per square yard.

Males have noticeably rougher skins than females, are slightly smaller, and, during the breeding season, develop dark-brown nuptial pads on the inner-upper surfaces of the first two fingers. When in full chorus, calling males will attempt to clasp any object approximately the dimensions of a toad, including the footwear of intruding naturalists. At the peak of breeding in mid-summer, males slightly precede females to the breeding site at night. The two sexes are intermingled and males may clasp females in transit and make the journey on the back of the females. Normally, amplexus (clasping) takes place at the male calling-station and egg deposition commences almost immediately. Oviposition may continue throughout the day as well as night, but no initial clasping has been observed during daylight. Early and late in the season, oviposition is often interrupted by a fall in temperature. Delays of up to three days have been observed when water temperatures fell below 72° F and oviposition continued again when the temperature returned to 78° F.

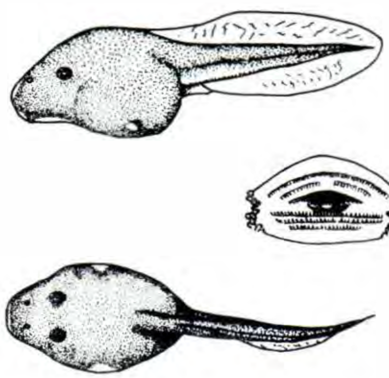
Eggs

Amplexus is effected by the male forcing the hand, particularly the nuptial pads on the first two fingers, into the axilla (armpit) of the female. A long jelly-like string with black eggs dotted along it is drawn out behind the mated pair as the female moves forward after each sporadic liberation of sperm and eggs. The egg mass is anchored to irregularities of the substrate as deposition proceeds. Each of the highly pigmented eggs is approximately 1 mm in diameter, and sits in a small fluid-filled envelope separated from the next by a septum of 3 mm of dense jelly. A continuous outer membrane nearly 4 mm in diameter encloses these vittiline envelopes. The number of eggs produced varies, with the size and age of the female, from 8,000 to perhaps 35,000.

Within forty-eight hours, some embryos will be hatching, and, after three days, the supporting jelly and membranes disintegrate, as hatching is completed. The larvae are immobile at this stage and circulation through the external gills will not have started in most of them. For the next few days, they remain largely immobile as the external gills disappear and the development of the operculum is completed. The tadpoles then become active and commence feeding. As they grow, the tail becomes proportionally longer. The rate of growth and of development is depicted in the accompanying graph. Except for the obvious addition of the hind limbs, the overall appearance of the tadpole remains remarkably constant. The upper surface is richly supplied with melanophores (black pigment cells) and there are a few scattered golden pigment cells along the tail and on the under surface, which is transparent, showing the typical, tightly



The average rate of growth and development of "cane toad" tadpoles from stage 25 (commencement of feeding) to stage 40 (commencement of metamorphosis) at 77° F. [Graph by the author.]



The "cane toad" tadpole from the left side and from above (five times natural size) and detail of its mouth (twenty times natural size) at stage 25, when feeding commences. [Diagram by the author.]

coiled gut inside. The basic structure of the mouth, with two upper and three lower rows of peg-like teeth, and with papillae restricted to the corners, also remains throughout larval life. These features and the medially opening anus make the recognition of the tadpole of *Bufo marinus* relatively easy. The illustration shows the tadpole at the stage at which it commences feeding.

Metamorphosis

Metamorphosis is usually initiated in the twelfth week after deposition of eggs. The skin covering the developing forelegs becomes transparent and the limbs break through, elbow first, as the tail is being resorbed. The tadpole mouth transforms into the adult form with toothless jaws. At completion, the toadlets average 16 mm (half an inch to three-quarters of an inch) in length.

At the peak period of emergence, breeding ponds are an amazing sight: metamorphosing tadpoles may form a solid band up to 2 feet wide around the edge. The whole band seems to move up the bank as newly metamorphosed toadlets, some still with vestiges of the tail, disperse from the pond.

Juveniles emerging in March after the mid-summer breeding peak reach sexual maturity at the beginning of their second summer as adults. The average size of these approximately 2-year-old toads is close to 3 inches and, at least until they are 5 years old, they will grow roughly 1 inch per year.

Once the adult has become established, it retains the same shelter position year after year, barring disturbance of the habitat, and returns to breed in the same waterholes. As winter draws on and conditions become drier, fewer suitable shelters remain. If all these are already occupied, the juveniles are forced to move away from the area. When this occurs near the margins of distribution, the area occupied expands as that generation matures and commences breeding in new waterholes.

Few predators

Natural predators are few. Except for birds which butcher the toads and eat only the internals, the predators suffer with the prey, as the toad is protected by large poison glands on the shoulders. It seems that toad numbers are limited only by the supply of suitable shelter from desiccation during the dry season.

A few feeding toads may be seen out on winter nights, but usually sufficient fat reserves are built up during the active summer months to last through the winter. Although toads will attempt to devour any moving object that comes within reach, their diet is composed mainly of insects. Sometimes the stomach may be crammed with a single species of prey. When a large sample (over 1,000 specimens) is taken, however, the most common food component found is beetles (50 per cent) followed by hymenoptera (20 per cent). Other insect groups account for all but 10 per cent of the remaining food. Small mammals constitute the most abundant part of the non-insect food.

The distribution of this introduced species is by no means static, and, even during the recent bad drought years, its range has expanded.

STUDY OF METEORITES

The Curator of Minerals and Rocks at the Australian Museum, Mr R. ●. Chalmers, is at present studying meteorites and tektites at Museums and other institutions in Britain, U.S.A., Europe and Asia. He hopes to visit tektite localities in Czechoslovakia and Thailand. He will also attend a general meeting of the International Mineralogical Association in Cambridge and the International Gemmological Conference in Barcelona. He will return to Sydney in November.

THE AUSTRALIAN MUSEUM

HYDE PARK, SYDNEY

DIRECTOR:

F. H. TALBOT, M.Sc., Ph.D.

DEPUTY DIRECTOR:

H. O. FLETCHER, M.Sc.

SCIENTIFIC STAFF:

Birds: H. J. de S. DISNEY, M.A., Curator.
Reptiles and Amphibians: H. G. COGGER, M.Sc., Curator.
Mammals: B. J. MARLOW, B.Sc., Curator.
Fishes: Vacant.
Insects and Arachnids: C. N. SMITHERS, M.Sc., Curator; D. K. McALPINE, M.Sc., Assistant Curator.
Molluscs: D. F. McMICHAEL, M.A., Ph.D., Curator.
Crustacea and Coelenterates: J. C. YALDWYN, M.Sc., Ph.D., Curator, D. J. G. Griffin, M.Sc., Assistant Curator.
Worms and Echinoderms: ELIZABETH C. POPE, M.Sc., Curator.
Minerals and Rocks: R. O. CHALMERS, A.S.T.C., Curator
Fossils: H. O. FLETCHER, M.Sc., Curator.
Anthropology: D. R. MOORE, M.A., Dip.Anthrop., Curator.

EDITORIAL ASSISTANT AND PUBLIC RELATIONS OFFICER:
PETER COLLIS.

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

EXHIBITION DEPARTMENT, ART AND DESIGN SECTION:
F. J. BEEMAN.

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

PHOTOGRAPHER AND VISUAL AIDS OFFICER:
H. HUGHES, A.R.P.S.

The Australian Museum

The Museum is open free, daily, at the following times: Tuesday to Saturday, and public holidays, 10 a.m. to 5 p.m.; Mondays, 12 noon to 5 p.m. (during school holidays 10 a.m. to 5 p.m.); Sundays, 2 to 5 p.m. It is closed on Good Friday and Christmas Day.

To teachers and pupils of schools and other educational organizations special facilities for study will be afforded if the Director is previously advised of intended visits. A trained teacher is available for advice and assistance.

Gifts of even the commonest specimens of natural history (if in good condition) and specimens of minerals, fossils and native handiwork are always welcome.

The office is open from 9.30 a.m. to 1 p.m. and 2 to 4.30 p.m. (Monday to Friday), and visitors applying for information there will receive every attention from Museum officials.

College St., Hyde Park, Sydney

Wholly set up and printed in Australia for the proprietors, The Trustees of the Australian Museum, by V. C. N. Blight, Government Printer, Sydney, N.S.W.