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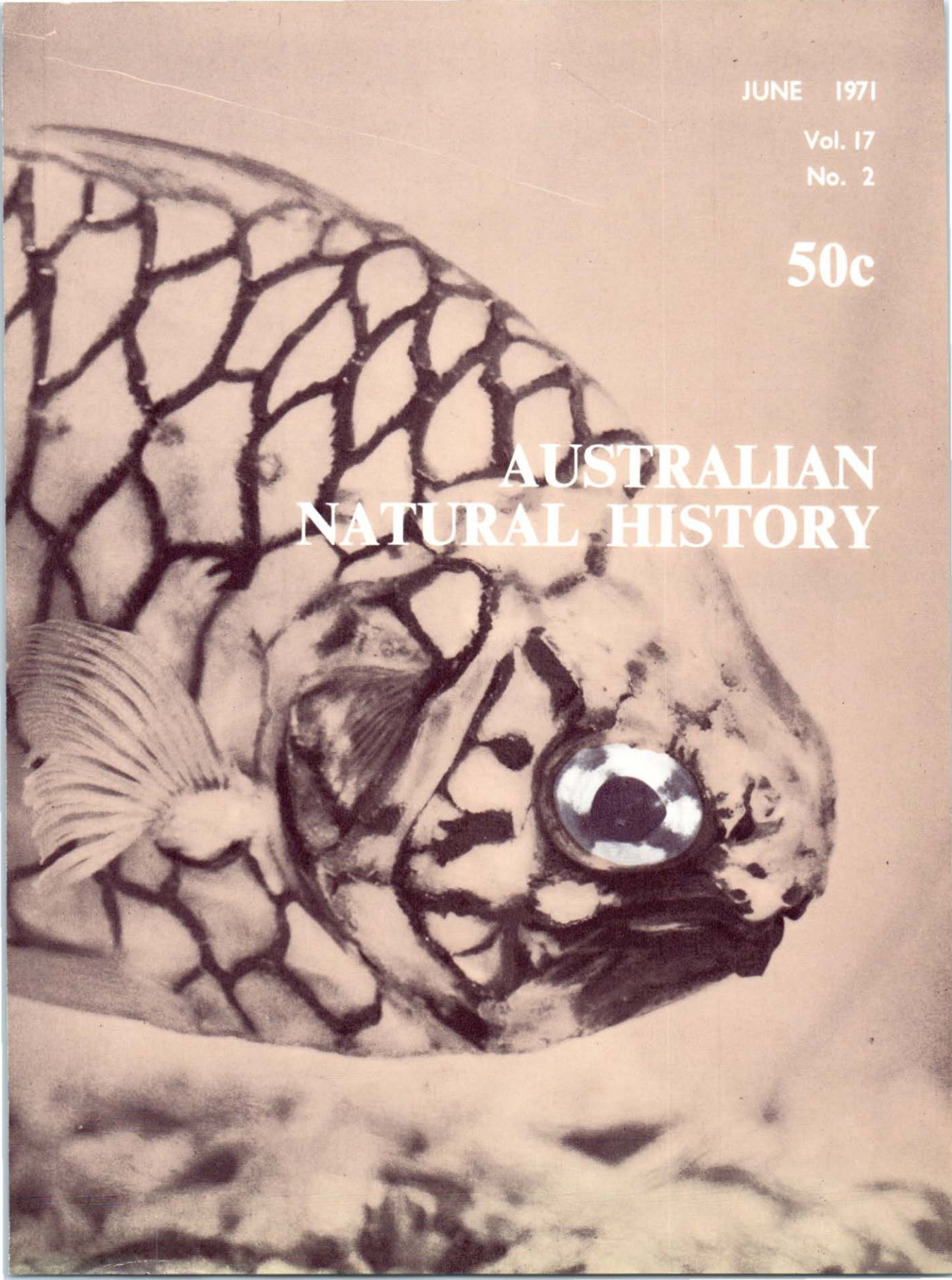
AUSTRALIAN NATURAL HISTORY



AUSTRALIAN NATURAL HISTORY

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● **FRONT COVER:** The Australian Pineapple Fish (*Cleidopus gloriamaris*) is also known as the Pinecone, Knight, Coat of Mail, and Port and Starboard Light Fish. The thick yellow scales bordered by black pigment form a heavy protective armour, and the strong dorsal and pelvic spines can be locked into an extended position. A light organ on each lower jaw houses a colony of luminescent bacteria that emit a constant blue-green light. Light emission is controlled by opening and closing the jaws, but its function is unknown. Pineapple Fish are active nocturnally and quiescent during the day. Unknown outside Australian waters, *C. gloriamaris* occurs in the east from southern Queensland to south of Sydney and in the west around Fremantle. It has a maximum length of 9 inches, and inhabits harbour mouths and the open coasts at depths ranging from 30 to 500 feet. **BACK COVER:** The young fruiting body of a fungus of the kind generally known as mushrooms and toadstools emerging through leaf mould in Darkes Forest, between Waterfall and Bulli, New South Wales. [Photos: C. V. Turner.]

This is the first colour photo ever published of the Grey Grass-Wren (Amytornis barbatus), Australia's most recent bird discovery. The wren was discovered in July, 1967, in the Bulloo River flood-plains of southwestern Queensland and northwestern New South Wales. It is 6¾ inches long, including the tail, and lives in grass clumps and lignum tussocks. Len Robinson, Melbourne naturalist, who took this photo, describes the bird's call as almost inaudible. The Grey Grass-Wren is No. 558 in the National Photographic Index of Australian Birds, an article on which appears on page 40.

41677-A

Angophora and *Banksia* near the top of a high dune at Myall Lakes. The trees are bent and twisted by the wind and appear to be creeping and straining up the dune, much as a tired walker might. A person climbing this dune will find a mining survey peg at the summit. [Photo: Author.]

THE MYALL LAKES—NOW AND TOMORROW

By HARRY F. RECHER
Head of the Department of Environmental Studies, Australian Museum

IN 1936 A. J. Marshall wrote of "The Myall Lakes: Then and Now" for the *Australian Museum Magazine*. In that article he traced the history of Myall Lakes, a little over 100 miles north of Sydney, back to Tertiary times, many millions of years ago, through the development of the region by the Australian Agricultural Company in the 1800's and its virtual abandonment by 1850. Since that time, Myall Lakes has been a backwater of civilization. Marshall described the area as a haven for emus and other wildlife which had been displaced from most coastal areas by the "congested settlement" of that era.

"Jock" Marshall went on to become one of Australia's great biologists and a leading advocate of the need to conserve Australia's wildlife resources. In the three decades before his death in 1968, Marshall was a witness to great changes in Australia. In 1966 he published *The Great Extermination*, which is an articulate and damning account of the havoc and waste being created by the unplanned and short-term exploitation of Australia's natural wealth. Yet despite the changes throughout Australia, her unprecendented prosperity and increase in population, Myall Lakes remained unchanged. True, the emus fell victim to

irresponsible shooting and squatters' shacks appeared among the dunes, but mostly the vegetation and wildlife are the way they were in 1936.

Tomorrow it may be different. Tomorrow the Myall Lakes might be surrounded by subdivisions and water skiers, red-tile roofs, and noise. The great sand dunes with their forests of blackbutt and *Angophora* might be churned and levelled by sand miners. Or instead there could be a great national park. A choice must be made soon. Mining is already in progress, and in July, 1970, the New South Wales Government announced that it would begin the development of deep-water port facilities at Port Stephens. Port Stephens, which borders the Myall Lakes, will become a large industrial centre. It is easy to see that, unless planned otherwise, these developments will quickly and irrevocably change Myall Lakes. Others have proposed to protect Myall Lakes from development by setting aside a large area as a national park.

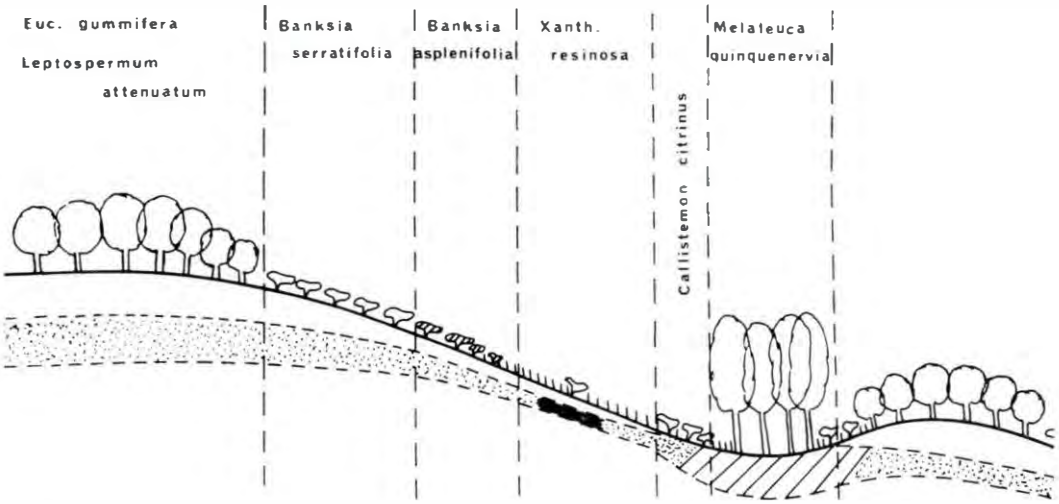
A national park is to be dedicated—but how big should it be, and why? These are important questions and they urgently demand answers. Let us look first at Myall Lakes as it is *now* and then consider what it might be *tomorrow*. By doing this, we will know what we could lose and what we might gain by the development of Myall Lakes or by its reservation as a national park.

The North Coast of New South Wales is a series of long sand beaches separated by rocky headlands. Rich coastal lakes and estuaries lie behind many of the beaches. Myall Lakes is the last of these beach and lake systems which remain in a natural state. The headlands provide spectacular scenery, with massive rock faces into which the sea has carved arches and caves; Point Plomer, north of Port Macquarie, and Seal Rocks, near Myall Lakes, are good examples of this. The headlands have very different kinds of plant communities (and therefore different kinds of animals) from the dunes behind the beaches. Indeed, because of differences in soils and climate, the vegetation of each headland is distinctive. The beaches are backed by dunes which usually continue as a series of ridges behind the beach and parallel to it. In places on the North Coast it is possible to trace this sytem of parallel dunes for more than 10 miles from the sea.

These dunes are a record of the recent (or relatively recent) history of the coast and of changes in sea-level. As we shall see, dunes are also important in the ecology of the plant communities of the coast. During glaciations, a vast amount of water is bound up in ice and the level of the sea falls. At the maximum of the last glacial period, about 30,000 years ago, the sea was more than 400 feet below its present level. About 18,000 years ago the sea began to rise until nearly 4,000 years ago it had virtually reached its limit. As the sea rose it washed up and deposited on the beaches the sand which had been washed into it from the continent.

Once the sea reached its maximum height it continued to bring to and deposit sand on the beaches, piling it up in the form of sand dunes. The dunes were built until the source of sand was exhausted. Thus, our coastal dunes are the relatively recent creations of the past 4,000 years. However, there are not one but two systems of sand ridges along the coast. There is the "outer barrier" system which, as we have said, is about

The high dunes at Myall Lakes support a forest of blackbutt and *Angophora*. The dunes themselves exceed 200 feet in height, and many of the blackbutts are over 100 feet high. [Photo: Author.]



A diagrammatic section of the inner barrier dunes, showing the location of some of the more prominent species. The "B" soil horizon is also shown. Its texture influences the permeability of the soil to water, and has a considerable effect on plants. The dotted areas are the loose "B" horizon, the solid black area is the hard "B" horizon, and the diagonal strokes are a peaty area. The diagram is adapted from one in R. Carolin's "Myall Lakes: an Ancient and Modern Monument", in *Proceedings of the Ecological Society of Australia.*

4,000 years old, and an "inner barrier" system which dates back to the last interglacial period and is about 60,000 years old. These sand ridges are an invaluable record of climatic changes during the last 60,000 years. This was a period of great change for the plants and animals of Australia. The last 20,000 years were of particular importance. Many animals—including all the giant forms—became extinct. Man arrived and began altering the ecology of the continent. The climate became drier. We can understand the impact of man on the Australian environment only if we have an accurate record of the climatic changes which were occurring at the same time. The coastal sand barrier systems contain much of the required information, but it will be many years before the message can be uncovered and understood. If representative samples of the barrier systems are not reserved now, a great deal of very valuable information will be lost for all time.

But the ridges themselves are important to the wildlife of the coast. Work done at Myall Lakes by botanists from the University of Sydney has shown how plant communities change from the high ridges to the low and from the top of a ridge to the swale between ridges (see diagram). Even the ridge slopes have different kinds of plants. At Myall Lakes there is a large heathland which lies between the dunes of the outer barrier system and the lakeshore. The heath looks level, but is really the series of parallel sand dunes of the inner barrier system. In the spring, anyone with a small knowledge of botany or an eye for flowers can quickly pick the tops, slopes, and swales of the old dunes. Though the ridges of the inner barrier dunes are low and changes from top to swale to top again occur within a few yards, each part of the ridge has its own kinds of plants. In the spring when the heath is in bloom, the different parts of the ridges are marked by bands of different flowers.

Scientists are interested in how organisms interact with one another and their environment. The coastal sand ridges are a great natural experiment, where all the plants are exposed to the same climate and where physical changes in the soil and water table occur abruptly over a few feet instead of gradually over hundreds of feet as is usually the case. The dunes of the outer barrier system have been shifted and moved about by the wind so that in places at Myall Lakes they are quite high (up to 200 feet) and no longer lie parallel to the beach. These high dunes are now stable and support magnificent

Paperbark forests border the lakes and wet areas throughout the Myall Lakes region. Above, they are seen on the edge of an extensive glade of rushes and sedges. Christmas Bells are abundant in this area. [Photo: Author.]

forests of blackbutt and *Angophora*. Professor Carolin, of the University of Sydney, has pointed out that forests of this kind occur at only three places—Myall Lakes, Seal Rocks, and Norah Head. All will be destroyed by beach-sand mining. It would be interesting to know how and under what conditions forests come to grow on such high dunes. It is fairly certain that the climate of eastern Australia is now in a dry period. Possibly the *Angophora* and blackbutt forests developed under moister conditions and survive only because they themselves maintain a favourable micro-climate. If this is true and they are removed, it is unlikely that the forests could be re-established or even that the high dunes could be stabilized.

In contrast, the lower and most seaward dunes at Myall Lakes are not stable; there are moving sands at many places between Hawks Nest and Seal Rocks. Elsewhere along the North Coast human activities and carelessness (e.g., overgrazing and fires) have caused the deterioration of coastal dunes, but this does not seem to have happened at Myall Lakes. Probably these dunes are unstable because the climate is now drier and plants find it difficult to become established. The plants growing on these dunes are pioneer types—spinifex grass, pig face, and sea rocket. Where the dunes are more stable and protected from sea spray, banksia scrub develops.

The different dune systems, headlands, low hills, swamps, and lake shores provide for a diversity of plant communities. Myall Lakes is truly a cross-section of the North Coast.

Each of these plant communities has its own fauna but, in contrast to our improved knowledge of the plant life and geomorphology of the coast, information about the animals found there is scarcely greater than in 1936. We know enough to be able to say that the animals at Myall Lakes are mostly the same as found elsewhere along the North Coast in similar habitats. We can say that goannas and snakes are very abundant. The Big Gibber is an excellent place to study death adders, if anyone is so inclined. However, we do know something more about the mammals and birds.

The mammal fauna of Australia is not a rich one. There are relatively few species of mammals compared to other continents, and over large areas native mammals are not very abundant. East of the Great Dividing Range in New South Wales there are about sixty kinds of mammals — thirty-four marsupials, two monotremes and twenty-four placentals. Sixteen of the placentals are bats, seven are rodents, and the last is the dingo. Most of the mammal species found in eastern New South Wales also occur in Victoria and Queensland, but there is an overall decrease in the number of species from north to south. In the narrow coastal strip of northern New South Wales, east of the Pacific Highway, the number of mammals is naturally smaller—about seventeen marsupials, two monotremes, and five placental mammals other than bats. Swamp Wallabies and Red-necked Wallabies are common at Myall Lakes. The Swamp Wallabies occur through the dunes of the outer barrier system and on the heaths, but the Red-necked Wallabies are seen most often in the teatree forest bordering the lakes. Bandicoots, dingos, spiny ant-eaters, small insect-eating marsupials, two kinds of native rat, various bats and, of course, possums, are common. There are also the usual fugitives from civilization—wild cattle, horses, cats, rats, and fishermen.

The mammals which occur in the coastal regions are, with one exception, also widely distributed west of the Pacific Highway. Moreover, most of the native mammals found on the coast are relatively common and occur in a wide range of habitats other than those which will be most affected by beach-sand mining and other forms of coastal development. Indeed, it is unlikely that the survival of any native mammal will be seriously affected by coastal development. Some kinds might be exterminated on the coast, but they would survive elsewhere.

Previously, some concern had been expressed for the survival of the New Holland Mouse, a small native rodent, which occurs only on the coast and was considered very rare. Recently, however, this animal has been found by Mr Posamentier, of the Australian Museum, at a number of coastal localities, and it has also been discovered in Kuring-gai Chase and Royal National Parks. Thus, it does not appear to be in any great danger of extinction.

As with mammals, most birds which occur on the North Coast are widely distributed. There are no endemic species of birds along the coast, nor can any species of birds on the North Coast be considered rare. But birds are one of the great natural attractions of the coast. In contrast to mammals, birds are extremely abundant and conspicuous. It is not unusual to record eighty or ninety species of birds during a day's outing around Myall Lakes. Nor would it be surprising to see 150 species over the course of a year. There are many kinds of waterfowl and wading birds on the lakes, including flocks of the elegant Black Swan. Shore birds and sea birds occur along the beaches. But the truly great avian spectacle of Myall Lakes occurs during the winter and early spring, when the flowering of the coastal vegetation (especially the banksias) attracts countless honeyeaters. Thousands of individuals and as many as fifteen species may occur together

Coast Banksia (*Banksia integrifolia*) in full bloom. These trees, near Yagons Head, support large numbers of honeyeaters, including the Little Wattle Bird and the White-bearded Honeyeater. [Photo: Author.]

on a few acres of heath. Most of these are birds from further south and west; some probably come from Victoria and South Australia. The heath and banksia woodlands of Myall Lakes are an important feeding ground for these birds. Honeyeaters travel great distances during the winter, as nectar-rich flowers bloom first at one place and then at another. The movements of these birds provide an ever-changing scene as new flocks arrive and others leave.

But not all the attractions at Myall Lakes are found on land. The lakes themselves teem with life, the ocean beaches are renowed for their fishing, and it is easy to gather beach worms and pipis right on the spot. There are offshore islands with colonies of seabirds, and seals can be seen at Seal Rocks.

Myall Lakes is an area of great natural beauty and an abundance of wildlife. In all honesty, it cannot be described in a few words. As the saying goes, it must be seen to be believed. In fairness to yourself and to your children, take a trip to Myall Lakes. Look at it and think about what it is and what it might be. The alternatives will be discussed in the next issue of *Australian Natural History*, but the choice lies with you.

SUGGESTED READING

Carolin, R., 1970: "Myall Lakes: an ancient and modern monument." *Proceedings of the Ecological Society of Australia.*

Marshall, A. J., 1936: "The Myall Lakes: Then and Now." *The Australian Museum Magazine*, Vol. 6, No. 1, pages 32–36.

NEW BOOK ON BIRDS REVIEWED

BIRDS IN THE AUSTRALIAN HIGH COUNTRY, by H. J. Frith (editor) and illustrated by Betty Temple Watts; A. H. & A. W. Reed, 1970; 481 pages; $9.50.

Ornithologists and birdwatchers in Australia have been struggling with inadequate textbooks for identifying the birds they see for many years. For almost 40 years the only books readily available giving a full cover of all the species have been *What Bird is That*, by Neville W. Cayley, and *An Australian Bird Book*, by J. A. Leach, and the revised editions of those books.

At last new additional information has been obtained and it is hoped that the present book will be the forerunner of a comprehensive handbook, but there is still much basic information required before this can be done. The present book is more than just an identification book, as the introductory chapters at the beginning on the region, history, habitats, geography, movements, and breeding seasons must be read to fully understand the birds in the area covered. The editor clearly defines in his preface the area covered, and "local" is more or less the "home range" of the contributors (all of whom are based in Canberra) and is from Canberra to about Kosciusko.

The illustrations by Mrs Betty Temple Watts are very good and all the birds are in natural, lifelike poses. A good feature about the plate keys is that they give the number of the page on which to find the text of the bird illustrated, as it is always annoying not being able to quickly find the text of an illustrated bird.

The text is good, with much new information on soft parts, colours, and plumage, particularly of females and immatures. However, in one or two cases the text does not match the illustration or what is said under the keys to the illustrations. For instance, the text says that in the Peregrine the cere and colour round the eye are blue, but the illustration shows them as yellow. The illustration is correct. The blue colour occurs in the juvenile. In the key to plate XII the Red-necked Stint is given as a rare summer visitor, but in the text it says they occur in small numbers by Lake George every summer.

The actual size of the book is unnecessarily large, and the publishers would have pleased ornithologists more by making it smaller. There are 269 bird species listed, and thus this book is useful over much of Australia, especially in regard to the water birds.

The editor, Dr H. J. Frith, and his contributors are to be congratulated on this book. It is an important step forward in Australian bird books, and one hopes that when more of the essential information on Australian birds—like plumages of females and immatures and juveniles and information on incubation and fledgling periods—is known it will be possible to produce a Handbook of Australian Birds.

Betty Temple Watts and Dr H. J. Frith and his contributors have directed that all royalties from this book be given to the Australian Conservation Foundation to help conservation in Australia.—*H. J. de S. Disney, Australian Museum.*

A Sulphur-crested Cockatoo (*Cacatua galerita*) on the wing. These large (20 inches long) white birds, with yellow crests and yellow under the wings and tail, are familiar as domestic pets. The Sulphur-crested Cockatoo is found from the Kimberleys (northern Western Australia) across to Cape York, and southward to southeast Australia, including Tasmania. It also occurs in New Guinea. It is No. 28 in the National Photographic Index of Australian Birds. [Photo: A. D. Trounson and M. C. Clampett.]

The National Photographic Index of Australian Birds

By A. D. TROUNSON
Originator of the Index, and Executive Officer to its Committee of Trustees

THE National Photographic Index of Australian Birds came into existence on 3rd June, 1969, for it was on this date that its distinguished Committee of Trustees, formed under the chairmanship of Sir Percy Spender, met for the first time and decided to set operations in motion.

Thus began a project to establish a comprehensive national reference collection of 5,000 photographic colour prints recording Australia's 700 or so species of birds, to be in twin form—with one set at the Australian Museum in Sydney, Australia's oldest scientific institution, and the other at the National Library in Canberra.

Although the project derived from my own enjoyment of Australia's unique and colourful bird life, and the feeling that more people should be able to share this pleasure, it could not have materialized except for a chain of most fortunate circumstances.

The time was propitious, for never before has there been so much public anxiety about the fate of the environment, and sympathy is drawn immediately to the side

of any positive undertaking which puts its weight behind the cause of conservation.

Museum approval

Dr F. H. Talbot, Director of the Australian Museum, to whom I went with my ideas in 1967, felt that the proposed collection had merit from a scientific point of view, and that its formation would also become an activity of popular appeal which would help to link people more closely with the Museum.

The Museum's Board of Trustees happily decided to espouse the project, and this was to prove an important factor in fostering its development, for it invested it with the hallmark of a learned institution and demonstrated the existence of a need.

During those early formative days, we were also exceedingly fortunate in finding an ally in Sir Percy Spender, who, among his many attributes, is a lover of pictures, and was stimulated by the prospect of the collection becoming, as he put it, "a photographic Gould". He was impressed with the originality of the scheme, and believed that it deserved support as a worthwhile cause. He accepted an invitation by the Museum Trustees to form a sub-Trust to carry out the project on their behalf, and found immediate and willing response from all who were approached to serve on this Trust. Its present composition is as follows: The Hon. Sir Percy Spender, K.C.V.O., K.B.E., K.St.J., Q.C. (Chairman); Mr F. P. Buckley, C.B.E. (former Agent-General for N.S.W. in London); Mr J. C. H. Gill, LL.B., F.R.Hist. S.Q. (Chairman of the Board of Trustees of the Queensland Museum); Dr Ursula Hoff, O.B.E., Ph.D. (Assistant Director of the National Gallery of Victoria, also a member of the Council of the National Library, and its representative on the Trust); Professor Sir Leonard Huxley, K.B.E., D.Phil., M.A., F.Inst.P., F.A.A. (former Vice-Chancellor of the Australian National University); Mr Laurence Le Guay, F.R.P.S., E.F.I.A.P., A.I.A.P. (representing the photographic profession); Mr Robert E. Porter (Lord Mayor of Adelaide); Mr R. C. Richard (a Trustee of the Australian Museum, and Chairman of Chubb's Australian Co. Ltd); Dr F. H. Talbot, M.Sc., Ph.D., F.L.S. (Director of the Australian Museum); the Honourable Sir Vernon Treatt, K.B.E., M.M., Q.C. (Chief Commissioner of the City of Sydney 1967–1970); Mr R. W. Turner (Vice-Chairman of the Bowater Paper Co. Ltd, and Chairman of the Trust's Executive Committee); Sir Harold Wyndham, C.B.E., M.A., Ed.D. (former Director-General of Education, New South Wales).

The Executive Committee comprises Mr R. W. Turner (Chairman), Mr F. P. Buckley, Mr L. Le Guay, Dr F. H. Talbot, and Sir Harold Wyndham, together with myself, as Executive Officer, and Miss M. C. Clampett, as Honorary Secretary. The Committee began its work in April, 1968, and meets monthly.

The project has thus been established on a sound constitutional footing, and a trust deed exists to give expression to the arrangements which have been reached.

The National Library

The National Library came into association with the project in the middle of 1968, following acceptance by its Council of a proposal that a replica of the collection should be provided for the Library, and that the Library should nominate a representative to serve on the Committee of Trustees.

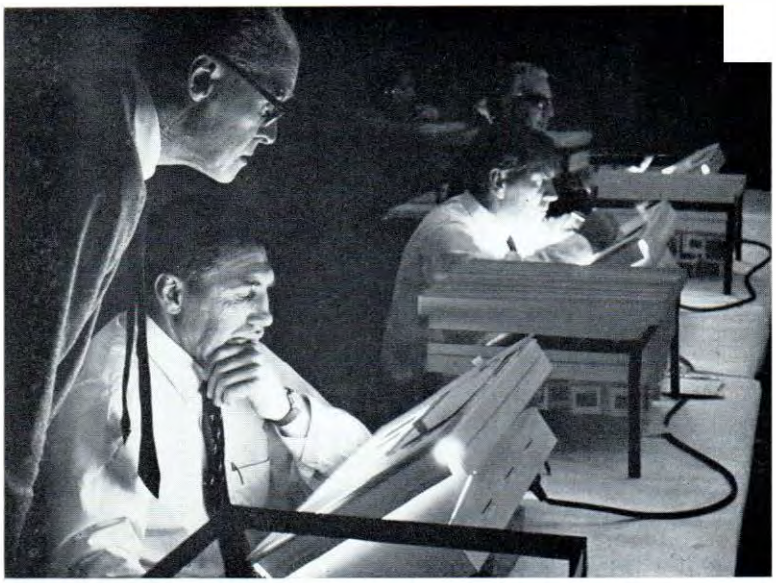
Generous support

An early pledge of $7,000 towards the cost of the project was promised by a well-wisher in Melbourne, to be followed by a generous gesture by the Bushell Trust of a further pledge of $20,000—with an advance of $4,000 in 1968 as a launching fund. This enabled us to get under way.

A year was to pass, however, before the project was able to emerge from its chrysalis stage, during which much essential groundwork was done by the Executive Committee and efforts were made to enlist further financial support.

Overseas collections

The opportunity was also taken by myself during a private trip overseas towards the end of 1968 to compare notes with leading bird photographers in the U.S.A. and the U.K. and with other bodies engaged in building collections of wildlife photographs.



The adjudication of photos entered for Stage 2 of the Index, included in the Order of Perching Birds, in September, 1970. The four adjudicators, and the headings under which they evaluated the entries, were (left to right): the late Keith A. Hindwood, chairman of adjudicators; H. J. de S. Disney (scientific value); Ederic C. Slater (technical standards); Arthur Ro-b inson (artistic qualities). [Photo: Geoffrey O. Cummings.]

The National Collection of Nature Photographs in London—founded in 1955 by the Nature Conservancy in co-operation with the Zoological Photographic Club and the Nature Photographic Society—proved to be the nearest in concept to our own project. The collection is, however, in monochrome and embraces mammals, reptiles, insects and plants as well as birds. Some 1,500 prints have been gathered. These are preserved in an archive and are used mainly for exhibition purposes.

The Royal Society for the Protection of Birds in the U.K., and the Laboratory of Ornithology at Cornell University in the U.S.A., were also visited. Their libraries exist for different purposes. The Society's collection—which covers 350 of the 425 British species, and which consists mostly of black and white prints—is used mainly to illustrate their magazine *Birds*. On the other hand, the Laboratory's collection—which covers approximately 50 per cent of the 600 or so North American species, and which is entirely in the form of colour transparencies—is used for the production of slides for sale to contribute towards its budget.

Photographers' reservations

The experience of these institutions is that photographers are not, as a rule, averse to giving monochrome prints, but they are reluctant to part with their colour transparencies—despite the payment of a modest fee, in the case of the Royal Society for the Protection of Birds, and the inducement of being able to claim taxation relief on the value of such donations, in the case of the Laboratory of Ornithology (even in a country where the minimum reproduction fee for colour is $125).

The reason is not far to seek. In the case of black and white photographs, the negative remains in the possession of the photographer, and the cost of producing a print is small. In the case of colour photographs, however, the photographer loses his material and, if he is a professional, this means parting with a revenue-producing asset. The result is that either he will decline to co-operate or, if he does co-operate, will contribute only his second-best work.

Recent correspondence with the Library of the World Wildlife Fund at Morges in Switzerland—which contains some 20,000 wildlife photographs from all parts of the world—suggests that it, too, is confronted with this problem.

The difficulty does not arise, however, with the Index, since, being in print form, all that is needed is the *loan* of original material for copying. The production of

colour prints is, of course, expensive, but all the evidence indicates that it is a price that has to be paid if uninhibited photographer participation is to be secured. There is, too, the added advantage that prints are much more convenient for reference (the main purpose of the Index) than are transparencies.

While the idea of lending work for reproduction in the Index, with retention of exclusive copyright by the contributor, is favoured by the majority of photographers, it is open to them, if they wish, either to donate original material to the Index, or make it available on call for commercial reproduction on a joint copyright basis, for the benefit of the Index fund. (These options are categorized as C, A, and B respectively.)

These 10-tray visible-edge units have been specially designed to house the Index. Each can hold 180 photos, which are printed to a standard 7 in x 7 in or 7 in x 5 in size, according to the shape of the original transparency. A data sheet accompanies each photo, and the whole is sealed under a protective acetate sheath. Twenty-eight units will eventually be required at the Australian Museum and twenty-eight at the National Library to house the Index when complete. Photos are filed by Index number in order of accession. [Photo: C. V. Turner.]

No fees are offered to the photographer, but successful contributors receive an attractively-mounted print of every photograph accepted for the Index—together with a commendatory certificate signed by the Chairman of the Committee of Trustees following each adjudication. There is also the incentive that every effort is made to encourage the use of the Index by publishers, etc., and that work represented in it may well attract their attention.

Photographers' "charter"

The procedures governing the formation and control of the Index are set out in detail in a document entitled "Notes for the Guidance of Photographers". This has been conceived as a charter for the photographer, and it deals with such matters as the protection of copyright, the exercise of impartiality in the selection of work, and the care of material.

A register of the names of over 250 nature photographers has been compiled. The response during the first 2 years of operations indicates that the project has been tackled on lines which are acceptable to the photographer, and has amply confirmed our belief that all its objectives are attainable, given the necessary financial support.

Adjudication

The selection of work for the Index is entrusted to independent adjudication panels of experts, and three criteria are applied: aesthetic appeal, technical quality, and scientific value. Work accepted for scientific reasons which does not meet required technical standards is designated with the letter "O" in the Index.

Operational plan

Originally, the project was planned on the basis of an intensive 3½-year programme, with an estimated budget of $140,000 to be raised in advance. In the event, the Trustees decided to set the project in motion with a tentative programme geared to funds already in hand, and accept a progressive fund-raising commitment. They envisaged a programme to be unfolded in stages, in step with funds which became available,

The catalogue. — The entries in the catalogue are arranged in the scientific order of species in accordance with the Official Checklist of the Royal Australasian Ornithologists' Union. The system is infinitely expandible and lends itself to any arrangement of sub-classification desired. [Photo: C. V. Turner.]

without a target date for the completion of the project.

The first programme, designated Stage One, had as its aim the collection of available photographs of Australia's 60 forms of parrots. Submissions by 40 photographers were examined by an adjudication panel on 7th November, 1969, as a result of which 127 photographs were selected to form the nucleus of the Index.

The Trustees also decided that an effort should be made to herald the start of the enterprise with an exhibition, which they felt would also be valuable as a means of demonstrating performance to our supporters and making the existence of the project widely known. Accordingly, $3,000 was spent on producing prints of the 80 best photographs in the nucleus, scaled as far as possible to the life-size of the bird. The exhibition was inaugurated by the Governor-General at the National Library in Canberra in January, 1970, and has since been shown at the National Gallery of Victoria, the Australian Museum, and the Queensland Museum. Arrangements are being negotiated to tour it throughout Australia.

Stage Two, which embraced the available photographs of the 352 species included in the Order of Perching Birds (the Order Passeriformes, the largest order of birds), has also been completed. The ajudication of work in September, 1970, attracted no less than 1,344 submissions from 56 photographers in every State in Australia. It resulted in the incorporation of a further 425 photographs, bringing the total in the Index to 552, with 239 species represented.

Stage Three will deal with the available photographs of the remaining 300 or so species, and, on completion, it is expected that at least half of the species will be represented in the Index, with a total of perhaps 1,000 photographs.

The remaining stages will be devoted to filling the gaps, updating the existing material, and extending the range of photographs for a given species to show the differences between the sexes and between juveniles and adults, seasonal plumage changes, geographical mutations, and other diagnostic features. It is also hoped to achieve the greatest possible variety of photographs in the collection, e.g., of birds in flight, as well as those at the nest.

Archive of bird photography

Ancillary to the Index is an Archive of Bird Photography. This exists for the purpose of accommodating Category A donations which do not find acceptance for the Index itself, and as a repository for valuable collections of bird photographs, including work in black-and-white, which might otherwise be lost, e.g., on the death of a photographer.

What the Index will achieve

What do we hope the Index to achieve? In the first place, it will preserve for all

A male Striated Pardalote (*Pardalotus substriatus*) at its nesting hole, with a spider in its beak. This bird is about 4¼ inches long. Its name comes from the white striations on its black head. It has a patch of yellow in front of the white stripe above the eye. The back is greyish-brown, the wings are black with well-marked white patches, the throat is yellow, and the underparts are whitish. The Striated Pardalote is widely distributed in Australia south of the Tropic of Capricorn. It is No. 367 in the Index. [Photo: M. McNaughton.]

time a vivid visual record of one of the most attractive features of the Australian natural environment—so that all may know what we may soon destroy. It will provide a valuable range of comparative visual material conveying vital information on the living bird for the scientist, which could not be obtained in any other way. It will encourage those who are interested in photographing birds by providing an honoured place for the best of their work. It will stimulate the use of bird photographs for illustrative purposes by publishers, and thereby help to bring home to the community as a whole the beauty and variety of Australia's birds, and, by so doing, engender concern for their preservation.

In conclusion, I feel that I cannot let the opportunity pass to pay tribute to all who have so readily given their time, energy, and enthusiasm to the Index—to those mentioned in this article, to the members of the adjudication panels, and to those who have shared the burden of the executive work with me in a voluntary capacity from the inception of the project. For the photographers, without whose co-operation the project could not succeed and for whose contributions we extend our thanks, we hope that the Index will bring rewards which might not otherwise have come their way. To others whose imagination has been captured by the Index and who have given it their financial support—school-children, bird-lovers, philanthropic bodies, and business houses—we are especially grateful, for the Index has depended entirely on their donations for its existence. Without the participation of all these people, it would not have been possible to embark on this ambitious and constructive national undertaking.

BOOK REVIEW

AUSTRALIAN NATIVE ORCHIDS IN COLOUR, by Leo Cady and E. R. Rotherham, published by A. H. & A. W. Reed, Sydney, 1970; $3.95.

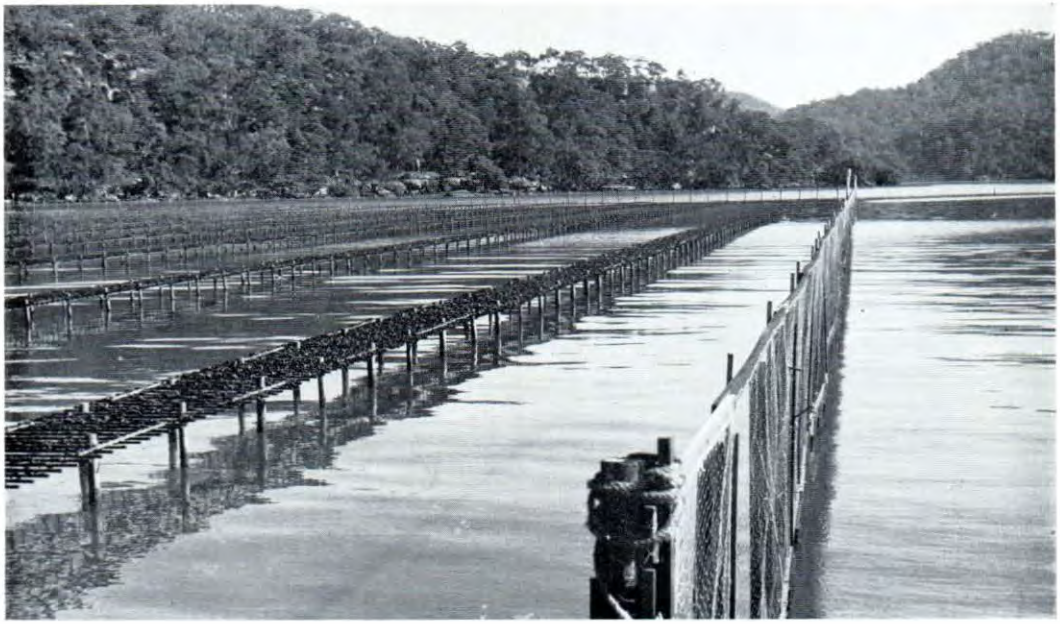
This book is a useful addition to the growing total of books on Australian orchids. The photography is excellent, as we have come to expect from Ted Rotherham. The reproduction of his plates is also very good. The book, is comprehensive in its brief coverage of Australian orchids. Distribution, both intra- and extra-Australian, pollination where known, cultivation, and many other bits of information are covered in a readable text. Unfortunately, this information is not well separated in each section, but I feel that the approach used perhaps makes for a more "chatty" book. Also, unfortunately, many errors are apparent. A few of the most obvious are:

Page 11, plates 1 and 2.—(i) lily flower has a filament of a stamen labelled stigma; (ii) one of the orchid flower's lateral sepals is labelled petal, and vice versa; (iii) the dorsal sepal of the orchid flower is labelled column; (iv) the floral bract of the orchid flower is labelled stem bract.

Page 14.—"There are now 78 taxa or named species of *Pterostylis* which extend beyond Australia to New Zealand, New Caledonia and to Papua". There are only a few species of *Pterostylis* which occur both in and outside Australia, certainly not 78!

Spelling errors and obviously faulty proof-reading mar an otherwise excellent book.

The book is certainly very good value for the price, particularly in view of the wonderful colour plates.—*Don F. Blaxell, Botanist, National Herbarium, Royal Botanic Gardens, Sydney.*



A typical well-managed oyster lease on the Hawkesbury River, showing oyster-bearing sticks set out on racks. [Photo: P. Wolf.]

THE SYDNEY ROCK OYSTER

By W. B. MALCOLM
Senior Biologist, Fisheries Branch, Chief Secretary's Department, New South Wales

ONE of the most esteemed of sea foods, the Sydney Rock Oyster (*Crassostrea commercialis*) occupies a unique position amongst the fisheries resources of Australia in that it is the only marine or estuarine species cultivated. Cultivation practices, developed over the years, have reached a high level of efficiency and the industry now reaps the benefit of a $4 million annual production.

Cultivation of oysters, in Australia and elsewhere in the world, is far from a recent innovation. There is evidence that the Japanese raised oysters as early as 2,000 B.C. and the Romans about 100 B.C.; the initial development of cultivation practices in New South Wales can be traced back to late in the last century.

Utilization of natural stocks of oysters in New South Wales has a much longer history. The Aborigines of the coastal regions feasted on oysters, and the shell remains are to be found in kitchen middens common along the coast. Some of the shell deposits have been carbon-dated to 6,000 B.C. With colonization of New South Wales, oysters took on a new role. Not only were they still gathered for food, but the shell, dead and alive, was collected in large quantities and burnt to provide lime for mortar. As the population increased, the demand for oysters for food and lime increased rapidly and resulted in depletion of the natural stocks. This depletion precipitated the introduction in 1868 of legislation prohibiting the burning of live oysters for lime, and the establishment of cultivation practices.

Biology

A number of species of oysters are found on the Australian coast, but it is the Sydney Rock Oyster only that supports any real commercial fishery. The species is estuarine in habitat and is distributed from Wingan Inlet in eastern Victoria through New South Wales to Moreton Bay in Queensland. Under natural conditions it can survive and grow well on the bottom while completely submerged, but is most abundant on rocky substrate in the intertidal zone.

The species changes sex during its life. Most, if not all, young oysters spawn for the first time as males but change to females later in life. The gonads comprise a considerable portion of the body tissue and, when ripe, are full and white and give the oyster its prime condition. After spawning the gonad becomes shrunken and watery and the condition of the oyster is poor.

Spawning occurs chiefly during summer, but, because of a relationship between spawning and water temperature, considerable variation in spawning time occurs between areas. The eggs are fertilized in the water and within hours develop into free-swimming microscopic "veliger" larvae. Two to three weeks later these larvae settle on a suitable substrate and at this stage are commonly known as "spat". Shell development commences and the young quickly take on the more familiar oyster characteristics.

Micro-organisms, filtered from the water by gills, comprise the food of the oyster. Growth is variable, but generally 3 years are required to attain a marketable oyster.

Early cultivation

Systematic oyster cultivation first commenced around 1870 when Mr Thomas Holt, M.L.A., attempted to establish the French system of growing oysters in canals or "claires". A network of canals, some 22 feet in width and capable of holding a depth of 2 to 4 feet of water at low tide, was constructed at Gwawley Bay on the Georges River, near Sydney. Water circulation in the canals was regulated by dams and floodgates. Oysters were laid on the bottom of the canals, but the venture proved unsuccessful, reportedly because of high mortality caused by high water temperatures during the summer and siltation.

Failure of the Gwawley Bay project deterred further cultivation trials for a short period, but then oystermen began to set out suitable substrate to catch spat and support it until a marketable-sized oyster was realized. The substrate material, referred to as cultch, comprised stone slabs, sticks, and oyster shell. From this early start the present highly efficient cultivation developed.

A number of cultivation methods are now in use, but all are dependent on settlement of natural spat. Young oysters collected in various ways are laid out on shell beds or specially constructed trays to obtain final growth, or fixed or movable cultch material is used to grow the oyster from the settling stage to marketable size. Movable cultch material has the advantage of being readily transferrable to other areas.

Shell beds

Shell beds can be constructed on any bottom, but are not commonly used these days. A firm base must be prepared to prevent the oysters from sinking into the mud, and smothering of the crop by silt must be avoided.

Beds are prepared by providing a solid base of stone, shell, boughs of suitable trees, shellgrit, sand, or a combination of these. A layer of dead oyster shell is then placed on the prepared base, and young oysters are laid out. When ready for marketing, the oysters can be picked up by hand at low tide.

Rock beds

Once the mainstay of the industry, rock or stone leases can be seen along the foreshores of most estuaries. Slabs of stone, roughly 2 feet by 1 foot, are placed upright in the mud, or in some cases are laid horizontally on timber bearers, low timber racks, or tripods of small stakes. Sandstone or shale is preferred to other stone because the grown oysters are more easily removed.

Use of stone slabs certainly avoids costs associated with replacement of other types of cultch material, but this advantage is outweighed by a number of disadvantages. Stone cultch is fixed, precluding transfer of the growing oysters from one area to another, and constant attention is required maintaining the stones in an upright position and keeping them clean of other marine growth. Siltation

Tray-cultivated oysters at Oyster Bay, George's River. [Photo: P. Wolf.]

and predators can cause heavy losses, and considerable time and money are spent in harvesting the grown oysters.

Stick cultivation

Stick culture has supplanted the use of stone slabs as the basic cultivation technique. The sticks, either natural or sawn, are approximately 6 feet in length and an inch in cross section, and are set out on racks supported above the bottom by timber posts.

Prior to the settling season of the free-swimming larvae, the sticks are set out to collect the young oysters. Natural sticks, mangrove or other suitable types, are tied in bundles, while sawn sticks are nailed to battens and assembled in batteries so that each stick in the battery is approximately 1 inch apart. The batteries of sawn timber are tarred before setting out. Use of bundles or batteries of sticks protects the bulk of the newly settled young oysters from predation by bream and other species, and makes more effective use of the water column in obtaining settlement.

About 6 months after settlement, the young oysters are generally sufficiently well grown and hard shelled to be resistant to the worst ravages of predators. When they have reached this stage, the bundles or batteries are broken apart and the sticks set out approximately 9 inches apart on racks.

Oysters grown on sticks show good growth and shape and are easily removed for marketing. Sticks also carry a high density of oysters, but the prime advantage of this type of cultivation is that the sticks are movable. Good spat-catching areas are invariably not good growing areas, while growing height is important for efficient cultivation. Sticks can be set out in areas of maximum spat settlement, and then at an appropriate time transferred and nailed out on racks in areas where maximum growth is obtained. And, whereas with rock or shell bed cultivation the oysters must be grown on or near the bottom, rack heights for sticks can be set at a depth where maximum growth is obtained and the effects of many of the oysters' enemies are reduced.

When it is observed that sufficient growth has been obtained, the sticks are removed from the racks and taken to shore depots. The oysters are removed from the sticks and sorted. The larger oysters are then marketed and the smaller ones placed out on trays to obtain further growth.

Tray culture

This method makes use of trays 6 to 9 feet in length and 3 feet in width. Of timber frame construction, the trays have a wire mesh bottom and are normally divided into three sections. The trays are tarred before use and then set out on racks similar to those used for sticks.

The purpose of trays is not to collect spat, and for this reason tray culture is normally used in conjunction with other forms of cultivation. Tray oysters are generally accepted as being of the best shape and quality; because of this young oysters obtained during culling of sticks or from natural substrate, such as rocky foreshores or mangroves, are laid out on trays to bring them to marketable size. Oysters set out on trays are generally in an advanced stage of growth and, as only a minimum time is required to bring them to marketable size, trays are normally put out for a period of some 9 months.

Tray culture allows easy culling for marketable-sized oysters, and because the trays are readily movable growing height can be varied and transfer from area to area effected.

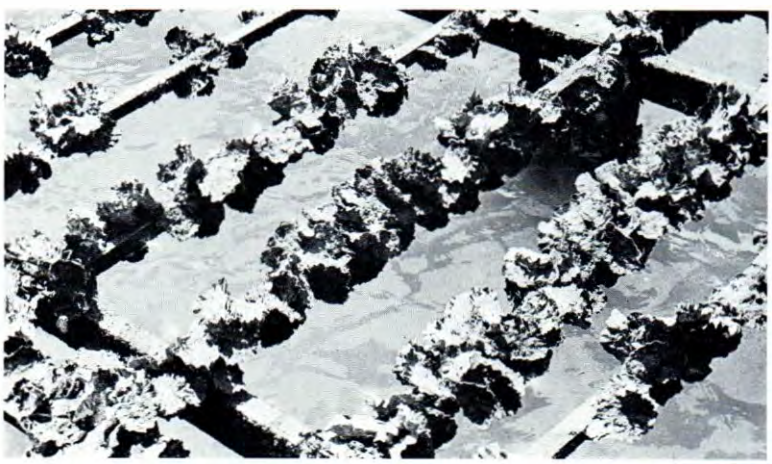
Oysters' enemies

Oysters are subject to heavy mortality during the larval and soft-shelled phases. Many larvae die because of unfavourable environmental conditions, while predation takes a heavy toll of the larvae and newly settled spat. Bream and other fish species feed voraciously on spat and it is necessary for the oyster farmer to set the catching sticks in bundles or batteries to prevent fish gaining access to the young crop.

The growing hard-shelled oyster certainly gives the appearance of hardiness, but it is far from free of enemies. Stingrays can cause havoc on trays and shell beds, while the mangrove crab can crush an oyster with ease. Octopus can be of nuisance value by heaping shell-bed oysters to make a nest, this invariably resulting in smothering of the oysters.

Heavy losses can be caused by whelks and starfish. The whelk, depending on the species, either drills a hole in the shell or chips away at the edge of the lip to make an opening. A digestive juice is then secreted into the oyster and this kills and partly digests the oyster meat, which is then sucked out. It has been suggested that the starfish releases a poison in the water in front of the oyster's inhalent siphon and the poison, once inhaled, affects the adductor muscle which controls the closing and opening of the shell. The muscle relaxes, allowing the starfish to open the shell and digest the oyster. Oyster farmers must therefore be continually on the watch to prevent a build-up of these predators in cultivation areas.

A mudworm (*Polydora*) affects oysters in the lower intertidal zone, particularly if they are grown on or near the bottom. The worm enters the oyster and builds a mud tube between the shell and body of the oyster.



A good crop of stick-grown oysters at Port Stephens. [Photo: P. Wolf.]

Irritated by the presence of the worm, the oyster secretes a thin-shelled blister around the worm tube, but the worm maintains connection between the tube entrance and the outside environment, allowing it to feed and grow. Heavy infestations of mudworms cause the oyster to lose condition, but the worst feature of mudworm infestation is that the shell blister is easily broken when the oyster is opened and the mud released from the blister detracts from the appearance and taste of the oyster.

The worst enemy of the oyster is a disease commonly known as "winter mortality". Caused by an unidentified micro-organism, its effect on the crop varies from year to year and from area to area, but a severe outbreak in an area can destroy up to 80 per cent of the marketable crop. Heaviest mortality is normally in the larger oysters, and cold water temperatures and high salinity appear to be associated with a high incidence of the disease. The growing height and over-crowding also influence mortality rate, and research is being conducted by the New South Wales State Fisheries to determine a means of eliminating the disease or reducing its effects. When a heavy kill is expected, oyster farmers, where possible, move oysters up into less saline areas or to a growing level near high-water mark in order to reduce mortality.

Other enemies of the oyster include high temperatures, flooding, siltation, and pollution. During summer, because of high temperatures, mortality is common, and severe killings can occur when low tides expose the oysters for long periods on excessively hot days. Immersion of oysters in fresh water for several days is not injurious, but exposure to fresh water for long periods, as can occur during flooding, causes high mortality. Moving silt or sand can smother oysters, while industrial wastes and oil can taint the flesh or cause mortality.

Since the inception of cultivation practices, the annual production of oysters has increased steadily. However, the demand for oysters is high and will continue to rise, so it is essential that the upward trend in production be maintained.

A simple means of increasing production would be to put more areas under cultivation. However, the situation has now been reached where a large proportion of the available areas suitable for cultivation using present culture techniques is already under lease. Heavy wave action, flooding, problems associated with urbanization, and waterway demands relating to fishing, navigation, and foreshore development preclude certain estuarine areas from leasing, while environmental characteristics of other areas render them unsuitable for good oyster growth.

Because of the limited availability of new areas for cultivation, any marked increase in production will need to be achieved by other means. Improvement of existing cultivation techniques, more efficient management of leases by some oyster farmers, and elimination or reduction of the effects of winter mortality will all contribute to an increased annual production, but if the continually increasing demand is to be met it is probable that establishment of entirely new operational procedures will be required in the future.

Although the oyster industry currently operates with highly efficient cultivation techniques, the estuarine environment cannot be controlled and a successful harvest is dependent on favourable conditions for spat settlement and subsequent growth. However, it is anticipated that this inadequacy of control will be gradually removed through scientific research, and the future will see the oyster farmer setting out laboratory produced spat of a selected fast-growing, disease-resistant strain of oyster in environmentally controlled ponds as well as in the estuary. Construction of a modern well-equipped research station at Port Stephens for the Fisheries Branch is nearing completion, and research will be commenced in the near future to establish the validity of these anticipated future cultivation procedures.

MAGPIE HARASSES SNAKE: A STUDY IN BIRD BEHAVIOUR

By LAURENCE R. RICHARDSON
Former Professor of Zoology, Victoria University, Wellington, New Zealand

STUDY of birds leads to the recognition of behaviour patterns—some short term, such as are repeated through the day, others longer, as in annual cycles of reproduction, migration, etc. Different species repeat their patterns, each in its own manner, and in the same manner for generation after generation. The young bird courts for the first time, selecting a nesting site, and building its nest in the manner of the parents from whom it had separated without experience of the complexities of this task. This and other examples led long ago to assessment of the patterned behaviour of birds as inborn, "innate", entirely instinctive, animal automatism without the capacity to reason, and inflexible.

Dr Jenner wrote of the swallow, in the *Philosophical Transactions of 1824*, that "the economy of the animal seems to be regulated by some external impulse which leads to a train of consequences" not ceasing until it accomplishes the end for which it was begun, procreation, nest-building, incubation, hatching, nutrition, and education of the young. Dr Jenner is not referred to very often now, but he foreshadowed recent views of the behaviour of birds as totally patterned.

These views regard bird behaviour as inborn, transmitted from generation to generation through the genetic mechanism, a mechanism providing the detail of the individual, including the nerve pathways in the nervous system, each pathway consisting of nerve cells, their contacts with other nerve cells as also with receptors and effectors: sense organs, glands, muscle, etc.

"Neurophysiological" explanation

The cerebral cortex of the mammal brain is provably associated with learning, intelligence, and a flexibility of behaviour, modifying instinctive reflex activities which are co-ordinated in the striate body. The bird lacks a cerebral cortex. It has a large striate body which, in the absence of a cortex, provides behaviour only in terms of co-ordinated reflex activity. The behaviour is accordingly modifiable only in those few changes possible within the physiology of the reflex. A reflex may accommodate to a stimulus and fail to respond (habitude), or it may "condition" with a change in rate of activity. Learning is limited to no higher level than imitation, trial and error; problem solving is limited to a very primitive, elementary form of "insight" far below recognizable creative intelligence.

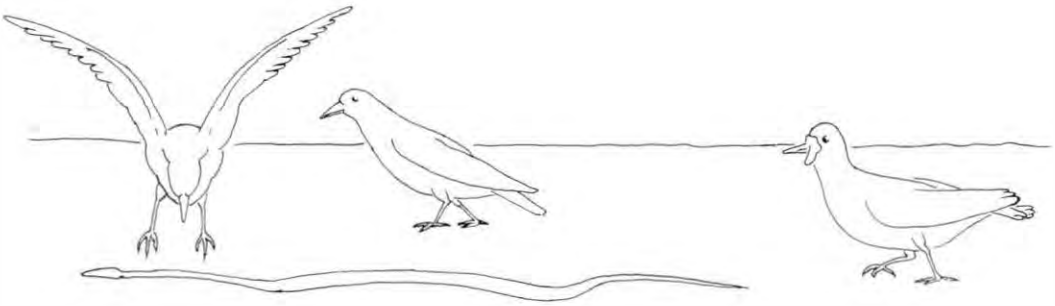
With this, emotional life and drives are restricted to the lowest quanta—or totally denied, and the individual bird deprived of any capacity to devise new complex behaviour.

This "neurophysiological" basis for bird behaviour has been extended with the inclusion of interpretations from analytic psychology, so providing a seemingly comprehensive approach to the interpretation of bird behaviour; but the physiology of the reflex is a poor foundation for the whole behaviour of the entire animal. The proposal requires acceptance of a principle that the behaviour of the individual is no more than an algebraic equation of the actions of its parts, with the animal having no directive control over the parts of the equation.

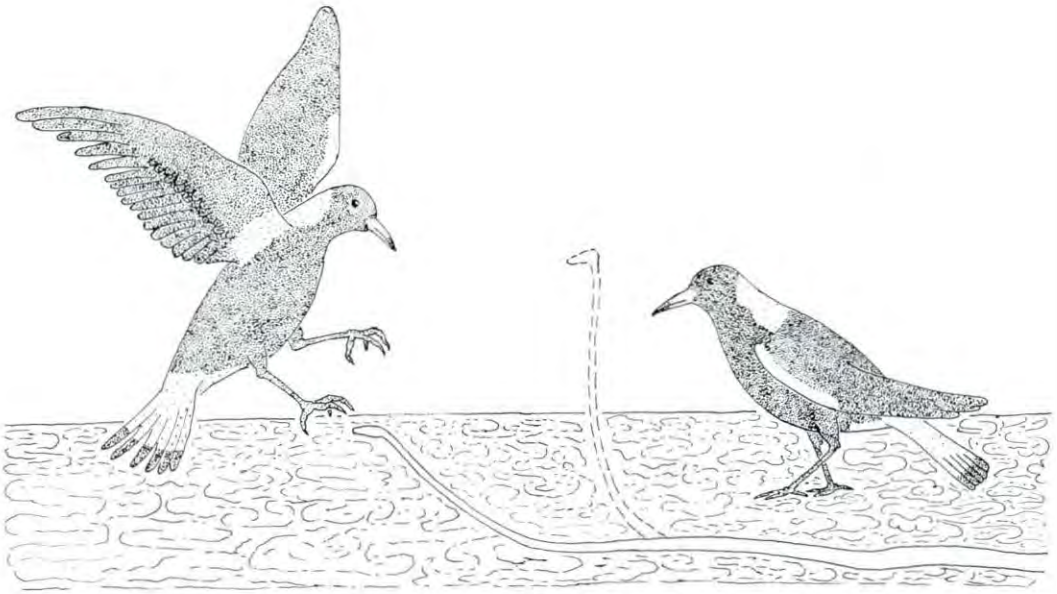
New Zealand gull's behaviour

Play as exhibited by birds is described neurophysiologically as being "a diversion or displacement of reflex sequences in a non-purposive activity to release neurophysiological tension created in continued repeated stimulation without discharge in the reflex sequence appropriate to the stimulus". The words differ, but the essential theme is little changed from Jenner.

The Black-backed Gull in New Zealand occasionally plays "tag", with anywhere up



A diagrammatic representation of the two actions of the first magpie when harassing the snake. *Above:* the relative positions of the first and second magpies and, at right, the plover, when the snake was prone. *Below:* the short flighted hop made when the snake struck. [Diagrams by the author.]



to fifty birds chasing one bird in the air and on the ground, this bird carrying some small object which, when dropped, is taken by another, and then another bird, and so on, each being pursued in turn by the others. The "tag" recovered on one occasion was a waterworn jack-bone from a lamb. It had been carried successively by nine birds over a period of some 20 minutes.

Of the many birds involved, only a few would divert to recover the "tag" when it was dropped, showing that neither the object nor the action had the nature of a compulsive stimulus: but as this one item was recovered each time, even from amongst litter and gravel, the object had temporarily acquired value. It had become something "symbolic" in nature, and this not with just one individual but with a group of individuals. A temporary symbolic value among a group of individuals is inadmissible in a concept of purely innate reflex behaviour.

Magpie's harassment of snake

Zoologists can provide many observations of bird behaviour in the field, observations indicating behaviour originating other than in an innate mechanism. The example given below is worthy of most careful consideration.

A Black-backed Magpie, *Gymnorhina tibicen*, was seen acting in an unusual

manner on the ground in a field, close to the fence separating the field from the road. This bird fluttered briefly up and down, performing flighted hops of about a foot, and with its attention directed to a small area in front of it. A second magpie, about 2 feet from the first, was watching the same area, and, 2 feet from this bird, a Spur-wing Plover stood looking at the same place.

The car was stopped, and backed until in line with and no more than 40 feet from the three birds, which totally disregarded the car and continued with their attention concentrated on the one area. A snake raised itself in front of the first magpie, and the stiuation resolved as: the first magpie facing the reared snake at a distance of some 2 feet; the second magpie standing about 2 feet to the right of the snake, parallel with it and slightly behind the level of the reared head; the plover immediately behind the snake and facing toward it. The ground was covered with flat weed.

The following sequence was seen:

The snake lowered its head to the ground, to be fully prone, and on this the first magpie flighted up just clear of its head, then crosswise over the snake to flutter with the feet pendent as though raptorial; the feet were no more than an inch above the snake, and some 6 inches behind the head, but the bird did not touch the snake, nor did it touch it when the action was repeated. The snake remained prone in the 4 or 5 seconds the magpie was above it, and then the magpie returned to its former position, standing with its feet not more than 6 inches in front of the head of the prone snake.

After a brief interval the snake reared, remained poised as long as 10 or 15 seconds, and then struck at the magpie, which, continuing to face the snake, flighted briefly up and so clear of it, even though close to it. This action carried the bird back a little, but not more than a foot. The snake advanced, but not so far as to place it beneath the magpie, which landed and moved forward, closing up on the lowered head of the snake. The second magpie and the plover moved forward, keeping their positions relative to the snake.

These two actions on the part of the first magpie and the snake were repeated two or three times a minute throughout the sequence, which continued for 8 to 10 minutes. With the snake fully prone on the ground, the first magpie would again hover briefly, crosswise, some 6 inches behind the head of the snake, which always remained prone and did not attempt to move with the bird above it. Then the magpie would return to confront it, standing no more than 6 inches from its head, and the snake made no move forward. There might be a longer or a shorter interval, occasionally none, before the snake would rear, poise, hold this attitude, sometimes lower to the ground, or strike, and the magpie flutter up, when the snake might move forward. The progress of the snake was slow and interrupted, and, over the greater part of the sequence, the snake did not advance even 20 feet, but always maintained the one direction.

The sequence terminated with the snake raising its head only some 6 inches above the ground and moving forward with the head above the ground. The first magpie then flew into the lower branch of a small willow tree some 60 feet away and in the direct track maintained by the snake throughout the sequence. The snake now travelled at speed to the tree and up into it. The first magpie flew to the second, and both, as also the plover, flew away. In this last episode, the snake was recognized as a Brown Tree Snake and estimated to be about 4 feet in length.

Comment on birds' behaviour

The departure of the magpies indicates there was no defence of a nest, or of young, nor was there a suitable nesting tree or other tree within several hundred yards. The sequence was conducted in silence, except for one brief cry from the first magpie part-way through the sequence; this cry was given as the snake once struck seemingly so close as to touch the feet of the flighting magpie, but there was no other sign that it had touched the bird's feet.

The persistent interference with the progression of the snake was harassment in all true sense of this term, but whether it was playful or aggressive cannot be assessed.

The actions of the first magpie were performed with close precision. This bird exhibited a full appreciation of the attitudes

adopted by the snake, of its inability to strike from the prone position, of its behaviour when prone and threatened from above, and a close measure of the direction, speed and range of the strike, this latter a variable with snakes of different sizes. The range of the strike was measured as no further than the position of the head when prone, and the first magpie stood close to this point without movement as the snake reared and poised, fluttering up only as the snake struck.

The position of the second magpie indicated appreciation of the inability of the snake to strike toward it with any success at the distance which was carefully maintained.

The plover conveyed only the impression of a most closely interested bystander. The position it held is the same as I have seen taken by a kookaburra near a black snake which was 5 feet long, but the kookaburra exhibited an alert and cautious timidity not shown by the plover.

An interpretation of the behaviour of the first magpie in terms of inflexible innate behaviour can be maintained only by disregarding, devaluing or denying that this bird exhibited a full appreciation of the safety factors essential in closely approaching and harassing a snake. Three such factors can be identified. In each there is an element of judgement which cannot be accepted other than from prior observation. For the first magpie to repeatedly utilize two different actions with constant regard to the necessary safety factors involves essentials of learning, analysis, judgement, and flexibility in behaviour. The abrupt termination of the sequence on a change in behaviour of the snake is further evidence of judgement, a recognition that the snake was no longer safely controllable.

It is more than difficult to see this as containing no component of intelligence. Habitude, conditioning, imitation, trial and error, and limited-insight problem-solving offer no prospect for the development of two kinds of action both closely applied, with appropriate safety factors, in an essentially dangerous situation. That the tree snake is back-fanged does not eliminate danger. Mr G. Hastings, of Grafton, New South Wales, has described to me the long struggle on the ground of a kookaburra to free itself from the coils of a tree snake which it had seized near the middle of the body, and I am told locally that the magpie harasses the Black Snake and other snakes.

FURTHER READING

Van Tyne, J., and Berger, A. J., 1959: *Fundamentals of Ornithology*, Science Editions, 1966, J. Wiley & Sons, New York.

DEATH OF KEITH HINDWOOD

The sudden death of Keith Alfred Hindwood, Honorary Ornithologist to the Australian Museum, on 18th March, 1971, deeply shocked his many friends.

Keith Hindwood, who was 66, had been the Museum's Honorary Ornithologist for the past 40 years. His knowledge was of great value to lay and professional ornithologists alike, and the Museum often sought his advice. He carried on an extensive correspondence, as many people wrote to him for information and he was always ready to help anyone genuinely interested in birds. He took many overseas visitors to vantage points from which they could see local birds.

Keith Hindwood was a Fellow and Past President of both the Royal Australian Ornithologists' Union and the Royal Zoological Society of New South Wales, and was a Corresponding Fellow of the American Ornithologists' Union. He was awarded the Australian Natural History Medallion in 1959.

He published many papers and short notes on birds, mainly in *The Emu*. One of his most important papers was on the birds of Lord Howe Island. This was published in *The Emu* and also as a book. A very valuable paper, which was published in *The Records of the Australian Museum*, was the list of Australian type specimens held by the Museum.

Keith Hindwood was author and joint author of several books, and always succeeded in bringing together in the text much information not readily available elsewhere. At the time of his death he was working, with others, on a book of the birds of New South Wales. It is hoped that his co-workers will be able to complete this book.

He is survived by his widow, son, and daughter.

His death is a very real loss to the Australian Museum and to his many friends on the staff.

F. H. Talbot.

CARNIVOROUS SNAILS OF THE FAMILY PARYPHANTIDAE

By BRIAN J. SMITH
Curator of Invertebrates, National Museum of Victoria, Melbourne

SNAILS, to most people, are the slimy pests which seem to show preference for the few home-grown vegetables or prize plants of the suburban garden, and in most general textbooks land snails are usually quoted as herbivores or feeders on rotting vegetable material. It therefore comes as a surprise to many people to learn that there are quite a number of groups of snails in the world which are carnivorous and even predatory in habit, catching, killing, and eating live animal prey. In most cases the carnivorous species are highly specialized members of generally "conventionally" feeding families. There are, however, several families of exclusively carnivorous snails. The largest and most diverse of these is the family Paryphantidae (or Rhytididae), all members of which show extensive modifications to the carnivorous mode of feeding. This family is found in New Zealand, Australia, the South Pacific Islands, and southeast Asia, and two rare genera of the family are found in South Africa. They are most common, widespread, and diverse in form in New Zealand and Australia.

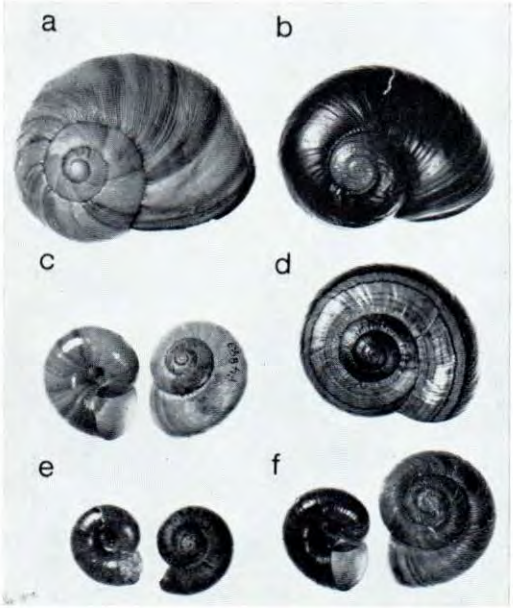


Figure 1. Shells of several species of paryphantids (× 0·4). a, *Natalina* (*Natalina*) *cafra* (Ferussac), from South Africa. b, *Paryphanta* (*Paryphanta*) *busbyi* (Gray), from North Island, New Zealand. c, *Rhytida* (*Strangesta*) *capillacea* (Ferussac), from Blackall Range, southeast Queensland. d, *Paryphanta* (*Powelliphanta*) *hochstetteri* (Pfeiffer), from Takaka Range, near Nelson, New Zealand. e, *Ouagapia* (*Ouagapia*) *raynali* (Gassies), from New Caledonia. f, *Rhytida* (*Strangesta*) *sheridani* (Brazier), from north Queensland. [Photos: E. Rotherham.]

Three major groups

In a brief review of the family in the South Pacific area, A. Solem (1959) recognized three major groupings of species and genera.

Group A of Solem's division contains nearly all the large species, with globose (spherical) or auriform (ear-shaped) shells composed mainly of a thick layer of the horny substance conchin. These are confined to New Zealand, with only three or four small species from southeastern Australia. The New Zealand ones include the large, colourful, and very spectacular *Paryphanta* (*Paryphanta*) species (fig. 1, b) and *Paryphanta* (*Powelliphanta*) species (fig. 1, d) groups and the genera *Waimuia* and *Schizoglossa*. Quite a number of species and varietal forms have been described, but they all have very restricted ranges and are confined to humid forest conditions. The same is true of the Australian forms in the group. There are two species of the genus *Victaphanta*, confined to wet forest regions of Victoria, and one or two Tasmanian species from the forests of the west coast, whose status is under study at the moment.

Group B contains the small to medium, thin, helicoid shells considered to be the primitive stock from which the other two

groups are derived. This consists of the medium-sized, yellow shells of New Zealand, Australia, and New Caledonia of the genus *Rhytida*. These show great variation in eastern Australia in the group *Rhytida* (*Strangesta*) (fig. 1, c, and f), in which there are many named forms. Apart from a few species of the genus *Delos* which occur in New Zealand and Australia, all the other members of this group are found exclusively in the islands of the South Pacific and eastern Indian Ocean. These include the small species of the genera *Delos* and *Macrocycloides* and the larger shells of the genus *Ouagapia* (fig. 1, e).

Group C contains only one genus, *Diplomphalus*, which consists of small, flat, many-whorled shells and is confined to New Caledonia.

Figure 2. Large Victorian paryphantid *Victaphanta atramentaria*. This specimen is the neotype of the species. [Photo: F. Guy.]

There are two genera in South Africa which form a separate subgroup within the family. The genus *Nata* is in an equivalent position to the Australian *Delos*, while the genus *Natalina* (fig. 1, a) can be considered analogous to the Austro-Zelandic *Rhytida*.

In Australia the members of the family are confined to the eastern States, except for one species, on which work is being carried out at the moment, from Western Australia. The Australian species were divided into eleven genera by T. Iredale (1938), but many of these groups will probably be found unnecessary, while others will be relegated to subgenus level. They are found in most types of habitat, except the very dry localities, from the damp litter of the rainforests to the low scrub of coastal cliffs. For example, the two species of *Victaphanta* are confined to the rainforest areas of central and southwestern Victoria, while at the other end of the scale Dr Helene Laws, of the South Australian Museum, once showed me a small colony of *Rhytida* (*Strangesta*) *gawleri* under very low scrub on a steep hillside only 30 or 40 yards from a beach south of Adelaide.

Specialized feeding method

Although the carnivorous mode of feeding is such an unusual and specialized one in land molluscs, requiring gross anatomical and behavioural modifications to the usual pattern, comparatively little work has been carried out on the anatomy, and still less on the feeding mechanisms, in this and similar groups. Only two references are to be found in literature to observations on feeding in paryphantids:

- M. F. Woodward (1895) describes how he fed the large South African species, *Natalina* (*Natalina*) *cafra* on live snails: "*Natalina* itself preys on snails, into whose shells it creeps, and then, by the aid of its powerful buccal muscles and large hooked teeth, literally scrapes the inhabitants out mouthful by mouthful. The specimens kept alive by me would clear out the shell of a large *Helix*, in a few days, and apparently kept steadily at work until this was accomplished, rarely leaving anything but the kidney behind".

- H. Suter (1899) describes how the New Zealand *Paryphanta* species extend the odontophore, hook the prey with the long sharp teeth of the radula, and pass the prey slowly down into the stomach by withdrawing the tongue.

Feeding behaviour

Recently Miss Helen G. Webster, from Melbourne University, gave in an unpublished undergraduate project a good account of the feeding behaviour and food preferences of the large Victorian paryphantid, *Victaphanta atramentaria* (fig. 2). In this work she made observations of the general habitat and activity-time preferences, carried out food-choice experiments, and made detailed observations on the capture and ingestion of worms and snails by the predator. She found that the snails preferred very

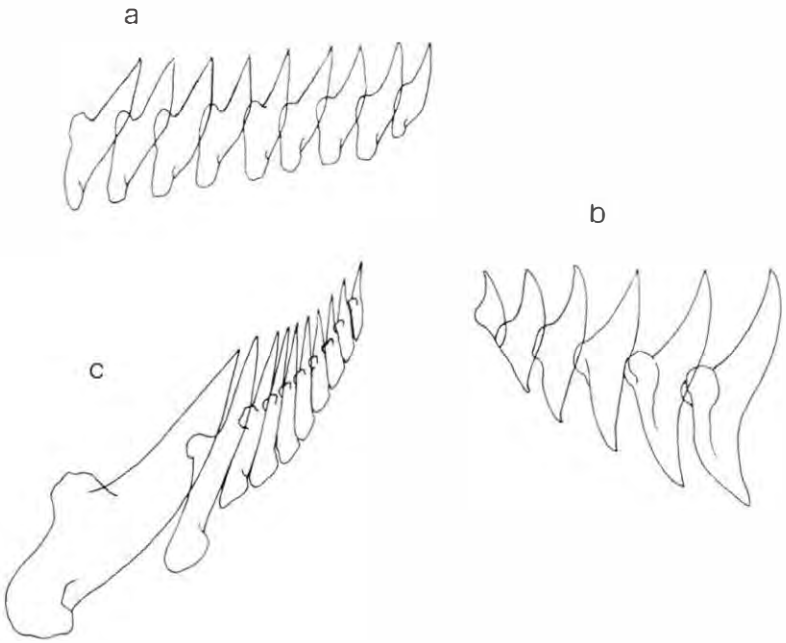


Figure 3. Diagrams of the teeth of various genera of paryphantids (after Powell, 1930). a, *Victaphanta;* b, *Paryphanta;* c, *Rhytida.* [Drawing by Miss R. Plant.]

damp and even waterlogged conditions, and would live and feed quite readily when completely buried in wet soil. Dry conditions, however, very quickly upset their normal activity patterns and they were very susceptible to dessication. Given a choice of worms, slugs, garden snails, millipeds, beetles, and earwigs, the snails took the soft-bodied animals readily, while even starving snails did not take any forms with chitinous exoskeletons.

Snails became active after dark but searching for food seemed to be random, depending on a chance meeting between predator and prey. In common with all carnivorous animals, it was found that quite some time usually elapsed between meals, ranging from 1 or 2 days to 18 days.

On encountering a worm the pharynx is partially everted and the prey is securely impaled by the long, sharp, curved radula teeth. It is then drawn rapidly into the mouth, the whole process taking about 5 minutes. To aid in the capture large quantities of viscous mucus is secreted from the front of the foot. This envelops the prey, thus restricting its movement. A worm can be attacked at any point: one observed by Miss Webster was attacked half-way along its length and drawn into the mouth as a double strand. On another occasion a very large worm (7 inches long and 0·4 inches thick) was attacked. About half of it was eaten and the remainder discarded.

They also readily attacked the garden snail *Helix aspersa.* They do this by crawling into the aperture of the shell of the prey and gradually pulling the body out of the shell and devouring it. This process takes several days; they will completely clean out the shell, except in large snails, where they may leave the kidney.

Although Miss Webster made several attempts to induce a *Victaphanta* to eat one of its own kind, by putting two starved snails in close proximity to each other, they made no attempt to attack. It can therefore be suggested that, although they are voracious carnivores, they are not cannibals.

Snails' teeth

Because of the specialized mode of feeding, the alimentary canal and other parts of the anatomy of the paryphantids show extensive modification from the normal pattern. All snails have a long ribbon of rows and rows of hard, sharp teeth, the radula, which is worn out at the front and continuously replaced throughout life. In most snails the

teeth are short and wide and act like a rasp for breaking off bits of plant material. However, in the Paryphantidae, they are modified into long, sharp, backward-pointing "lances" (fig. 3, a–c), which sink deep into the soft body of the prey and hold it firmly while it is drawn back into the large muscular pharynx. The pharynx or buccal mass is very much enlarged and strengthened. In herbivorous snails the buccal mass is short, with musculature only sufficient to move the radula. In the paryphantids it almost fills the whole of the exposed part of the body. This is because it has to have the potential for expanding to take a large piece of food and has to be strong enough to hold and ingest a strong, live animal which is usually taking active avoidance and escape action. In most herbivorous snails there are two sharp, horny jaws just inside the mouth. These enable the snail to "crop" the plant material in small bites. These jaws are entirely absent in the paryphantids, as biting a piece off would allow the prey to escape, since the only holding apparatus is inside the mouth. Another structure present in herbivorous snails which is of no value, and therefore lost, in paryphantids is a large holding crop, where the difficult job of breaking down the plant food, particularly cellulose, is commenced. In this region in herbivorous snails a very powerful enzyme, cellulase, for breaking down the cellulose cell walls, is produced. A useful piece of work would be to search for this enzyme in paryphantids, as its absence would add a further piece of evidence for specialization to the carnivorous habit.

New View on Mystery Engraving

To the Editor,

Dear Sir—I have read with interest the article "Prehistoric Papuan Engraving", by J. P. White, H. J. de S. Disney, and J. C. Yaldwyn, in *Australian Natural History*, June, 1970, pages 344–345, concerning a prehistoric engraving of an unidentified bird on a shell.

The engraved shell. No other similar objects are known from Melanesia, and it is therefore one of the mysteries in the prehistory of Papua-New Guinea. [Photo: C. V. Turner.]

I would like to suggest that the bird might be a crane of the genus *Grus*, but not the Brolga (*G. rubicunda*) nor the Sarus Crane (*G. antigone*), the only cranes known to occur in the Australasian region.

Bill, head, neck, and body are of the correct shape and proportions for a crane. The stripes on the forehead and the nape may indicate skin folds on the naked portions of the head, and there is a notch which may indicate a naked ear in about the right location for a crane with a naked head.

The secondaries of cranes form an elongated ornamental "tail" which may aid in species recognition during flock and pair formation. Several crane species have a "tail" which resembles in size, shape, and location the scroll on the rump of the engraved bird. They include: the Crane (*G. grus*), the Whooping Crane (*G. americana*), the Sandhill Crane (*G. canadensis*), the Hooded Crane (*G. monacha*), and the Black-necked Crane (*G. nigricollis*). They are all migratory Northern Hemisphere species which are not known to occur south of the equator. It is conceivable that during the last ice age one or more of them might have migrated further south and reached southeastern New Guinea, or might have been known to the artist elsewhere in the Indo-Pacific area.

The "tails" of the Brolga and of the Sarus Crane curve down and do not form a structure resembling the scroll on the rump of the engraved bird.—*G. F. van Tets, CSIRO Division of Wildlife Research.*

Sharks, Aeroplanes and Evolution

By J. R. SIMONS
Senior Lecturer, School of Biological Sciences, University of Sydney

SHARKS and their allies, the various kinds of skates and rays, differ so markedly from ordinary fish, such as bream or trout, that they are classified separately as the elasmobranchs. Among the many differences are the structure of the tail, the structure and method of use of the pectoral fins, and, correlated with these, their mode of swimming.

The movement of a shark or a dogfish through the water is remarkably similar to the flight of an aeroplane through the air. One could say, in fact, that apart from the obvious difference in the source of motive power, the only difference is the medium in which the action takes place. To call the shark's progress swimming rather than flying is to agree with Marshall MacLuhan that "the medium is the message". The swimming of an ordinary fish is quite different, being analogous with the flight of a balloon, or, more exactly, with that of those powered dirigibles, the zeppelins and airships, which competed with the aeroplane during the first three decades of this century.

The difference is essentially due to fish possessing a device by which the overall density of the body can be adjusted. The device is the swim-bladder—a distensible, gas-filled compartment within the body. This enables the fish to float, just like the balloon in the sky, at a preferred depth without expending energy. Along with the swim-bladder, indeed, made possible by its presence, there has been evolutionary modification of the fish's fins and their use, particularly those of the pectoral and tail regions. It is an intriguing fact, incidentally, that while man conquered the air first by using balloons and later "heavier than air" machines, the aquatic vertebrates conquered the waters in the reverse order. Originally they were all "heavier than water" creatures —the elasmobranchs have remained so— and then, much later in evolution, by virtue of the swim-bladder came the "lighter than water" fish that have been so amazingly successful in colonizing the waters of the world.

Being more dense than water, a shark must expend energy if it is to stay off the sea bed. An aeroplane can stay air-borne only as long as its motor continues to develop sufficient power. The moment it cuts out, or is throttled back, the machine begins to lose height. In exactly the same way, sharks, as soon as the tail stops undulating, begin to sink.

Longitudinal stability

It is one thing to say, as a generality, that sharks appear to perform like aeroplanes but quite another to specify exactly what is involved in the analogy. The problem which has interested me lately is the way in which a shark maintains its longitudinal stability— that is to say, the manner in which it can prevent the tendency to "see-saw" or pitch in the fore-and-aft direction. When analysing the control, not only of stability, but also of the diving and climbing deflections, it turns out that the aeroplane analogy can be pressed to a considerable degree, at least as far as conventional types are concerned.

The forces which control the longitudinal stability of a shark are shown in diagram 1a.

The weight (W) acts downward through the centre of gravity (CG). The lift (L), generated by the pectoral fins as the shark moves forward through the water, acts upwards through the centre of lift (CL). A second force (B) also acts as a lift force. It is present whether the shark is swimming or not, since it is the general buoyancy exerted by the surrounding water. It is a considerable force amounting to some 94 per cent of the shark's weight, so if a shark were to weigh 1,000 pounds in air it would be found to weigh an apparent 60 pounds in the water, buoyancy in this case accounting for the 940 pounds difference.

Two other forces operate—the thrust (T) developed by the motion of the tail and a

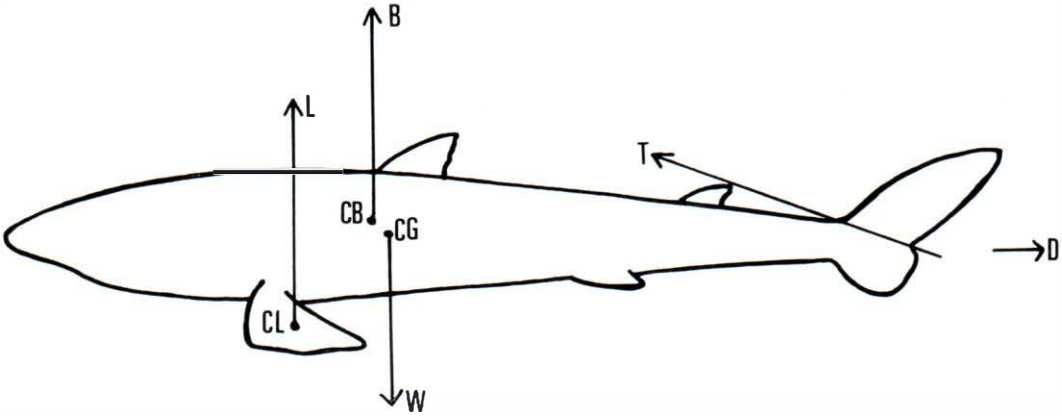
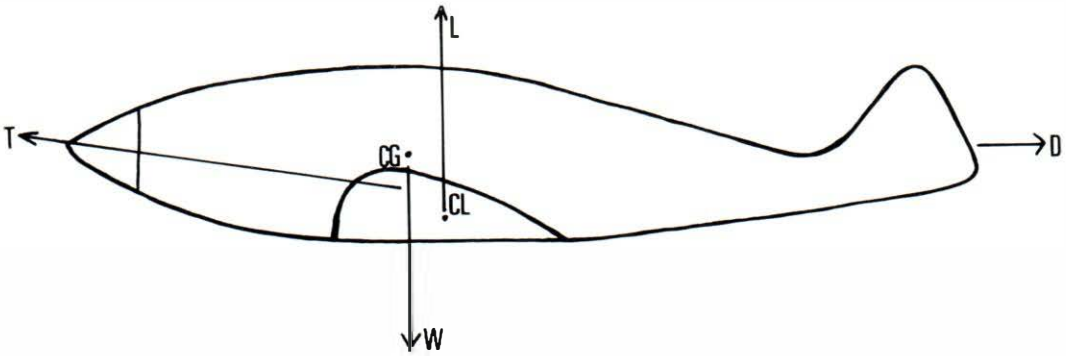


Diagram 1a (*above*) shows the distribution and direction of the forces controlling the longitudinal stability of a swimming shark. Diagram 1b (*below*) depicts the distribution and direction of the forces controlling the longitudinal stability of a flying low-winged monoplane. [Diagrams by the author.]



drag force (D) occasioned by the resistance of the water to the passage of the shark's body as it moves forward.

In various sharks which I have so far examined the centre of lift is positioned well in front of the centre of gravity, while the centre of buoyancy tends to lie just in front of, or coincident with, it. Considering the relative positions of the three centres and the direction of the relevant forces, it is obvious that there will be a tendency for the body to swing, head-up, tail-down. As an aeronautical engineer would say, the system possesses inherent "positive pitch". If the positive pitch were not counteracted in some way the creature would not be able to swim horizontally, but would move forward head-up tail-down, tending to loop-the-loop. The necessary counter-balancing negative pitch is provided by the action of the tail, which is so constructed that the line of the thrust force passes above the centre of gravity. The tail action is therefore not only to push the animal forwards, but also to raise the tail end and depress the head. (One should mention that the drag force is also involved, but for simplicity it can be left out of the discussion without affecting the main conclusions.)

The only significant upward-acting force operating on an aeroplane is the lift generated by the wings. It is true that a buoyancy force is present, but it is so small as to be negligible. Conventional design locates the centre of gravity slightly in front of the centre of lift, the arrangement producing negative pitch, tending to point the nose down. To balance this the line of thrust of the motor is positioned with respect to the centre of gravity so as to produce positive pitch.

In diagram 1b the line of thrust is shown as angled to produce "upthrust", as in the shark, but in an actual aeroplane, depending on the vertical location of the centre of gravity and the line of action of drag forces, the motor may well be angled to produce a "downthrust". However, whatever the situation, the principle remains the same: the thrust of the motor is deliberately used to create a moment of pitch about the centre of gravity which will counterbalance an opposite moment of pitch produced by the lift force. The balance is desirable because it produces stable equilibrium—that is to say, a state which, when any passing disturbance deflects the aircraft from its horizontal course, automatically corrects to re-establish the equilibrium and bring the machine back on course.

In general, the balance of forces producing stable equilibrium is sufficient to deal with small disturbances to the course but not necessarily large changes. In order to correct, or produce, large deflections in the fore-and-aft direction conventional aircraft make use of the elevators, which are movable control surfaces mounted horizontally on the tail plane. By moving the elevators the aeroplane can be made to dive or climb.

Shark has no "elevators"

Here we note an obvious structural difference between the shark and the aeroplane: there is no horizontal component on the shark's tail equivalent to the elevators of the aeroplane. This is not to say, however, that there is no mechanism which serves the same purpose, for it turns out that the tail, as well as being a propulsive and steering structure, also serves the same purpose as the plane's elevators, namely, to correct or produce large deflections of the longitudinal axis.

Sharks have a very characteristic tail: it is divided into two lobes, one of which, the upper, is generally held well above the horizontal centre-line of the body. The area of the lower lobe is usually, but not always, the smaller. The upper lobe always contains the final length of the vertebral column, which is therefore inflected upwards from the general axis of the body. Such a tail is spoken of as heterocercal.

It has long been known that the heterocercal tail acted not only to drive the animal forward but also to lift the rear end of the body up, but until recently the exact way in which the tail achieved "upthrust" was a matter of debate. Some

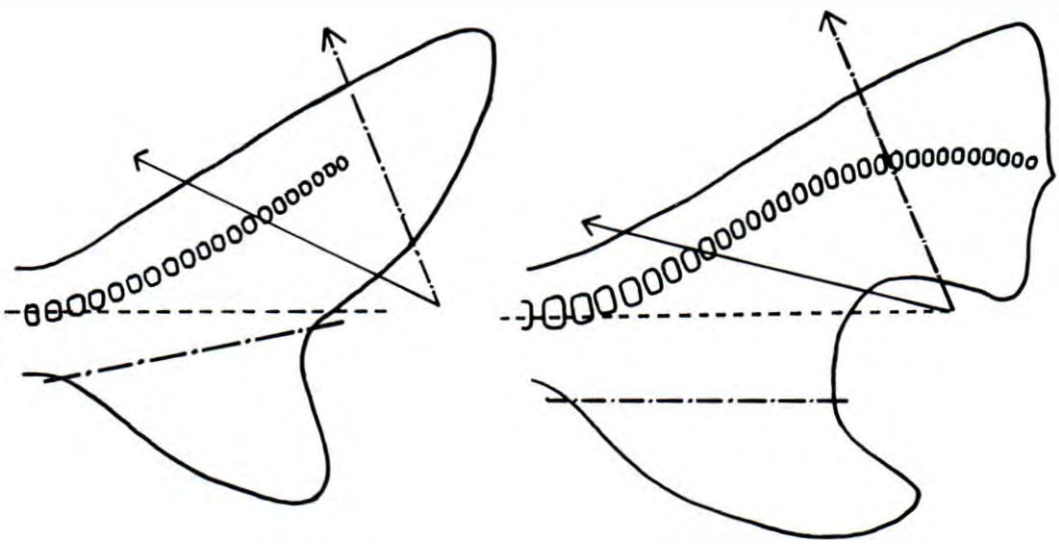


Diagram 2. The heterocercal tails of two dissimilar sharks, the Piked Dogfish (*Squalus megalops*), left, and the Port Jackson Shark (*Heterodontus portusjacksoni*). In the whole tail the line of thrust generated by the tail is indicated by the solid arrow. When the lower lobe of the tail (the area below the dot-dash line) is removed the thrust line (dot-dash arrow) is more steeply inflected above the horizontal axis of the body (dash line). The position of the terminal length of the vertebral column in the upper lobe of the tail is also indicated. [Diagram by the author.]

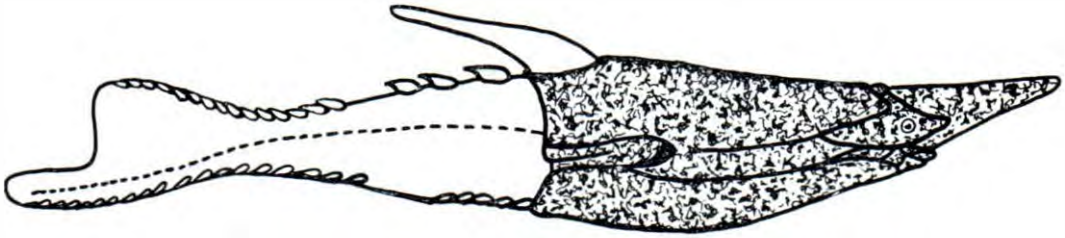
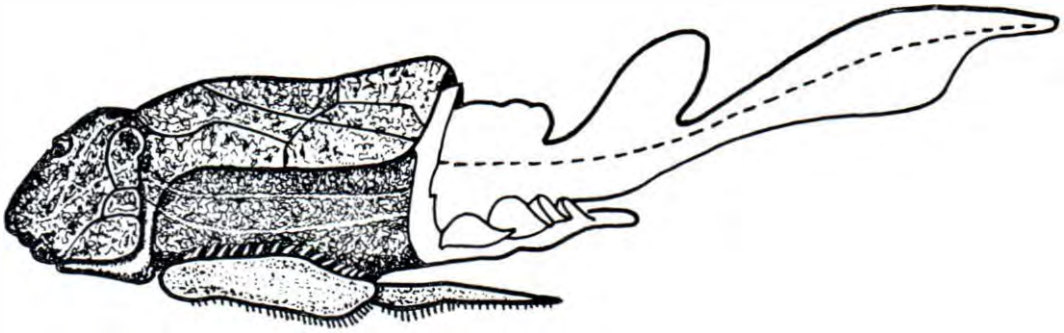


Diagram 3a (above): *Pteraspis*, a jawless aquatic vertebrate of lower Devonian times. Note the hypocercal tail and the heavy front end of the body enclosed in a bony carapace. The animal was probably capable of rising through the water by balancing a downwardly directed thrust from the tail against the negative pitch caused by the heavy front end of the body. Later related forms developed a laterally placed membrane, stretched over spines, in what appears to be an analogue for pectoral fins. Such forms could probably swim in a manner resembling the performance of a kite. Diagram 3b (below): *Bothriolepis*, a jawed vertebrate of Devonian times. The heterocercal tail, the anterior bony carapace, and the lack of definite pectoral fins would by themselves have made swimming difficult, if not impossible. However, primitive lungs have been described for these animals and they would have given buoyancy and therefore the positive pitch necessary to balance the effect of the heterocercal tail. For the most part these animals probably skated over the lake-bed using their pectoral appendages as "runners" and, in less energetic locomotion, as sculls. [Diagrams by the author.]



authorities argued that the lower lobe was responsible, while others claimed it was the upper.

The difference of opinion arose mainly because neither side had demonstrated unequivocally where the thrust force developed by the tail might be considered to act, or what direction it took. A relatively simple method, which I have published elsewhere, has shown that in two dissimilar elasmobranchs, the Port Jackson Shark and the Piked Dogfish, the tails produce a thrust which is angled upwards at average values of 12 and 26 degrees respectively (diagram 2). Furthermore, it can also be shown that if the lower lobe of the tail is removed the line of thrust becomes angled even more steeply. The conclusion drawn, therefore, is that it is the upper lobe which produces "upthrust" while the lower lobe is a modifier serving to reduce the angle of divergence of the line of thrust from that of the longitudinal axis.

Another point about the lower lobe is significant: it is equipped with special sets of muscles by which it may be stiffened or relaxed as the tail as a whole moves from side to side. These radial muscles, as they are called, are located on the right and left sides of the lower lobe. If the right-hand set is contracted as the tail as a whole moves to the right the modifier effect of the lower lobe is increased. That is to say, the "upthrust" of the tail is further reduced and may in fact become reversed to give "downthrust". The lower lobe is therefore a functional equivalent of the aeroplane's elevators, although the elevators are set horizontally while the shark's tail is set vertically.

Early evolution

The structure and function of the parts of the heterocercal tail are of some interest in thinking of the early evolution of the aquatic vertebrates. During Silurian and Devonian times a large variety of aquatic vertebrates appeared in the lakes and rivers. There were two great divisions, one consisting of those creatures which possessed a mouth but not jaws and the other embracing the jawed varieties. All were fish-like in general body form, but had the front of the body encased in heavy bony armature. In addition, the earlier forms did not possess pectoral fins, although later types evolved various kinds of surfaces (such as skin stretched across spines from the side of the body) which could have acted as equivalent structures. The jawless forms sported heterocercal tails for the most part, but some developed an inverted form of the tail in which the lower lobe was the larger and contained the end of the vertebral column, which, of course, was now inflected downwards rather than up. This form of the tail is referred to as hypocercal. Among the jawed forms the heterocercal tail seems to have been established as the norm very early in their evolution (diagrams 3a and 3b).

In the earliest heterocercal tails the lower lobe was either absent altogether or only poorly developed. One would argue, therefore, that in these forms the line of thrust must have been angled well up from the general body axis and a considerable amount of negative pitch generated. Since the front end of the body was encased with the bony shielding the centre of gravity would have been positioned in front of the centre of buoyancy; hence, when the creatures swam, their heads would have been forced down. Initially this would not have mattered: indeed, it may well have been an advantage because the jawless variety certainly, and most probably the earliest forms of the jawed types, fed on the beds of lakes or rivers, sucking up the mud and sand and sifting it for food material. One can imagine them moving around rather like little vacuum cleaners, with their heads closely applied to, if not actually shoved in, the mud. Swimming in the sense of "taking off" from the bottom and becoming truly water-borne could be achieved before the loss of head armour or the development of pectoral fins by reversing the heterocercal tail to produce the hypocercal type. With such a tail the balance of positive and negative pitch could be established and level swimming made possible. The control would, however, be easily upset, particularly if the creature attempted any burst of speed. One such creature is shown in diagram 3a.

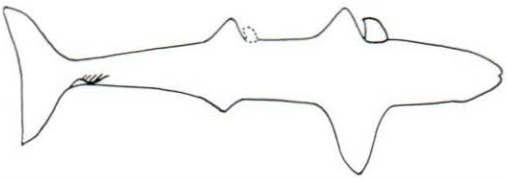


Diagram 4. *Cladoselache*, one of the proto-sharks of upper Devonian times. Note the extraordinary development of the ventral lobe of the heterocercal tail, and the large pectoral fins. External bony armature has been shed, and internally the skeleton has been formed of cartilage rather than bone. Unlike modern sharks, the pectoral fin was probably incapable of much inflection, and so longitudinal stability was controlled from the tail region. The horizontal surfaces (the small area shown hatched) near the base of the tail probably functioned as "elevators" to aid the action of the lower lobe of the tail. [Diagram by the author.]

Proto-shark

Among the jawed forms, reduction of the bone encasement (and even loss of the bone of the internal skeleton) accompanied the development of true pectoral fins and the expansion of the lower lobe of the heterocercal tail. By mid-Devonian times the proto-shark *Cladoselache* had appeared, but with this creature and its allies the pectoral fins were still not as flexible as those of any modern shark, being broad-based and hence incapable of being inflected to any great degree. Control of longitudinal pitch must still have been a matter of some imprecision. It is interesting to note, incidentally, that even with the large ventral lobe of the tail (diagram 4) of *Cladoselache*, what appear to be auxiliary longitudinal control surfaces, in the form of small horizontal fins, were placed on the base of the tail. The tail of this small shark therefore resembles the tail complex of a conventional aeroplane, with its vertical rudder and horizontal elevators, much more than any modern type does.

We shall never know the exact story of the details of the evolution of the heterocercal tail and why it occurred, but one gains a very strong impression that natural selection was operating in those far-off days to perfect the mechanism of controlling the longitudinal stability of swimming "heavier than water" vertebrates. Three hundred million years later, man more or less saw a repetition in miniature of the process when, between 1903 and the First World War, from among a weird variety of "heavier than air" machines, the conventional design of the aeroplane we know so well was settled upon, the solution to the problem being identical with that adopted by Nature.

FURTHER READING

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H. F. RECHER is Head of the Department of Environmental Studies at the Australian Museum. He was born in the United States and received his doctorate in biology from Stanford University, where he worked with Professor Paul Ehrlich. Dr Recher came to Australia in 1967 as a Lecturer in Biology at the University of Sydney, and joined the Australian Museum in 1968. Since then he has conducted biological surveys of the New South Wales coast and Lord Howe Island and has done research on the population dynamics of small mammals and on the foraging ecology of herons.

L. R. RICHARDSON, Ph.D., F.R.S.N.Z., left Australia in 1926 to study at the University of British Columbia and McGill University, Canada, where he joined the staff. From 1931 to 1936, he undertook an ecological survey of the freshwaters of southeastern Quebec as a basis for game-fish management, becoming involved with parasitic and other problems affecting game-fish and other fish. In 1940, he was appointed to the staff of the Biology Department, Victoria University, New Zealand, becoming Professor in 1944. He resigned to return to live in Australia at the end of 1964. He was awarded the Hutton Medal of the Royal Society of New Zealand, for zoological researches in Cook Strait. Currently Dr Richardson is studying the Australian freshwater and terrestrial leeches.

J. R. SIMONS came to science as an ex-Service trainee, and graduated with honours in Zoology from the University of Sydney in 1949. He later took his Master's degree at Sydney, and then went to England, where he gained a fellowship at Guy's Hospital, ultimately taking his Ph.D. there. He is now Senior Lecturer in the School of Biological Sciences and a Sub-Dean of the Faculty of Science at the University of Sydney. Dr Simons' main line of research has been on the blood circulatory physiology of lower vertebrates, but in his article in this issue an interest in aeroplanes has been combined with his zoological interests in an attempt to explain some facts of the evolution of early aquatic vertebrates.

BRIAN J. SMITH, Curator of Invertebrates at the National Museum of Victoria, Melbourne, since 1967, was educated at the University of Wales. He came to Australia in 1964 to take up the position of Lecturer in Zoology at Monash University, Melbourne. Although his curatorial duties have led him to studies in a wider field, he has retained the interest in land molluscs which started with his research into the reproductive physiology of slugs in Britain. He recently instituted a long-term programme to survey the land and freshwater molluscs of Victoria.

A. DONALD TROUNSON was born and educated in England. A former member of the British Diplomatic Service, he served as a Second Secretary at the British Embassy in Rome from 1947 to 1953, and subsequently as a spokesman for the Foreign Office, the U.K. Delegation at the United Nations, and the Commonwealth Relations Office. He was appointed to the Sydney office of the British High Commission in Australia in 1959, and was in charge of the British Information Services in New South Wales until he retired at the end of 1967. During the Second World War, he was commissioned in the British Army, and served in North Africa, Sicily, and Italy. His interests have included motor-racing, music, water-colour painting, archaeology, photography, and, latterly, birds.

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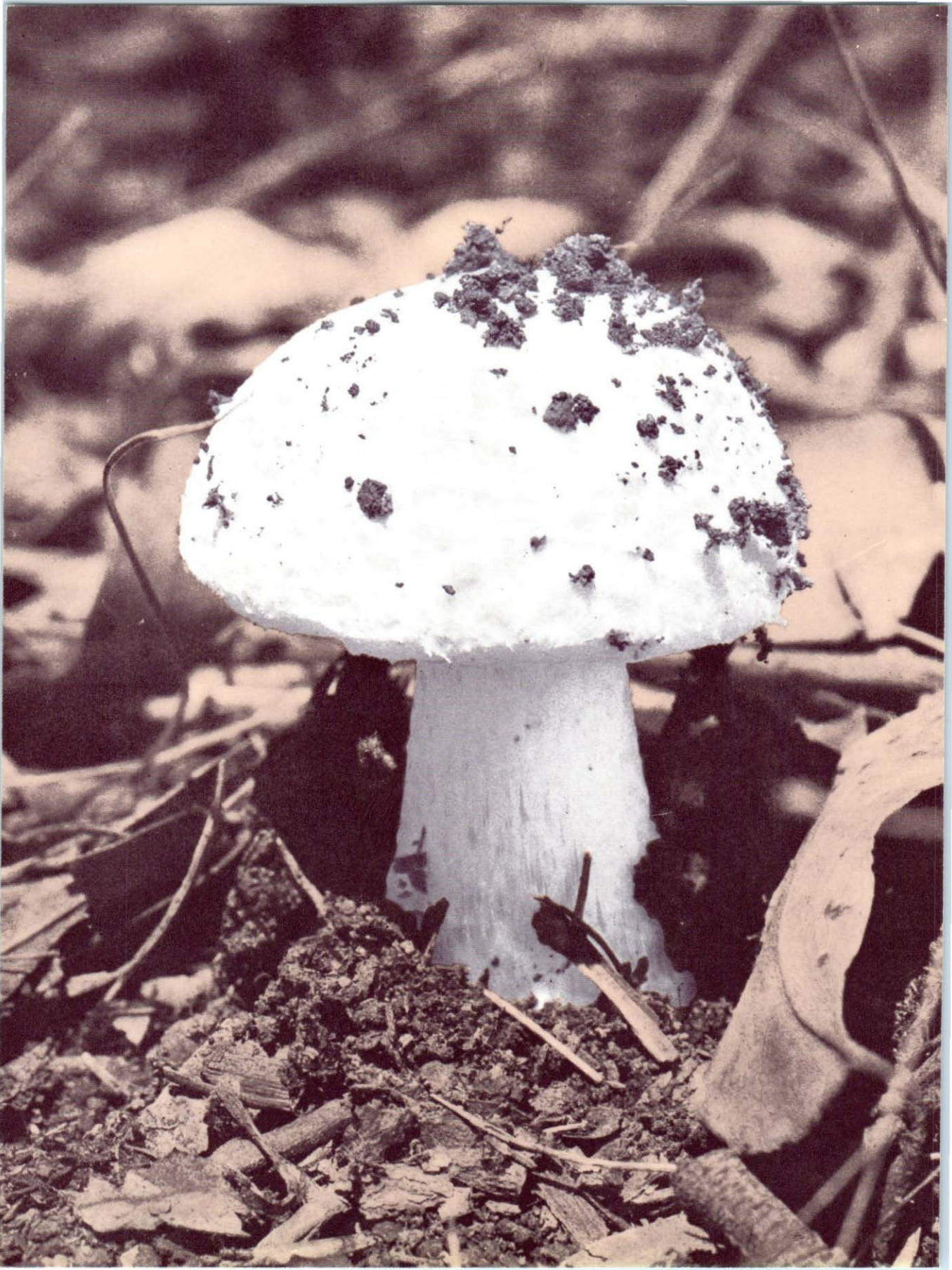
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