

AUSTRALIAN NATURAL HISTORY



SEPTEMBER 1974 VOLUME 18 NUMBER 3 70c

Habitat AUSTRALIA



EDUCATIONAL SUPPLEMENT

Volume 2, No. 3, August 1974.
Educational Supplement compiled by B. J. Johnson, B.Ag.Sc., Dip.Ed.

Habitat AUSTRALIA



with ACF Educational Supplement and a special article by Dr. Moss Cass



Habitat

is the national magazine of the Australian Conservation Foundation.

Habitat is devoted to matters concerning conservation and the environment. Habitat is published 6 times each year and costs 60 cents per issue or \$3 for 6 issues. Subscriptions can be made direct to ACF or can be paid to any authorised newsagent. Single copies can be bought at newsagents throughout Australia.

Free with each issue is an education supplement invaluable to teachers and students of conservation and the environment.

THE AUSTRALIAN CONSERVATION
FOUNDATION
206 Clarendon Street,
Melbourne, Australia

AUSTRALIAN NATURAL HISTORY

SEPTEMBER 1974 VOLUME 18 NUMBER 3 PUBLISHED QUARTERLY BY THE AUSTRALIAN MUSEUM, 6-8 COLLEGE STREET, SYDNEY

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COVER: The Deaf Adder Creek Valley galleries of polychrome paintings are an important part of a rich heritage of Australian Aboriginal rock art. Fragments of ochre excavated from nearby cave deposits were dated to twenty thousand years ago. (Photo: Robert Edwards)

ABOVE: This sandstone shelter is one of many hundreds of important hand stencil sites at Mount Menara near Cobar, NSW. (Photo: Sue Walston)

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Bill Green

Shortly after hatching, this tiny croc displays his soon-to-be-dangerous teeth.

Australia has, in its Estuarine Crocodile, an animal of prodigious size and predatory skill—a survivor from many millenia past, but about which very little is known and documented. A long-term study of the biology of this crocodile is currently under way. This project, still in its early stages, is a joint one between the University of Sydney and the Department of the Northern Territory.

Two species of crocodile occur in Australia, the Freshwater Crocodile, *Crocodylus johnstoni* (to three metres long), and the Estuarine Crocodile, *Crocodylus porosus* (to eight metres or more). The former lives only in the freshwater sections of northern rivers and in billabongs; the latter is found in both fresh and saltwater situations. The Estuarine Crocodile also occurs in Papua and New Guinea, West Irian, and westwards through Java and Sumatra to Malaysia and India.

Since the Second World War the Estuarine Crocodiles—'salties'—and later on the 'freshies' as well, have been subject to massive killing for their hide which is tanned and made into shoes and handbags that command a high price and are of considerable fashion value. Small crocodiles were also stuffed in supposedly life-like poses for sale as curios. One could dwell at length on the sad situation wherein an animal group as long-lived as the Crocodilians is, within a few decades, brought close to extinction by uncontrolled hunting to provide leather for essentially trivial use.

In many places overseas, certain measures were finally taken to ensure protection of other crocodilian species. Alligators are now farmed in the USA, although places where they can be seen wild are few and getting fewer as areas such as Florida's Everglades are succumbing to invasions by man. Because of the tourist attraction provided by crocodiles, considerable protection has been afforded the Nile Crocodile (*C. niloticus*). A farm in Rhodesia is apparently now raising crocodiles with some success.

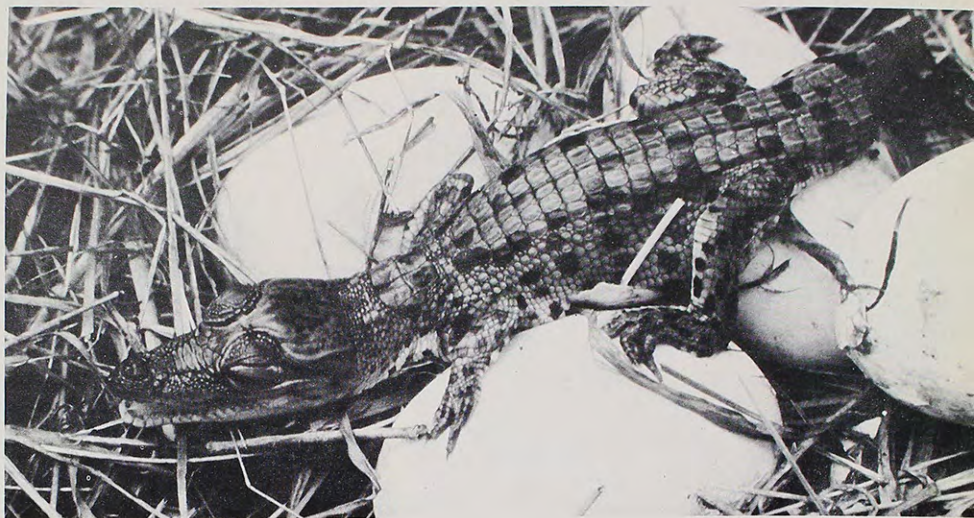
In Australia, total protection for crocodiles came into effect in Western Australia in 1971 and in the Northern Territory in 1972. Ironically, this coincided with reduction in crocodile numbers to a point where hunting them was becoming an uneconomic proposition. In Queensland it is still legal to shoot crocodiles and in an effort to reduce the profitability of this, the Commonwealth Government enacted, in 1973, laws which prevented the export of any crocodiles or crocodile products. This legislation was also designed to stop the flow of poached crocodiles from Western Australia and the Northern Territory into Queensland where they could be sold legally. The Queensland Government appears reluctant to enact its own protective legislation.

As a result of all this hunting pressure, crocodiles have been completely wiped out from some river systems, particularly those most readily accessible to the hunter with his spotlight

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ING IN TO CROCODILES

BY GORDON GRIGG



Bill Green

and outboard-powered dinghy. In most, if not all other rivers, severe reduction in numbers has occurred. The rivers of Arnhem Land have not been legally available for hunting by white men because Arnhem Land is an Aboriginal reserve, but we shall never know how much went on. Because of this there is no longer any way of really knowing what was a 'normal' population density of crocodiles in Northern Australia.

Despite the enormous amount of literature which has been written about the world's crocodilians, surprisingly little of it is of much value. Aside from thorough anatomical treatises, particularly from German workers last century, and some more recent publications in all areas of interest, much is more in the way of 'heroic' traveller's tales than of scientific observation. Compared with overseas crocodilians, Australia's feature very little in this literature.

The Crocodile research Programme is headed by Harry Messel, Head of the University of Sydney's School of Physics. Messel also directs the Science Foundation for Physics within the University and much of the financial support for

the programme comes from this source. That he is a physicist and not a biologist can hardly be said to have passed without comment, but Messel sees this as no paradox. He has always urged and worked for greater co-operation between the disciplines. In this programme, there is heavy emphasis on co-operation between biologists on the one hand and physicists and engineers on the other.

Broadly speaking, it is the aim of the Crocodile Research Programme to carry out a long-term and full-scale study of the biology of the Estuarine Crocodile and to use this study as a 'stalking horse' for the research and development of radiotelemetry techniques which can be applied initially to crocodile research and later on to many other biological and non-biological fields. In most cases, radiotelemetry and biology have tended to proceed independently. In our programme both aspects of the research are proceeding together—the demands of one influencing the direction of the other and the success of that influencing other progress.

More specifically, we currently have four major

This newly-emerged hatchling, now only about twenty-five centimetres long, may one day reach a length of as much as nine metres.



Bill Green

Biologist Grahame Webb weighs a future giant. This hatchling weighs only about 150 grams.

goals: (1) a survey of the relative abundance of crocodiles within the animal's range in Australia; (2) a detailed ecological and behavioural study of a population of crocodiles in the Liverpool River system, Arnhem Land; (3) a radiotelemetry research and development programme working toward suitable long-range, long-life tracking transmitters as well as biosensors; (4) a physiological study of the cardiovascular and respiratory systems of the crocodile and also thermoregulation. As the programme gains momentum, our scope will be broadened.

The programme is now about three years old and perhaps the earliest lesson learned has been that the rate of progress is very much dictated by the particular difficulties created by the remoteness of the crocodile habitats. The annual monsoon season destroys the already tenuous road access for up to eight months of each year. In short, crocodiles live in an area where logistic difficulties present themselves at every turn.

Mounting expeditions to some of these northern areas is an art in itself, to say nothing of conducting scientific activities once one is on the site. The early days of the programme have been spent learning to cope with the problems of

remoteness and inaccessibility, but despite this a good deal of initial survey work has been done. Until the last few months we relied mainly on four-wheel drive access to an area of interest and then set up a base camp. From this base camp survey work was carried out up and down the main rivers and their tributaries using aluminum open boats powered by outboard motors. In some cases access was gained not by road but by chartered vessel.

In an initial survey, two boats travel together, one on each bank, and note where crocodiles have left marks on mudbanks. Because tidal influence may extend sixty to eighty miles up from the mouth of the river, one must time the survey to coincide with low tides in the part of the river to be searched that day. Tides are quite unpredictable in some of these complex river systems, sometimes even on a day to day basis, and this has added to the difficulties. Only a few crocodiles may actually be sighted in such a traverse, for crocodiles are wary of man, but when they enter or leave the water across the exposed mud along the riverbank, tracks or 'slides' are left and one can gauge the size of the crocodile from these tracks. These 'slide counts' are used as an indication of relative abundance. Comparison of numbers gained in this way allows comparison of densities between different rivers.

Data from a second type of survey can also be considered. In this second technique, the same ground is traversed at night with a strong spotlight mounted on each boat. The reflective tapetum of a crocodile's eye shows up in the spotlight as a ruby red glow, even from several hundred yards away. The crocodile is then approached and its size estimated if one can get close enough. Once again, numbers recorded allow comparative assessments between different rivers and on the basis of this survey work future planning can be done in relation to areas with high or low population density.

In association with these initial survey stages, we began to learn how to capture crocodiles alive. This is an essential part of all the other aspects of the programme and live capture presented all sorts of problems. Crocodiles up to about a metre long can be seized from the water by a man standing in the bow of the boat—as long as the boat driver understands the technique and is sufficiently skilled to put the boat on the crocodile accurately and then back off before captor and captive are propelled over the bow should the boat strike the bank or a log. Snake 'tongs' can also be used where the small croc is lying at the surface or among mangrove roots or pandanus. These techniques can be employed only at

night as it is usually impossible to approach crocodiles closely in daylight.

We have tried a variety of systems for seizing larger crocodiles from the water and have developed a special net which is successful for crocodiles one or two metres in length. We have been experimenting with nets set in various ways. One of the problems here is that a crocodile will drown if netted in a way that prevents him from surfacing so the nets must be visited very frequently. To get around this problem we have developed a system of 'net alarms' which consist of a sensor on the net and a radio transmitter hung in a tree on the bank. When the net is shaken, the sensor triggers the radio transmitter to send out a signal in its own code. This way we know which of the five or six nets we have set needs to be investigated. One of the problems here is that sharks and catfish can also set off the alarm so we frequently have to cope with false alarms.

Netting is a very safe way of capturing large crocodiles because it seems a natural reaction for them to roll in an attempt to free themselves and this enmeshes the snout firmly. The jaws are thus immobilised and with some care the animal can then be handled in safety. Quite recently our group has developed and tried another technique for catching large crocodiles—setting a bag-like net on land, baited with a dead shark. When the crocodile enters the trap and tugs at the shark, the trap is sprung and a draw-string closes the bag behind him. This seems to be a very promising technique.

We have had considerable success immobilising crocodiles with drugs. This facilitates safe handling and minor surgical manoeuvres such as biosensor attachment once a large crocodile is captured. The idea of capturing crocs using an anaesthetic-loaded harpoon is very attractive but we have not pursued this because of the time taken for drugs to act. This technique always presents difficulties if applied to an aquatic animal.

As a result of the initial survey work, it became clear that the Liverpool River system has a fair population of crocodiles. The area has been selected for a detailed ecological and behavioural study now being implemented by Grahame Webb, a biologist who joined the programme last year on a full-time basis. Working in this area we have the logistic advantage of the settlement at Maningrida being at the mouth of the Liverpool. The Department of the Northern Territory has made available the premises which used to be operated by their Fisheries Section so we now have a permanent establishment there with a

laboratory, workshop, office, galley, and accommodation. A barge from Darwin calls every couple of weeks and can transport heavier items, and a regular air-service between Darwin and Maningrida facilitates transport of personnel. Maningrida will serve as a northern headquarters for all the crocodile work but it is primarily a base for the detailed work in progress in the Liverpool River area.

The aim of the programme in the Liverpool River system is to carry out a detailed ecological study. Already more than 400 crocodiles have been captured, weighed, measured, marked and released. Length-frequency data already establishes distinct year-classes among the population. Some animals have been recaptured after twelve months, and the growth rate of these individuals has been surprisingly high. Several nests are under observation to determine the incubation time and behaviour of the juveniles after hatching. One nest has been wired with thermocouples to assess the thermal environment of the incubating eggs. We hope to learn the role of the mother in guarding the nest and to look for evidence of predation on the incubating eggs. In time the breeding biology will be documented and estimates of survival made. Male and female territoriality will also be studied. The movement of

A large crocodile has left this impressive record of his presence on an exposed mudbank in the Liverpool River.

Gordon Grigg



'Dino', a two and a half metre croc, has just had his radio tracking transmitter attached.

individual crocodiles will be monitored using radio tracking techniques. Work on these techniques is well under way.

Radiotelemetry is not something new; it has been used by a wide variety of workers in many fields. But so far the development of radiotelemetry devices has been rather haphazard and there was great need for the establishment of a full-time radiotelemetry group for the development of sophisticated devices. The radiotelemetry within the programme is in the charge of Keith Brockelsby, an innovative electronics engineer with wide experience in satellite tracking. He assures me that the problems of tracking a spacecraft are minor compared with tracking a crocodile which spends some of its time under water, much of it muddy, and among vegetation along river banks. The telemetry unit now consists of a total of five people and this will be expanded shortly with the addition of two academic staff.

The group has been charged with the task of designing and building a transmitter with a long range and long lifetime—small enough to be carried by a crocodile—whose signal will traverse vegetation. Electronically the problems have centred on building an ultra-high-frequency transmitter and receiver. The long-life power supply has also caused problems. A transmitter has been developed which operates from rechargeable batteries—the recharging being done by solar cells. This takes advantage of the crocodiles' habit of basking in the sun. Choosing a suitable antenna

has often proved a problem in other biological tracking work. A whip antenna is difficult to mount on an animal. Brockelsby solved this by deciding to work at ultra-high frequency so the antenna is merely a short stub within the transmitter package. The first transmitter was put onto a 2.5 metre female croc in the Liverpool River last year and despite various trials and tribulations sufficient success was attained to demonstrate that radio tracking of crocodiles from the air is a feasibility. More transmitters are now in production and we expect to attach several more onto crocodiles in the 1974 dry season. A host of further developments by the telemetry group can be expected.

Not least among the problems encountered in the telemetry plan has been that of attaching the transmitter to the crocodile. We finally (after two years of experimenting) chose to site it on the animal's head—this giving maximum display of the solar cells to sunlight. But how to attach it? After months of experimenting and co-operative thought, we devised a system involving stainless steel clips into the skull platform and this seems to be a success. The crocodile we fitted with a transmitter in July last year is still wearing it under field conditions. In March we removed a dummy package that had been in place for ten months from a croc at Taronga Zoo. Theoretically the transmitter has an unlimited life because of the solar cells. If the attachment is completely successful it may be possible to monitor crocodile movements for years. The present tran-



Gordon Grigg

Bill Green



smitters are rather too large for animals less than two and a half metres long and plans are afoot for micro-circuit techniques and an increase in frequency so that the size will be further reduced, perhaps to one quarter or less. Concurrently with that, the telemetry unit is concerning itself with biosensor development to enable physiological data to be monitored. This is one part of the work with which I am closely associated and before this year is over I hope we will have made significant progress in this direction. Too long, I believe, have whole-animal physiologists studied animals under laboratory conditions. Through telemetry it will be possible to ask many of the same questions of animals free-ranging in the wild.

The physiological programme is one which is ripe for a broadened scope. Studies on thermoregulation and on respiratory and cardiovascular dynamics are in the early stages and these are a mixture of laboratory and field-based programmes.

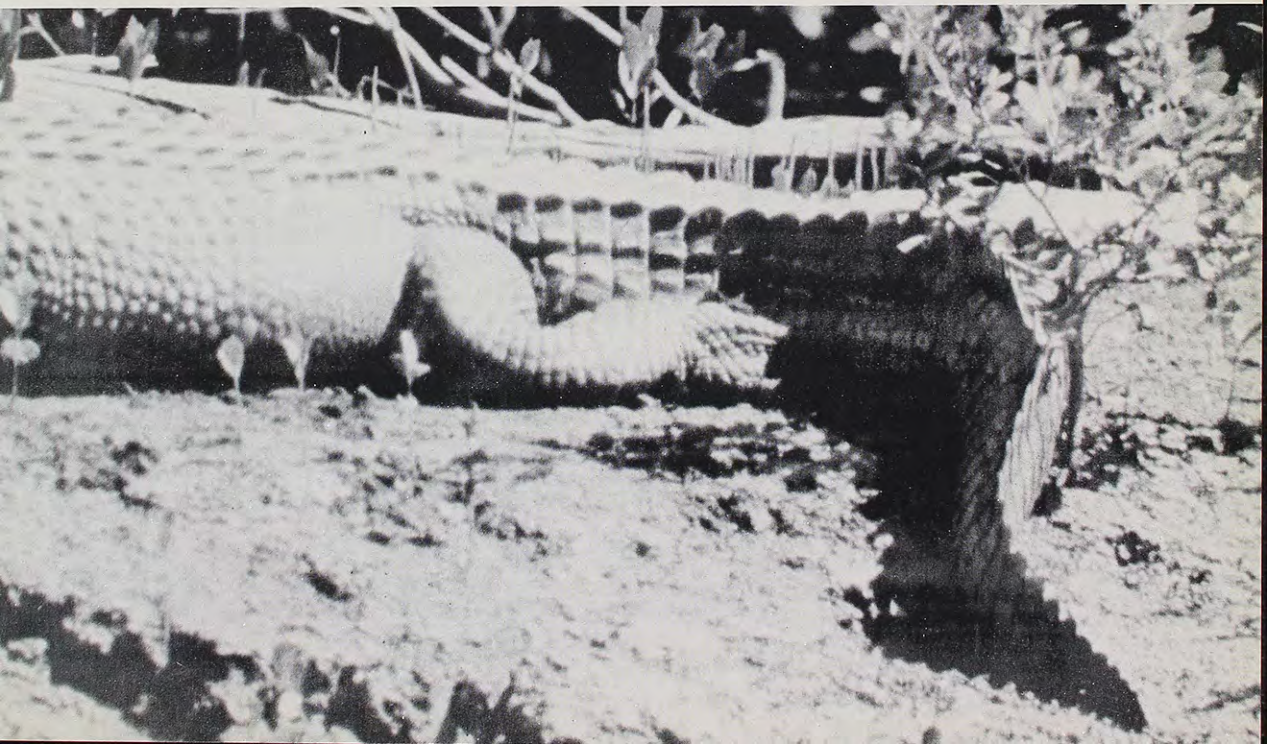
During the last year Messel has taken positive steps to cope more adequately with the logistic problems associated with the remoteness of crocodile country. A 21-metre, 127.5-tonne research vessel named 'The Harry Messel' by the Council of the Science Foundation has been launched and has undergone sea trials, and is now operating from Maningrida. It carries accommodation for eleven, a small laboratory, and two special five-metre aluminum boats powered by outboard motors. This is a floating base camp

which can gain access to the lower reaches of northern rivers allowing personnel to penetrate far up the rivers in the smaller boats. A light aircraft, Cessna 206, has also been purchased. This is to be equipped with floats as well as wheels so that it can operate to suitable aquatic landing sites and be used in conjunction with the ship for general logistic purposes and also for tracking crocodiles from the air.

The first three years' work has been biased towards solutions to logistic problems. Most of these amazingly difficult problems have, we hope, now been solved and the last few months have seen the beginning of serious data collection. We now have the facilities to carry out long-term studies in Northern Australia. This last wet season saw the beginning of what we hope will be continued student involvement. We provided return air fares and keep for seven biology students from several universities and in return, the work they did was invaluable. We will encourage this casual student participation in future and the time has now come when we look forward to students planning post-graduate programmes within the framework of the organisation. There is plenty of work to be done.

Why work on crocodiles? I pondered this question the year before last as I sat astride an immobilised thirteen-footer, suturing an electrocardiogram transmitter into place. There must be easier animals to work on. Perhaps, I decided, we are working on crocodiles because dinosaurs are extinct.

'Jocky', more than three and a half metres long, basks on the muddy shore of Gudgerama Creek. His radio transmitter can be seen on his head.



STOLEN SONGS AND OTHER SOUNDS

BY A.H. CHISHOLM

There has been sporadic discussion of late on whether vocal mimics among wild birds ever imitate sounds other than those of their feathered neighbours, and in particular whether any mimics (in a free state) ever imitate sounds produced by humanity.

Numbers of reports have made it clear that lyrebirds have been known to render the cries of

her home uttered a laughing scream the sound was promptly echoed by a Satin Bowerbird in the scrub closeby.

All eight species of Australian bowerbirds, including the stage-making Toothbilled Catbird, are vocal mimics. They appear to vary in competence according to species, and perhaps also according to locality within a species. The Regent Bowerbird, it would seem, is the least addicted to the practice, and the Spotted Bowerbird is the most consistent and talented performer. In addition to numbers of bird calls, mainly harsh ones, imitations recorded for the Spotted Bowerbird include the noise made by emus when scrambling through wire fences, the squealing of rabbits, the chopping of wood, the sounds of motorcycles, and even the rolling of thunder.

Still more remarkable, one of these mockers has been reported by Ms. D. McCulloch, to have reproduced faithfully the voices of three women in spirited chatter, as heard by the bowerbird from a perch near a homestead in central Queensland.

More recently, a similar achievement has been ascribed to the Fawn-breasted Bowerbird, the one member of the *Chlamydera* genus that has been little studied in Australia, though some evidence of its mimetic ability has been gained in the Cape York area. Lately, this bird has been subject to close attention in Papua.

In reporting on this subject, W. S. Peckover does not cite any instance of mimicry by the Fawn-breasted Bowerbird at its bower, but says that males may be heard while they are sitting quietly in trees imitating in low, clear tones the voices of other birds and the noise of passing trucks. He also states that the mimicry sometimes extends into imitations of a human conversation in the local language or in clear, understandable 'pidgin'.

What feats are these—wild bowerbirds 'talking' in two languages! Such performances surely rival and perhaps excel that of the Spotted Bowerbird in imitating the chatter of three women in argument! Certainly the two achievements (apart from other records) amply answer the question of whether wild birds ever imitate the human voice.



E. J. Whittourn/National Photographic Index of Australian Birds

Superb Lyrebird
(*Menura superba*)

native mammals and the barking of dogs, and among other observations of the kind, wild Black-backed Magpies have been heard in different areas, to reproduce the neigh of a horse, the bark of a fox, the bark of a dog, and cry of a cat.

Several species of Australian birds have also been credited with reproducing sounds of human origin. Achievements of the Superb Lyrebird include imitating the blast of a timber-mill whistle, the misleading of surveyor's men by imitations of a shrill code of signals, and—this on the part of a semi-domesticated bird—the use of words and phrases under the tuition of farmhands.

Imitations of human whistles have been credited also to the Rufous Thrush by Ms. H. Curtis of Tamborine Mt., Queensland, and to the Rufous Scrub-bird by S. W. Jackson. In Jackson's case the mimic gave its imitation immediately on hearing the original sound. Similarly, Ms. Curtis says that when a boy near

A.H. CHISHOLM, well-known journalist and naturalist, is a past president of the Royal Australasian Ornithologists' Union and has, over the past sixty-three years, written many articles and books on natural history subjects.

Should such imitations be regarded as freakish? In any event, they are in accord with the known ability of certain accomplished mimics to reproduce the jumbled chatter of birds in a flock.

The experienced 'lyrebirdologist' R. T. Littlejohns used to be astonished (as was I) by frequently hearing a Superb Lyrebird in Victoria's Sherbrooke Forest faithfully rendering the chatter of an entire flock of Crimson Parrots, and a bushman has told me that he was once greatly impressed on hearing a Spotted Bowerbird giving "a wonderful imitation of a whole flock of Apostlebirds".

Most reports of the Satin Bowerbird's mimicry have been based on specimens kept in aviaries. David Fleay, writing from West Burleigh in Queensland, gave a striking example. He said that a male in one of his aviaries, at the age of four and a half years (and then rapidly gaining adult plumage), revealed strong ability to use other birds' notes—and that, curiously, at second hand.

"Almost every day", Fleay said, "I hear this fellow rendering the cry of the Wedge-tailed Eagle, the calls of the Grey Thrush, the chatter of parrots, and various sounds of alarm, all of which are second-hand because this bowerbird merely copies the repertoires of local lyrebirds."

Although a dedicated ornithologist, and although he has seen much of the beautiful Golden Bowerbird during years of residence on the Atherton Tableland, north Queensland, J. A. Bravery rather rashly committed himself in 1970 to the statement that the species is "apparently unable to mimic". In so writing, he had



J. R. McCann/National Photographic Index of Australian Birds

overlooked definite records made by early observers, and also my own experience of the bird's mimetic ability.

Now, rather to my relief, Bravery has become 'converted'. Writing on 28th November, 1971, he informed me that when visiting the head of the Walsh River he heard and saw a Golden Bowerbird imitating perfectly calls of the Pied Currawong, Crimson Rosella, Stripe-breasted Thrush, and several other species. As the head of the Walsh is about 1160 metres above sea-level, it is suggested that altitude may have an influence on vocal production. Personally, I think it likely that seasonal conditions or physical factors, rather than altitude, create these variants.

That other distinguished stage-maker of our north-eastern highlands, the Toothbilled Catbird, also presents a problem with regard to vocalism. Some observers have never detected mimicry in this species; others have only heard vague suggestions of imitations in its extraordinary chattering songs. Still others have reported hearing competent mimicry.

Bravery says that near the spot where the mimetic golden bird performed he also heard a Toothbill clearly imitate calls of the White Cockatoo and several other species, and soon afterwards a second Toothbill rendered calls of Noisy Friarbirds.

He adds that the Toothbill is quite unpredictable as a vocalist and, as in the case of the other display artists of the area, he suggests that altitude may influence its performance.

As remarked earlier, it is now clear that all of Australia's bower-building birds (at least the males) are vocal mimics, their ability ranging from the modesty of the Regent Bowerbird to the remarkable skill of the Spotted Bowerbird. Is the practice, one wonders, common to all or most of the bowerbirds of Papua-New Guinea? Does it extend beyond the Fawn-breasted and possibly the

Yellow-throated Scrubwren (*Sericornis lathamii*)

N. Chaffer/National Photographic Index of Australian Birds



Lauterbach Bowerbird, both close relatives of the Spotted Bowerbird, to the beautiful Golden Regent Bowerbird? Also, does it extend to those remarkable Papuan artists, the Gardener Bowerbirds? Determination of these questions is awaited with interest.

Grey-backed Silvereye
(*Zosterops
halmaturina*)

Another pretty problem on the general subject relates to the use of mimicry by young birds. Ellis McNamara, of Mt. Kembla, NSW, records having heard, in mid-summer, an immature Whipbird, while fossicking about an open patch, repeating over and over calls of the Crimson Rosella, Golden Whistler, and Red-browed Treecreeper. The borrowings were interspersed with its own calls, and in general it appeared to be 'practising'. Later, in a different area, he saw and heard another immature Whipbird giving a similar performance, imitating chiefly the calls of the Grey-breasted Silvereye and the Grey Fantail. Such an achievement—slight voices rendered by a bird whose own chief notes are very robust—tallies with the ability of the Superb Lyrebird, which sometimes imitates quite well the slender voices of very small birds.



Spotted Bowerbird
(*Chlamydera maculata*)

N. Chaffer/National Photographic Index of Australian Birds

McNamara says that when he owned a pair of canaries their songs became favourite subjects for imitation by silvereyes in the surrounding orchard and also by Yellow-throated Scrubwrens in a gully nearby. Both of these birds are, of course, assured mimics.

When I first wrote on vocal mimicry at some length in 1932, the number of Australian species listed as vocal mimics stood at thirty-six. In 1964 I gave the figure as fifty-four. In 1967, five other species were cited on the authority of various observers, these being the Figbird, Brown Songlark, King Parrot, Crimson Rosella, and Palm Cockatoo. Especially notable, it was commented, were the records relating to the last-mentioned three. All were tendered by competent naturalists



N. Chaffer

and referred to free-flying specimens, and so they banished the belief that such birds never use imitations except when taught in captivity.

Now comes another unexpected addition to the list. Lyle and Eileen Courtney, of Maryborough, Victoria, have told me that when in the Wyperfeld National Park in September 1970 they saw and heard a fine male Golden Whistler, sitting a metre aloft, imitating notes of the Grey Thrush. The mimicry was not always perfect, nor was it rendered without effort—the mocker seemed to be concentrating very hard—but it was so unmistakably imitative of thrush notes that, on first hearing, both listeners expected to see a member of that species. No other imitations were heard.

As far as I know, the only other example of mimicry ascribed to a Whistler is one mentioned in the *Queensland Naturalist* in February 1968. It claims an instance of the Rufous Scrub-bird (itself a talented mimic), being vocally imitated by an Olive Whistler on the McPherson Range. This was possibly a case of confusion, and so I do not at present accept the claim.

Obviously, however, mimetic notes are apt to be produced spasmodically by an individual of a species that does not usually render imitations. The Golden Whistler record is a case of the kind. Others include my two surprising records of mimicry of the Scarlet Robin both by a Grey Fantail and a Red-capped Robin.

For the present, however, the tally of vocal mimics in this country stands at sixty native and four introduced species.

It should be added that in recent years the vocal reputations of several birds previously regarded as only casual mimics have been considerably enhanced. This applies especially to the Shriketit and the Speckled Warbler, and perhaps it also applies to the Mistletoe-bird and some of the thornbills.

The Shriketit is indeed a competent 'all-rounder', for in addition to being a skilled nest-builder and so resolute an insect-hunter that it may sometimes use a probe to dig prey out of tree-holes, it is able to vary its usual high-piping monotone by using, intermittently, the voices of several other species. I have also known it to produce, at odd times, a charming whisper-song of its own.

Another case of what appears to be inconsistency in the use of mimicry within a species is that of the Mallee Heathwren. Its highly gifted relative of near-coastal areas, the Chestnut-tailed Heathwren, has been known in the Sydney district to have imitated, as a species, the voices of thirty-five kinds of birds (as against twenty-three recorded for the more cloistered lyrebird), yet the Mallee Heathwren has rarely been reported as a mimic. Personally, I have never known this little inlander to intersperse its own spirited song with imitations. Nor did I know more than one record of the kind until recently J. N. Hobbs informed me that in May 1970, in western NSW, he heard and saw a Mallee Heathwren faithfully rendering the song of the Western Warbler.

Naturally, Hobbs was much impressed by hearing an elfin voice of the trees imitated (and that in the non-breeding season) by a lark-like voice of the ground. I have had a similar feeling on several occasions through hearing, near Sydney, a heathwren perched low in a shrub rendering finely though softly the rollick of the tree-dwelling Rufous Whistler. But, of course, you get this kind of oddity in reverse at times, as for example when an English Starling transfers the vocal explosion of a Blue Wren from a shrubbery to a rooftop.

Some of the later information regarding vocal imitations has come from banding activities, for netted birds are apt to produce 'distress mimicry'. A curious case in point is that of a Chestnut-tailed Thornbill which, while being banded, reproduced perfectly a diminutive imitation of the chuckling melody of the predatory Grey Butcherbird. Doubtless, distress mimicry should be regarded as being somewhat distinct from declaimed imitations (such as those of lyrebirds) and also distinct from those rendered as tranquil whisper-songs.

But all imitations, it would appear, lack utilitarian value. They are I think, used by birds that are not only sensitive to certain types of sounds but are capable of expressing their receptivity, and the impulse to 'souvenir' the sounds is in part pleasurable and in part simply automatic.

In the cases of master-mimics such as the lyrebirds, heathwrens, scrub-birds, and field-larks—'stolen' notes are retained and mingled with 'natural' notes. But, in numbers of other instances, species which are not assured mimics are apt to be engaged by certain short and distinctive calls of other birds (or, as mentioned earlier in this discussion, even certain human sounds), and may repeat them immediately but just as promptly forget them. The borrowings do not become part of their repertoires.

Two particular instances of the kind remain with me. As a female lyrebird near Sydney was walking slowly towards her nest a currawong passed high overhead and uttered its 'curra-wa, currawong', and at once the lyrebird, without lifting her head, quietly echoed the call. True, the female lyrebird is known to possess modest mimetic ability, but in this case the imitation appeared to be merely a spasmodic response to a resonant sound. In my second and more recent case the bird, also a female, was one that has never been recorded as a mimic. A Magpie-lark ('Peewee') was seeking fragments of food on a lawn in a Melbourne park when a raven flying



N. Chaffer/National Photographic Index of Australian Birds

past overhead uttered its harsh 'car-r', and immediately, to my astonishment, the Peewee casually repeated the call.

Chestnut-tailed
Heathwren (*Hylacola
pyrrhopygia*)

Those two cases—automatic reactions to compelling sounds—remind me of an occasion when, in a Sydney national park, two small boys involuntarily imitated the crack of a whipbird. That was in fact a double borrowing, for the call the lads were imitating was being rendered by a lyrebird!

FURTHER READING

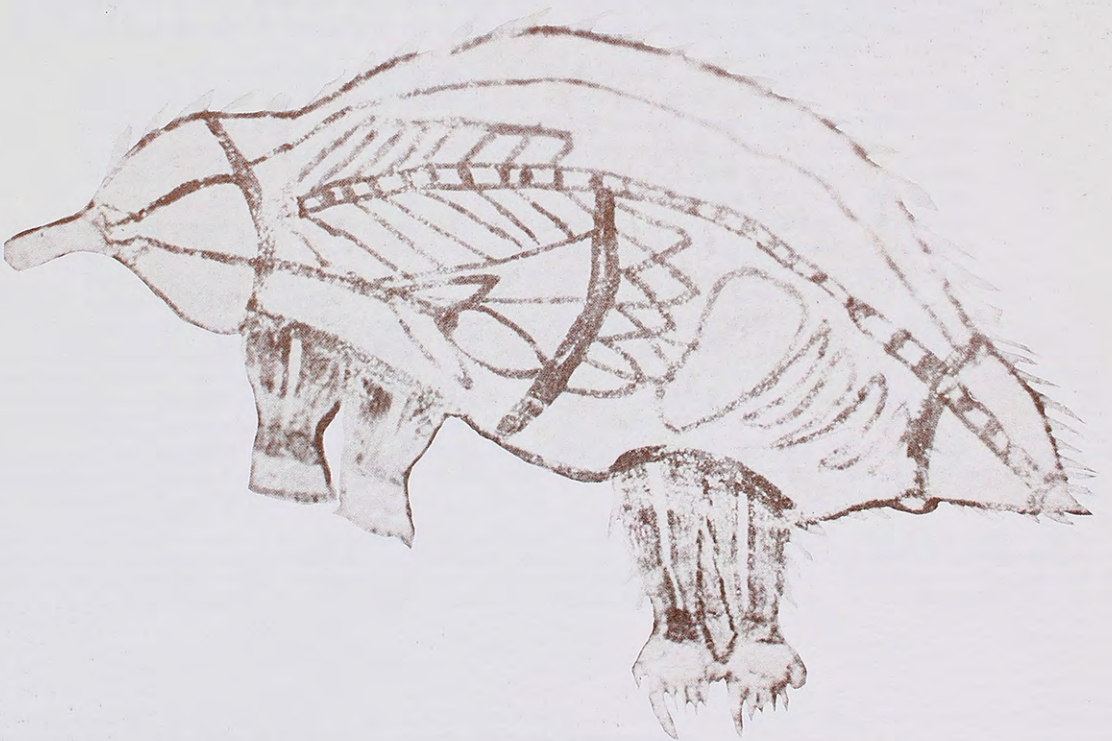
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Serpent and kangaroo ancestors met at this site in the legendary Dreamtime. Aborigines sometimes revisit the area to perform age-old rituals which perpetuate the journeys of the spirit heroes. (Central Arnhem Land)

ABORIGINAL ROCK PAINTINGS

CONSIDERATIONS FOR THEIR FUTURE



AUSTRALIAN NATURAL HISTORY/A SPECIAL SUPPLEMENT
SEPTEMBER 1974

Australian Aborigines painted and engraved many thousands of rock and cave sites throughout the continent. Traditionally, special relationships were created and re-created between the sites and generations of Aborigines. The closeness of these relationships varied from the involvement of keepers who painted, maintained and restored the sites to the less direct associations of those who simply obeyed the cultural law of not disturbing or interfering with them. All, however, were locked into a pattern of rights, responsibilities, and obligations within a general attitude which could most properly be called 'cultural respect'.

This traditional pattern is now fragmented; only in isolated areas are there sites with proper keepers and the consequent attitudes of cultural respect. Most sites are no longer being painted or restored according to cultural traditions. In these cases, the paintings are fast disappearing. Many people who were familiar with rock paintings in their childhood and who have returned to the same sites in later years can describe the changes and losses that have occurred. Occasionally the images have disappeared altogether. Sometimes just the lower limbs of figures have been rubbed away by animals huddling against the rock for shelter. There are often reports of large painted areas being washed away by heavy rain and even whole galleries becoming so faint that the details of the designs have been lost forever.

Today, increasing numbers of people are visiting painted and engraved sites—tourists with a special interest in Aboriginal cultures, explorers, archaeologists and anthropologists, and those concerned with the preservation of the sites. Such a range of visitors may indicate cultural awareness, but at the same time presents important ethical and conservation problems.

The familiar Western ethic assumes the right to preserve all material of sufficient antiquity, artistic or scientific merit which, undoubtedly, includes Australian Aboriginal rock paintings. Some people believe that this country's first responsibility is to preserve Aboriginal cultural material as part of the world heritage while others advocate a more parochial attitude to satisfy European Australian cultural interests. But is it ethical to ignore the cultural, emotional, political, and social interests of the Aborigines themselves? Aboriginal concern for these sites may be directed less toward physical preservation than toward their more urgent problems such as the nature of policy-making and control, site administration, and land rights. The future of painted and engraved sites can be seen as only a small part of the wider social and political issues in which Aborigines are involved. Such a diversity of attitudes and opinions both broadens and complicates the basis from which decision-making processes will determine the future of these sites.

This three-part article explores the many different and often conflicting issues related to Aboriginal sites in Australia—their significance to the people who painted them, their importance for Aborigines no longer directly associated with them, their value for scientific study and enjoyment by tourists, and the options available for their protection and preservation.

S.W. & T.W.

Over-
leaf: The
x-ray style
of painting
reached its
highest stage
of develop-
ment in Arnhem
Land. This figure
of a spiny ant-
eater was painted
in white and red
ochres on the wall
of a rock shelter
site occupied off
and on for some
twenty thou-
sand years. (Deaf
Adder Creek Valley,
Alligator Rivers
region, Arnhem Land)

PART ONE
FROM THE DREAMTIME...
BY ROBERT EDWARDS

PART TWO
STUDIES IN CONSERVATION
BY SUE WALSTON

PART THREE
POLITICS AND ETHICS
BY TERRY WIDDERS

ROBERT EDWARDS is Director of the Aboriginal Arts Board of the Australian Council for the Arts and Deputy Principal of the Australian Institute of Aboriginal Studies. He has had a life-long association with Aborigines and has worked with them on the preservation of their culture. Edwards was responsible for the organisation of a National Seminar in 1972 which led to the adoption by the Australian government of a five-year plan to locate and record Aboriginal sites of significance throughout Australia.

SUE WALSTON is in charge of the Conservation Laboratory at The Australian Museum. She is interested in the preservation of Aboriginal rock paintings and engraved sites and in studying the deterioration of wood and fibres in Australian and Pacific objects including Aboriginal bark paintings.

TERRY WIDDERS is Secretary of the Commission on Aboriginal Development of the Australian Council of Churches and a member of the Aboriginal Arts Board. He sees Aboriginal culture and, by implication, Australian culture imprisoned and stifled by the political state—for Aborigines by the curtailment of their personal and cultural freedom and for European Australia by the truncation of their cultural experience and by their fear of accepting and living in a multi-cultural nation and world.

The Trustees of The Australian Museum gratefully acknowledge a grant-in-aid from the Aboriginal Arts Board of the Australian Council for the Arts toward the production of this special supplement.

FROM THE DREAMTIME

When European settlers first came to Australia the whole continent was occupied by Aborigines who had lived in harmony with the land for more than thirty thousand years. Their cultures had adapted to a wide variety of environmental conditions, from the arid central deserts to the lush sub-tropical north. Although they did not erect large and complex structures or extensively modify their habitats, the evidence of their existence over this long time span is displayed throughout the continent in a manner uniquely Australian.

Wherever the Aborigines lived, they left traces of their special way of life and, necessarily, of their adaptation to the changing environment. Such evidence is very valuable to science and has implications to the whole history of mankind. For example, systematic excavation of typical rock shelters in Arnhem Land demonstrated that edge-ground axes were produced in Australia twenty thousand years ago. The antiquity of these artefacts is not paralleled anywhere else in the world. Stone arrangements, burial grounds, carved trees, bora rings, fish traps and hunting hides are further material traces of the Aboriginal oc-

cupation of the land. Aboriginal occupation sites also provide valuable information about prehistoric environments. Edible marine fauna gathered by Aborigines many thousands of years ago, not extant as shell middens, illustrates changes in climate and sea level. This forms part of the total ecological history of the continent.

European impact in Australia has been brief, harsh, and almost fatal to Aborigines and their sites. There is no need to reiterate the bitter history of contact between Aborigines and European settlers in Australia. The issue here is the physical survival of Aboriginal sites. To Europeans these sites are aesthetically pleasing and/or scientifically valuable, but more important, they are vital to traditional and urban Aborigines as a part of their culture or as links with their past.

The relationship of Aborigines to the land which they inhabited was precisely focused on features of the landscape. Some of these are spectacular; others are so subtle and insignificant to Europeans as to escape notice. Trees and waterholes were created by totemic ancestors. Rock outcrops manifest their final form. Rivers

An important rock art gallery known as Obiri Rock (Ubir) where an extensive overhang protects a large frieze of polychrome x-ray paintings. (East Alligator River Crossing, Arnhem Land)



ME....

meandering across the landscape are paths of the Rainbow Serpent. These sites which Europeans usually disregard embody the deepest levels of Aboriginal religion.

The walls of many caves and rock shelters display brilliantly coloured paintings in a wide variety of styles. These range from simple representations of animal tracks to complex and sophisticated motifs closely associated with the religious life of the tribes. Designs have also been engraved on rocks and trees. Radio-carbon dates indicate that some of this art is as old as the great classic art sites in western Europe. Apart from its intrinsic beauty, in many parts of Australia this art still has a vital role in Aboriginal culture. In other areas, paintings and engravings are the sole relics of a way of life which has gone forever. Even these essentially prehistoric art sites provide de-tribalised Aborigines with a valid appreciation of their rich cultural heritage.

Many landscape features have or had considerable significance of a sacred or mythological nature to living Aborigines and should therefore be regarded with respect and given due attention in any development plan. Identifying these sites is not always easy. The existence or nature of some sites is a secret not revealed at all, or at most to a few in the strictest confidence. Even then, information may be revealed only progressively.

To protect such sites, advice is needed from the Aborigines whose traditional rights may be concerned, but because of changes in the original distribution of tribes, there are problems in determining who is now affiliated with certain sites.

Tribal Aborigines belong to territorial clans. Amongst these, individuals may be found who are particularly knowledgeable and interested in matters concerning the land within their territories. Clan territories have no distinct boundaries. Their borders should be regarded as corridors rather than as well-defined lines. They are like clusters of sites that are significant to the clan. Territories and their bounds are determined by conspicuous natural features—rock outcrops, waterholes, etc.—that have economic or purely legendary, but more often mytho-totemic significance. Among the latter are the 'sacred-dangerous' sites which are often beyond the borders of a particular clan. The delineation of borders is thus complicated by the fact that certain

'sacred' sites or ceremonial grounds are shared by several not necessarily adjoining clans. This can result in apparently contradictory attributions unless the complex clan affiliations are understood. In Aboriginal tradition, there were no 'paramount chiefs'. Instead there were recognised leaders—initiated men who were 'experts' for each aspect of communal activity. Similarly, there was no one administrative border of the clan territory. Instead, interclan activities (economic, religious, ceremonial) created overlapping spheres of influence, and more than one clan may be concerned with the same site. There are, then, difficulties in identifying those who are most directly concerned with specific areas.

Practically all natural features—have Aboriginal names, most of which are equivalent to European geographical names. Some refer to favoured hunting, food-gathering, and camping places. Others have legendary significance. This category includes 'dreaming places' of a non-sacred nature. The most important sites are those of mytho-totemic significance—places where great ancestral being emerged from the ground, where they are now said to reside—features these mythical beings created during the 'Dreamtime' (the time of creation). Some of the sites are considered 'sacred' and/or 'dangerous'. That is, present-day Aborigines avoid approaching them for fear of being killed, contracting diseases, or

For many centuries, Aborigines in the Murray Valley cut large sheets of thick bark from River Red gums for use as canoes. Many of the scarred trees have survived to be a permanent reminder of this unique tradition. (Blancetown, South Australia)



Robert Edwards

causing natural catastrophies such as rock falls or floods. They also hesitate to reveal information about them to others.

Many of these 'sacred-dangerous' sites are connected with the Rainbow Snake or Serpent, one of the most powerful creator beings and well-established mythology is associated with some sites. These myths explain the existence of prominent natural features, their association with the people in whose territory they are located, and the sacredness and awe in which they are held. A simple myth related about one site follows.

"*Kudjumbandi*, in the Myra Falls area of the Northern Territory, was a good campsite and many different tribes used to meet there for ceremonies. Once there was an orphan with a group of people camped there. He cried for his mother. His relatives offered him different kinds of food but he kept on crying. They told him to stop or the Rainbow Serpent would come and get him. He kept crying and the Rainbow Serpent came and devoured all those people."

It must be emphasised that only the Aborigines for whom a particular site has ceremonial or clan relevance can provide details of its location and importance. Information may be revealed after the enquirer has won the confidence of the informants, but the extent of some sites may be difficult to define because of the Aborigines' fear of going near them. This in itself indicates their importance.

Anthropological writings indicate that the Aborigines' attitude to many of the sites recorded by Europeans is fear of any interference such as disturbance of ground, trees, or other associated features; even noise is felt to be dangerous in some instances. But all too often their feelings are disregarded—if considered at all.

A site which is highly sacred to the Pitjantjatjara people of central Australia was recently desecrated by a group of field geologists engaged in a survey of mineral resources. Unwittingly, they used a traditional stone arrangement to make one of their survey cairns. Other stones which represent parts of the bodies of totemic ancestors were smashed to provide routine petrological samples.

At the Laura Aboriginal galleries in Cape York, photographers moistened paintings to make them stand out for photography. As a result, whole figures were washed from the walls. Vandals frequently write names in charcoal in the galleries to the detriment of the art.

In Queensland, a small site near Mount Elliott, south of Townsville, was completely destroyed by a road gang. Certain rock art sites have also been 'improved' by the addition of figures; other sites

in the Carnarvon Ranges have been deliberately destroyed by overpainting.

At Ayers Rock lead based paints were sprayed over cave art, while near Alice Springs fragments of rock were levered and chiselled from a historic art site first recorded in 1896. In South Australia one site was destroyed by a large painted advertisement which completely covered a series of ancient red ochre drawings. Even in the depths of Koonalda Cave, vandals have scratched initials across the twenty thousand year old wall markings.

The comparative inaccessibility of some parts of north Australia until the last decade has minimised the instances of damage to art sites by vandals. It is refreshing to visit many remote galleries and find the paintings unmarked by initials and lettering and few instances where portions of painted rock have been levered from the walls. Vandalism will become a major problem only if the region is made easily accessible to large numbers of people without adequate safeguards and specific protection of important sites.

People who have settled in Australia in the last two hundred years have rarely appreciated its Aboriginal heritage. Their value system has been dramatically different. Apathy has permitted indiscriminate destruction of Aboriginal sites. This position has been aggravated by recent rapid development. Urban expansion, intensive agriculture, highway construction, power corridors, mineral exploitation, general population growth in remote areas, increased mobility and tourism all take a toll of these diminishing resources.

The need for urban expansion and rural development in Australia is recognised; however, it is very easy to lose sight of a vital resource in the desire for such development. Aboriginal sites are such a resource, and adequate steps must be taken to ensure their preservation. Unlike flora and fauna, once destroyed they do not regenerate.

The problems associated with the conservation of Aboriginal cultural sites have always concerned a dedicated few, but attempts to improve the situation have been sporadic and localised. State administrations have taken legislative initiatives for which they deserve full credit, but legislation is only a framework. In the final analysis, Australia's performance will be judged against that of other countries with similar problems and resources. So far, our showing is poor.

In 1968, attention was focused on the problem of locating and protecting sites and monuments when the Australian Institute of Aboriginal Studies convened a national symposium. The recommendations of that meeting were totally ignored. In 1972, another symposium on the same



topic reviewed the achievements of state administrations in this field. At the same meeting tribal Aborigines had, for the first time, the opportunity to express their distress at the current situation. As a result of this meeting, the Australian Government accepted as a priority a five-year plan for the recording, protection, conservation and development of Aboriginal sites throughout Australia.

An Executive Committee—comprising relevant state representatives, specialists in related fields, and Institute executive personnel—was set up to administer the programme. National priorities are its main concern. These are executed by the funding of on-the-ground surveys of Aboriginal sites, with the active involvement and co-operation of Aborigines at all levels. Aborigines are employed

as rangers, wardens and site surveyors. They are also represented on committees dealing with these matters at state and federal levels.

The main thrust of the programme is recording of sites which are significant to living Aborigines. The second priority is the recording of sites where no traditionally-oriented Aborigines survive. The importance of both aspects has been illustrated.

Twenty-one full-time positions have been created, of which twenty are administered by the appropriate state authorities. The work of these field officers has already resulted in the recording of many highly significant sites throughout the continent. As soon as the full complement of field workers has been appointed, more than a hundred sites per month should be recorded. This infor-

STUDIES IN CONSER

Over the thousands of years of human habitation in Australia, Aboriginal cultures developed into the highly complex, successful and specialised ways of life that thrived at the time of the European invasion. The painting and engraving of rock surfaces has been an integral part of this culture for as long as legends recall. Some sites have been proved very old, but scientific techniques cannot as yet provide reliable dates for the majority of sites in Australia.

The purpose, meaning, content and style of Aboriginal paintings varies from site to site as it does from region to region. Examples of the more spectacular paintings are widely known, such as the Wandjina in the Kimberleys, the Quinkans in southern Cape York, the Lightning Brothers at Delamere, and the X-ray figures in Arnhem Land.

The significance of some paintings may be in the visual image alone, while others take on meaning only in association with certain objects or activities. A new painting may exist in isolation, or it may be significant only in the relationship it forms with other symbols on the rock surface. The painter may apply new images over old paintings or he may pick a new space. He may choose to liberate powers bound up in earlier paintings by restoring them with fresh paint. However, the need and fulfillment of the

ceremony are shared by the community and do not belong to the painter alone. This is in contrast to so many other parts of the world where art is an esoteric expression performed and observed by the qualified minority only.

Robert Edwards



mation is already enabling state authorities to determine the appropriate application of relevant protective measures.

The initial allocation will enable site recording on a significant national scale. The next stages of the programme are a necessary follow-through and at present they are insufficiently funded.

It is important to create greater Aboriginal involvement in the general programme. Once sites have been surveyed, they must be protected. It is appropriate that Aborigines be deeply involved in this work. Permanent appointments for Aboriginal personnel in this field is an absolute first priority.

Physical protection of sites in relation to natural deterioration and environmental factors must also be given special and immediate attention.

Controlled development of particularly sig-

nificant sites as tourist attractions may be a means to ensure their protection. Such sites could contribute materially to the public's appreciation of the Aboriginal way of life. In some areas, the relevant authorities have chosen to develop selected sites for this purpose with the result of relieving the pressure on other sites of equal or greater significance.

It must be emphasised that these projects have to date been funded as pilot studies only. The main attention should be on an expansion of their application.

Urban and rural development and natural deterioration have resulted in the destruction of vast numbers of Aboriginal sites, but there are still opportunities to preserve a large part of Australia's Aboriginal heritage.

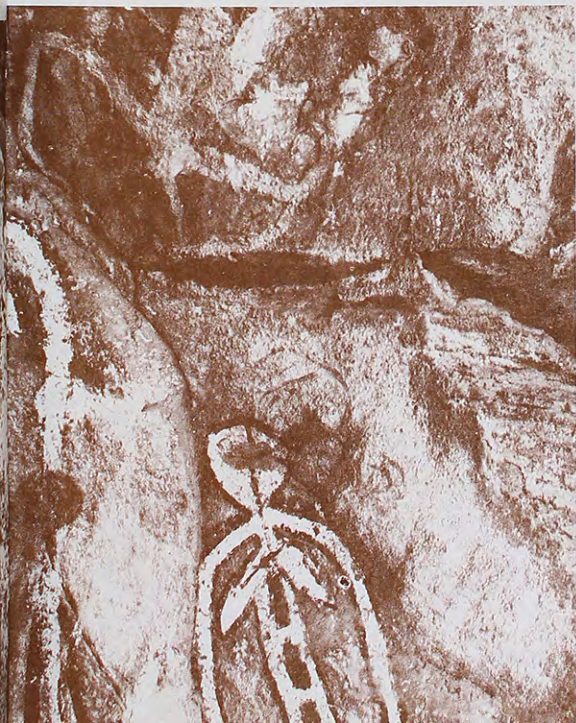
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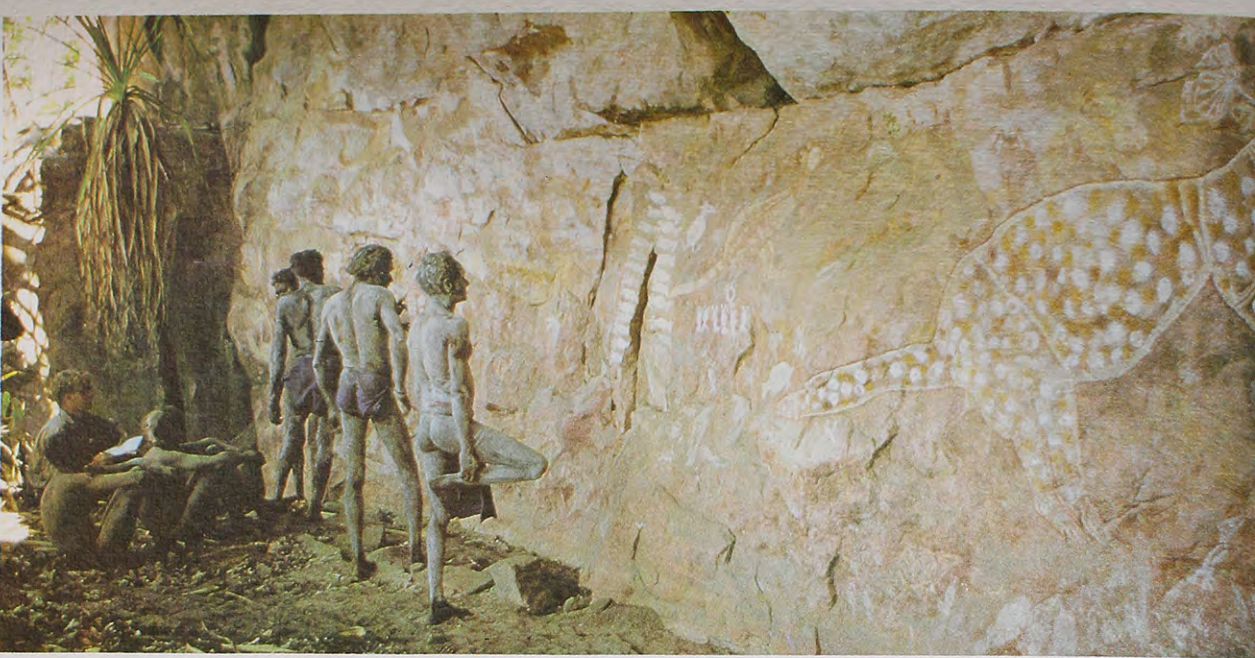
To understand and appreciate the magical, mythological, practical, or secret nature of the paintings may be beyond all but those most closely involved with Aboriginal culture; but in spite of continuing emotional and spiritual

feelings of Aboriginal groups towards their sites, the cultural gap between the traditional origins of the paintings and the present day is becoming wider. It is now rare for people to return to their sites to paint and restore according to customary needs and traditions. As the withdrawal of Aborigines from traditional activities continues, the deterioration and disappearance of their paintings becomes more apparent.

Since it is community involvement in the paintings that is important and not the longevity of the finished product, it is easy to understand why the development and use of durable materials has been of little consequence. The materials Aborigines use for painting are usually obtained from natural local minerals—yellow and red ochres, white clay and gypsum, and black manganese oxide and charcoal. These are either applied directly or ground to a powder, mixed with water and sprayed or painted on the roofs and walls of caves and rock shelters. Because binding media are seldom used, the paints tend to shrink and become brittle as they dry, increasing their vulnerability to weathering. Paint loss during this initial stage of deterioration may be serious, but it is only the first in a series of problems threatening painted sites that are no longer being restored.

Female spirit figures at the Nangaloar gallery are believed to have been of special significance to Aborigines of the region. Archaeological excavations of the adjacent cave floor deposits provided evidence of only recent occupation indicating that the site was sacred and not inhabited for long periods. (Noarlangie Rock region, Arnhem Land)





Robert Edwards





Robert Edwards



Robert Edwards



Top Left: The legends associated with rock art sites are recorded by anthropologists for future generations. (Central Arnhem Land)

Above:
There are many examples of paintings in northern Australia almost totally obliterated by channels made across the rock surface by white ants. Careful removal of the earth trails reveals that the ochres beneath have been destroyed as a result of this activity. (Deaf Adder Creek Valley, Alligator Rivers region, NT)

Left:
The Lightning Brothers, a site where regular rain-making ceremonies were held at the beginning of each wet season to ensure continuity of the regular seasons. Aborigines perpetuated the ritual for untold centuries until settlement caused extermination of the local group. (Delamere Station, Northern Territory)

Weathering of both the rock and the painted surface happens as a result of various mechanical, chemical and biological activities. Evaluation of the relative importance of different weathering mechanisms requires comprehensive data on the properties of the rock and the surroundings of the site. Rock is extremely diverse in composition, and even within similar rock types, the proportion of cementing mineral and the degree of cementation can vary considerably.

Water is the worst single factor contributing to the deterioration of rock paintings. The most obvious example is driving rain entering the caves and rock shelters and washing away unbound pigments. As well as such direct action, humidity, dew, surface water and groundwater, and their associated corrosive impurities can cause serious

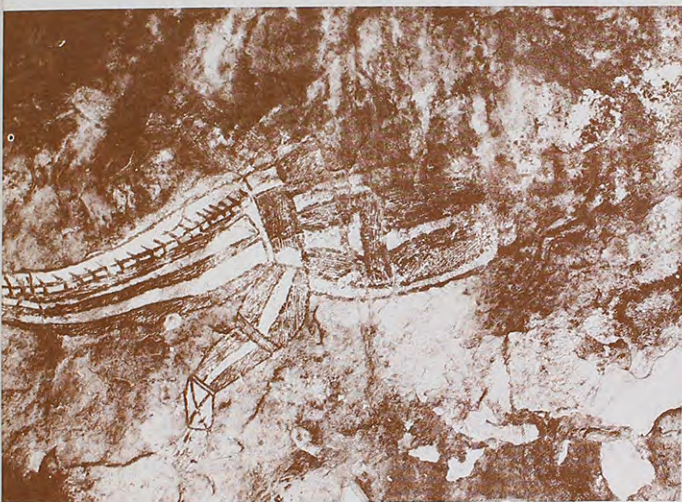
put the rock under tremendous strain. This often results in thermal differentiation cracks in more exposed situations.

The biological agents responsible for the decomposition of rock and its painted surfaces are often neglected. Where there is water, organic activity is likely. Algae, fungi, lichens, bacteria, mosses, and larger plant forms are responsible for both mechanical and chemical damage to the rock. Fungi, for example, produce destructive quantities of oxalic and citric acid which measurably increase the weathering rate of silicates. Bacteria may induce equally aggressive reactions. Most plants contribute to the deterioration of rock by their ability to retain water. The root action in plants produces humic, carbonic, and other organic acids which accelerate the breakdown of rock, particularly limestone. The continued growth of plant matter in the vicinity of the paintings encourages the formation of cracks which provide increasing access points for the seepage or flow of water. This water not only washes away paint but also deposits minerals on the rock surface that can discolour or completely obliterate the paintings.

Dust-laden winds may, in theory, damage the surface of Aboriginal painted rock shelters, but these paintings are often protected from the wind by a surface coating of silica. Over a long period of time, sufficient silicious material has been dissolved out of the sandstone by percolating water and deposited on the surface to form this hard protective layer. If however, this protective surface is disturbed, by either internal or external pressures, the underlying rock becomes extremely vulnerable to weathering.

Animals are also responsible for major defacement of paintings. Wild goats, kangaroos, and domestic animals rub away pigment from the lower regions of the caves and shelters, while birds and mud-daubing wasps can obscure details by building their nests on the roofs and walls.

Perhaps the one destructive element which does more to threaten the paintings than all of the others is the increasing numbers of visitors to the sites. It is the curiosity and increasingly vandalistic attention of humans that is potentially the most damaging. The more aggressive individuals come prepared with firearms or cans of aerosol enamel; others are content to scrawl their thoughts in chalk or charcoal found near the site. Some leave their mark permanently engraved in the rock surface or are compelled to use hammers to take portions of the rock as souvenirs. Many of the people who deface Aboriginal paintings are not even aware that their actions could possibly be offensive. Even those who come with interest



Robert Edwards

Water running back from the drip-line of this Arnhem Land cave has almost completely destroyed a large figure of a crocodile painted in x-ray style. Damage of this kind is prevalent throughout Australia. (Noarlangie Rock, Arnhem Land)

problems. Soluble salts carried through the capillary structure of the rock can have a devastating effect. Constant movement and swelling due to the drying and crystallisation of solids near the rock surface is a major factor in the splintering and flaking of the rock and the loss of pigment from the surface. The oxygen in rain and its readiness to combine with any unstable minerals in the same way that metallic iron rusts is a common reason for the discolouration of rock. Rain can also promote other harmful reactions. The removal of oxygen from certain minerals and their combination with water, results in alterations to the dimensions and composition of the rock and pigments.

Another destructive element, particularly in the inland regions, is wide temperature variation. Rock is composed of a variety of minerals which expand and contract at very different rates. The great fluctuations, even within twenty-four hours,

and appreciation may endanger the paintings since the physical and chemical effects of constant fingering increases the rate of deterioration.

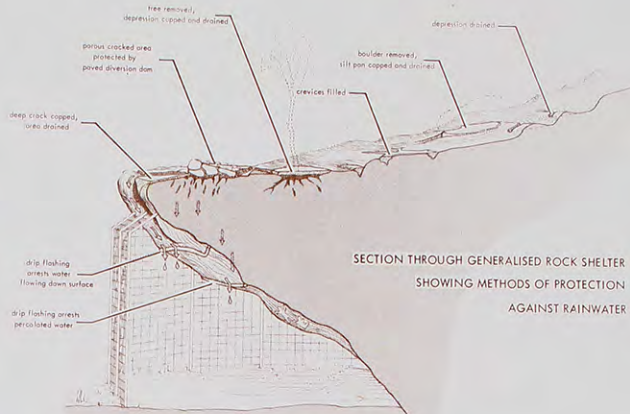
Although many people are intellectually committed to encouraging Aboriginal cultural traditions and to preserving Aboriginal antiquities, it is remarkable how little action has resulted from this interest. Extraordinarily few resources have yet been directed toward the conservation of Aboriginal paintings.

A programme for the conservation of rock paintings should start with the collection and interpretation of data from the Aboriginal sites and their associated environments. This would involve a study of the geology and land formations of an area supported by laboratory examination of rock samples, corrosion products, and pigments.

Field studies may identify the dominant mechanical weathering agents affecting rock paintings. In some cases the erosion process responsible for the initial formation of the shelters may still be active; in others this process may have been considerably altered by changing environmental conditions. It is important also to look into the reasons why certain sites have remained in good and apparently stable condition.

Further analysis of sample material should be undertaken in the laboratory. Mineralogical and petrographic examination will provide details on the composition of the rock and the degree of chemical and structural alteration it has undergone. Similar techniques may be used to identify the paints and their adhesive qualities, and the depth to which the paint has penetrated the rock may be measured.

Before beginning the scientific procedures necessary for the conservation of Aboriginal paintings, a programme of site priorities must be established. In selecting a site for preservation, certain practical considerations must be taken into account. A comparison should be made of the weathering rates of the sites under consideration. The composition of the rock at one



Brian Bertram from Sue Walston

SECTION THROUGH GENERALISED ROCK SHELTER
SHOWING METHODS OF PROTECTION
AGAINST RAINWATER

site may be so unstable that decomposition is inevitable in the near future. On the other hand, some sites are so protected and the rock and pigments so stable, that immediate action is unnecessary or even undesirable. The locations of sites are also of prime importance in allocating priorities for their preservation. A particular site may be impossible to protect if it is well-known and within easy access from a road, therefore it would rate a low priority on purely practical grounds. Finally, it is important to be cautious. Many of the experiments in rock and stone conservation throughout the world have resulted in accelerated deterioration.

The two areas in which I have been working demonstrate many of the problems affecting Aboriginal paintings. The sites at Mootwingee, in the arid northwestern corner of New South Wales, are composed of particularly unstable sandstone. Over the years, the gypsum and kaolinite cementing materials have dissolved out of the rock leaving it weak and crumbly. These minerals can often be seen as disfiguring patches of white crystalline powdery crust on the surface of the rock. Silicious material as well as the cementing material has been dissolved out of the rock. Probably the only reason the rock and the paintings have survived at all is that enough silica has built up on the surface to protect the weaker underlying rock.

Another series of painted shelters at Mt. Grenfell, near Cobar, are composed of consistently sturdier quartzitic sandstone. In this case it is not the rock that is the problem, but the paintings themselves. The pigments have been applied in thick layers and are extremely fragile. The rain that pours down the walls of the shelters and washes away large areas of the paintings is the critical concern.

It is possible to protect sites from rain and runoff by relatively simple and inexpensive

This section through a typical rock shelter shows methods of protection against rainwater.

In the sub-tropical north of Australia, wasps nests built over figures are a major contributor to the deterioration of many fine examples of ancient rock paintings. (Alligator Rivers region, Arnhem Land)



Robert Edwards



processes. This involves an initial survey of the site to determine the source and movement of the water above the shelter. Faults in the rock that permit water to penetrate through to the paintings below must be found. Channels can then be cut or built up to divert the water away from the entrance of the cave. Holes and cracks above the shelter that harbour silt and plants should be cleaned out and capped with cement. Strategic drainage improvements should greatly reduce the amount of water entering the shelter. Where water seepage continues to threaten, artificial drip lines can be applied to the rock to divert the flow of the water before it reaches the paintings.

The procedures developed for the protection of the Mt. Grenfell shelters can be readily adapted to any similar situation. These conservation procedures are particularly valuable where, as in the case of Mt. Grenfell and Mootwingee, they can be coupled with effective supervision and fencing to reduce vandalism and animal interference.

Programmes are now under way in Queensland and Western Australia as well as in New South Wales for the preservation of Aboriginal painted and engraved sites.

Other painted sites in the moist tropical regions of Australia are seriously affected by biological decay. A microbiological examination is required to determine the exact nature and source of the problem before any effective treatments can be developed.

It is relevant to look at the biological investigations that were carried out in France as part of the Lascaux conservation programme. Although Australian cave paintings occur in more exposed and better ventilated situations than the European Palaeolithic sites, their research is valuable to our own investigations.

A commission was set up to investigate the serious problems that occurred at Lascaux when the site was opened to the public. It comprised a team of leading people in the science, engineering, and technical fields. After considerable research, the bacteria and algae attacking the rock were identified. Their means of introduction to the site were traced and the environmental factors that promoted their growth and spread were analysed. From this basic information the team was able to develop specific antibiotics to arrest any further contamination. They also installed equipment to control and monitor the micro-climate within the grotto.

With rare exceptions such as the Lascaux study, the majority of research in other countries has so far been largely directed toward the preservation of building stone. Although this type of research has been under way since the mid-

nineteenth century, it is only recently that a major international effort has been concentrated in this field. The accelerating pollution problems affecting monuments all over the world have emphasised the urgent need for conservation.

Extensive work is now being done by research institutions in many different countries including Poland, Germany, Holland, France, Belgium, Italy, England and America. Chemists have developed a wide range of consolidants designed to arrest the crumbling and flaking of building stone. Waxes, soaps, oils, salts, and numerous synthetic resins have been tried, but a disappointingly large proportion have proved ineffectual or actually damaging to the stone. It has been difficult to ensure adequate penetration of the consolidant so as to impart overall strength to the stone. Usually a skin forms on the surface which is particularly susceptible to differential pressures, and often results in increased flaking. There are also many other problems associated with strengthening materials. Some tend to absorb moisture or break down under exposure to ultra-violet light, some discolour the stone, and others are particularly vulnerable to biological attack.

Although rock sites and buildings may require similar techniques for analysing and measuring the effects of weathering, they are unlike in most other ways. The obvious difference between the two is that rock shelters are a natural occurrence while building stones have necessarily been removed to an artificial situation.

The first priority for the preservation of building stone is that it should retain its solid architectural form. The requirements for rock paintings are more complex. A stable bond between the paint and the rock must be created as well as simply strengthening the rock. Even more important the visual quality of the paintings must not be changed in any way.

It is obvious that extreme caution must be used when considering the possible application of surface strengthening materials to Aboriginal rock paintings. Painted rock in an exposed field situation is considerably more difficult to treat than the relatively homogenous and isolated building stone. There is a need for research efforts to be concentrated specifically on Australian Aboriginal painted and engraved sites rather than having to rely on techniques designed for buildings under European conditions.

Further differences can be recognised between building stone and Aboriginal rock sites where restoration is considered. In almost any situation in the world, when a piece of monumental masonry is threatened, it may be replaced by a

Water flow during heavy rain has washed away the ochres from part of this rock painting. (Mount Grenfell, New South Wales)

The x-ray style of Arnhem Land is an attempt by Aboriginal artists to show that there is more to man and animal than outward appearance. Skeleton and internal organs are depicted in this precise painting of a local species of fish. (Deaf Adder Creek Valley, Alligator Rivers region, NT)

careful copy. But while restoration of historic buildings is accepted as a noble pastime, the question of restoring prehistoric Aboriginal paintings is viewed with horror or meticulously avoided.

It should be realised that restoration of the paintings before any details were lost would at least sustain their 'original' appearance. Perhaps this is a preferable alternative to their total decay and disappearance.

The ethical problems involved in restoration are very real. Is any 'improving' of original paintings ever desirable? Has a thorough and sympathetic consensus of opinion been obtained from all interested groups? Who might undertake such a project? Aborigines from different areas but who still retain their cultural traditions? Others associated with the site? Artists? Restorers? Anthropologists? Many arguments arise from this question and feelings run high. There are numerous arguments supporting Aboriginal supervision or control of sites based on emotional, cultural, and political views. There are equally numerous arguments for involvement by others based on scientific, artistic, or economic grounds. There is also discussion of the integration of ideas and expertise from all groups, but a sense of urgency needs to be introduced. These paintings cannot last forever.

Thus, for conservation, the ethical considerations are clear. It is the conservator's responsibility to bring the facts concerning the deterioration of Aboriginal paintings and engravings to the attention of those responsible for their protection and preservation. They should also indicate possible conservation techniques and the necessary research requirements for long-term preservation. If there is still insufficient support for the preservation of Aboriginal sites, then it will not be due to ignorance of the situation.

In addition to recognising the ethical and practical considerations for conservation, we have also to consider the potential contribution of different interest groups in Australia and the extent to which their sometimes conflicting priorities will effect the future of Aboriginal sites.

The most concentrated interest in Aboriginal rock art probably lies with prehistorians and social anthropologists. Prehistorians are concerned with the paintings mainly for the ancillary information they can provide for the interpretation of material from archaeological excavations. However, only limited reliance may be placed on the paintings; the activities they represent may not necessarily relate to the usage or distribution patterns of artefacts from the different occupation layers. The problem is that though the successive periods of occupation can be dated, the paintings cannot. Thousands of years may separate the cultures responsible for the manufacture of the tools and weapons recovered from excavations from those responsible for the paintings. Anthropologists have also carried out statistical

Robert Edwards



POLITICS AND ETHICS

In Australia today there are few areas (and these are small) where Aborigines are responsible—legally and culturally—for rock art, sites of significance, and artefacts: the material manifestations of Aboriginal culture. In these isolated cases, there is no question of 'the ethics of con-

servation' as the duties and responsibilities of conservation and protection are obvious to the Aboriginal people who are still rooted in tradition. Since most Aboriginal tribes have been displaced from their traditional grounds, however, the ceremonial/teaching cycle which supported the

analyses of the different painting styles, figures, objects, and symbols depicted in Aboriginal rock paintings, attempting to trace the patterns of cultural variation in Australia and by comparative studies with the paintings of European Palaeolithic cultures. Social anthropologists are restricted in their attempts to investigate the socio-cultural significance of rock paintings to those few sites for which there is information from local Aboriginal groups. The inhibiting or destructive effects of the spread of European settlement on Aborigines has left most sites devoid of any associated active cultural traditions. Even in remote areas, paintings at some sites appear to be 'prehistoric' to local Aborigines in that their origin and significance are no longer known. Thus the social anthropologists' primary concern—to investigate, record and explain Aboriginal social and cultural life—has tended to avoid, or at least overlook, the apparently unproductive study of rock paintings.

In terms of achieved results, the overall contribution of academic anthropology to the

evaluation of rock paintings may appear small, but this largely reflects the elusiveness of the material, and has no bearing on its inherent significance. Nevertheless, if the future of anthropological studies of Aboriginal rock paintings and engravings is to be guaranteed, the recording and conservation of the sites and their environments must be accelerated.

Tourism in Australia has developed gradually into a thriving industry. Travel became popular during Victorian times with the introduction of the railways. Now with a high percentage of the population owning cars, even the hitherto inaccessible northern, western, and central areas of Australia are attracting more and more tourists. The tendency of tourists to go on exploratory trips and camping holidays is being encouraged by government and local organisations. The scarcity of commercial attractions and facilities is compensated for by the historic, archaeological, and scenic qualities of each area, and these are being sought out and promoted.

The implications for protection of Aboriginal paintings are worrisome. The increasing numbers of visitors to the sites can only contribute to the deterioration of the paintings and the surrounding area. But is it ethical to restrict public access to the sites, or to force visitors to view the paintings through wire grilles? Must they absorb the atmosphere of the environment under heavy escort? Perhaps the majority of people seek out these sites because of their cultural content; on the other hand, they may just provide the focal point for a weekend picnic. In this case, a faithful facsimile constructed a little further along the range (out of harms way) could be an adequate substitute.

But in whatever manner these problems are to be resolved, the needs and wishes of everyone interested in the sites must be carefully and sympathetically investigated.

All too often the Aboriginal record of first contact with European explorers and settlers depicts guns. The advent of white people in Australia had a profound effect upon Aborigines who went to their sacred caves and painted images of the new arrivals in an attempt to allay their influence. (Tin Camp Creek region, Arnhem Land)



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responsibilities and rights to preserve and protect has lapsed—irretrievably so in most areas. Where these duties and responsibilities are no longer in the proper Aboriginal hands, such matters have become controlled by politicians and their advisers—anthropologists and archaeologists. Only

in this area of political control is there a need to discuss the ethics of conservation and protection.

I shall concentrate on the reality of the politico-anthropological 'method' of conservation and protection and not the myth. A quick historical survey of European concerns with

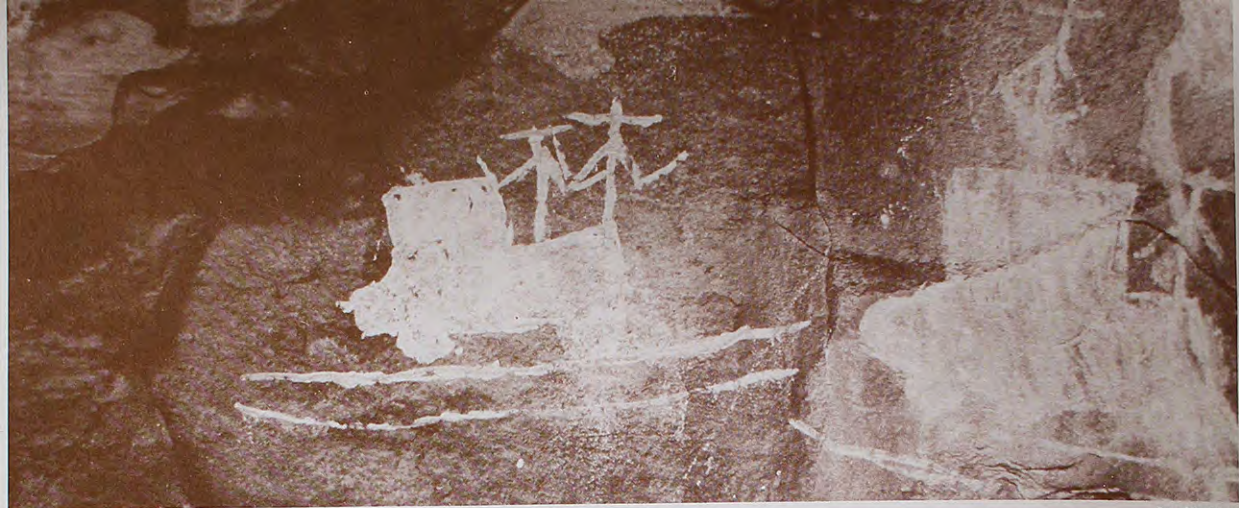


Photo: Robert Edwards

Aboriginal record of the construction of the Pine Creek-Darwin Railway by Chinese labourers in 1886-1889. (Cooper Creek region, Arnhem Land)

Deeply engraved designs on soft coastal rocks in Tasmania's northwest are evidence of an ancient link with the Australian mainland tradition of engraving. (Mount Cameron West, Tasmania)

Aboriginal cultural material tells the reality, which (in sequential order) has been: (a) an almost total ignorance and disregard of such matters; (b) a confused cultural response to Aboriginal art, religion, and social mores—resolved by unsure cultural elitism where contact existed (i.e. anger and persecution)—until strong, traditional Aboriginal culture was destroyed; (c) Aborigines, past and present, becoming objects of study, i.e. Aborigines were a 'dying race' (almost a reality) and making a study of them was the neatest way of tying together European cultural persecution and rejection, and the continuing existence of Aborigines.

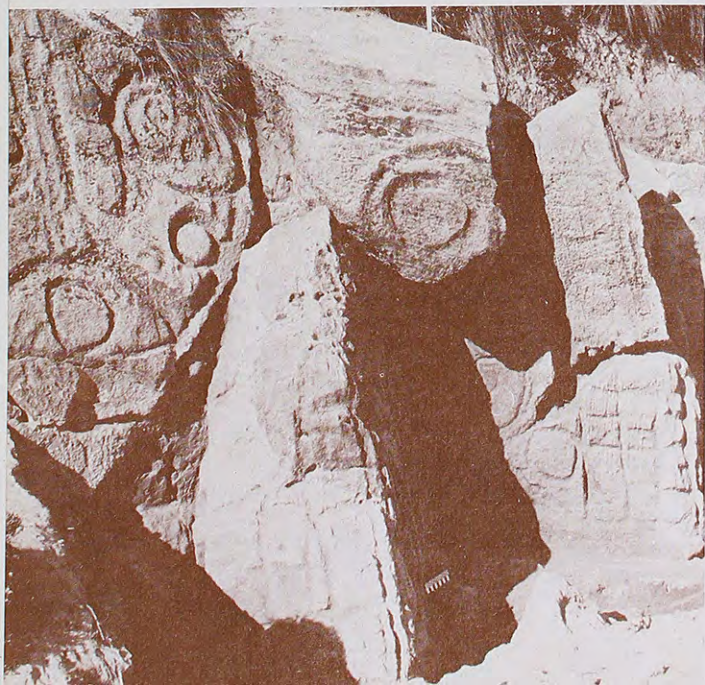
The contradiction within the latter attitude—the present reality of Europeans concerned (for individual reasons) with the ethics of 'preserving and protecting Aboriginal culture'—manifests it-

self in two ways. One is the quasi mixtures of moral, political, and legal 'do-gooding'—in the final analysis hypocritical. The other is the evolving 'uninvolved' academic study of Aborigines.

There is a definite historical sequence in the development of both facets of 'ethical' concern for Aboriginal culture, although the social realities of Aboriginal oppression which nurtured them were common to both. The dichotomy that evolved in the European culture approach—after the simple, straight-forward onslaught from 1788 onwards—was due to 'moral politicians' and 'concerned academics' electing to express views peculiar to themselves at times suitable to themselves. Neither group accepted or accepts any measure of responsibility for what had happened, or is happening, to Aboriginal society. Both, however, had and have selfish interests to exploit.

Take the first facet of 'ethical concern' for Aborigines—is it for our cultural material, or our social reality? It has never been clear to Aborigines just where we stand with European society since the 'Aboriginal situation/problem' has usually been the concern of politicians and academics. Aboriginal existence has never been accepted as an ideological confrontation with Western moves. Aborigines-as-a-moral-issue was primarily an individual (European) concern until the advent of the official states' and federal territories' policies of 'protection' late last century. These statements of 'ethical concern' said in effect "the past and present destruction of Aborigines has this day been officially recognised" and left it at that. This ideology, admittedly state initiated, still pervades all levels of policies today concerned with Aborigines and our culture. It is simply fobbing off Aborigines, politically.

In the first decades of this century the myth



Robert Edwards

makers of European society (the Daisy Bates, official government policies) had the urbanised Australian population believing that the Aborigine as a physical reality was dying away. This was certainly a potential fact, but made Aborigines a 'do-gooder's' moral issue, not an ideological problem to be tackled politically.

The inertia of public response no doubt convinced the various governments to further protect (from?) and succour surviving Aborigines until such time as they disappeared as a distinct race. Politicians did succeed in allowing Aborigines to die as a public issue. In support of such a policy was a growing body of studious anthropological writings and views, intent of course on establishing its own niche of influence. It did, and does, this simply by being 'academic' in its study of the destruction of Aboriginal society, and at appropriate 'ethical' moments advises government of what they think has been happening in Aboriginal society. A neat, double-parasitic relationship if ever there was one. The role is not wholly intentional, but is the most expedient one to adopt if 'science' is to continue in the role to which it has become accustomed.

It was in the mire of public ignorance about the stark realities of Aboriginal oppression that the fruits of past social, political, and personal discrimination were reaped and reinforced by the *apparent* concern of 'protection policies'; and the myth of the dying Aborigine established itself.

From then on, government concerned itself with forming political policy aimed at ameliorating the existing facts of past and present Aboriginal reality, while anthropologists were to conduct 'pure' study into 'Aboriginal culture'—traditional only, that is. The studied Aborigine was coming into vogue and the two chief bodies 'ethically' concerned with Aborigines merely consulted one another.

Up to and including the present, the 'artefacts' of Aboriginal culture have, generally speaking, attracted cultural voyeurs of all shades and hues. That is to say, the physical manifestations of Aboriginal culture—the art, song, and dance—have been preserved, conserved, and occasionally protected by Europeans for a multitude of reasons. Chief among these has been preservation for posterity and academic study, the ethics of which are self-explanatory for those concerned. Unwitting conservationists have included the odd curio-seeker and the ever-present entrepreneur making sales to various culture collectors, both private and professional.

A unique embodiment of all these concerns (though not necessarily entrepreneurial) was the establishment of the Institute of Aboriginal

Studies in 1961. This institution was fundamentally rooted in the premise that the Aboriginal race was dying—culturally—and that a comprehensive, well-sponsored programme was needed to 'salvage knowledge' for posterity. European controlled and directed, the Institute's programme of 'ethical concern' for Aboriginal culture concretely expressed and vindicated the academic 'concern' for same. The coloniser's (latent) attitude towards Aborigines could not have been more appropriately expressed in neo-colonial times—the oppressor mentality now exercising control over public understanding, or misunderstanding, of Aboriginal culture, now termed 'the minority sub-culture'.

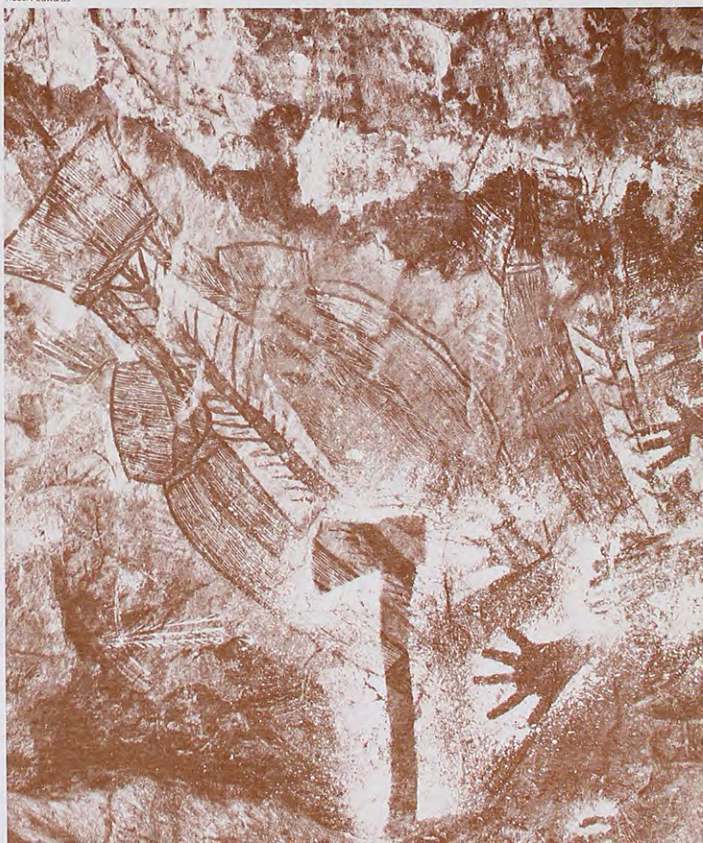
Through the Institute, 'uninvolved' academic studies could take place (subject to government grants, of course) and the rules of operation laid down for the Institute specifically curtails, politically, the Institute's 'involvement' in Aboriginal culture. The ethics of conservation was one thing for the Institute, and quite another for political parties. This was simply because Aboriginal politics had, and has, nothing going for it to interest politicians, either in numbers or in economic power.

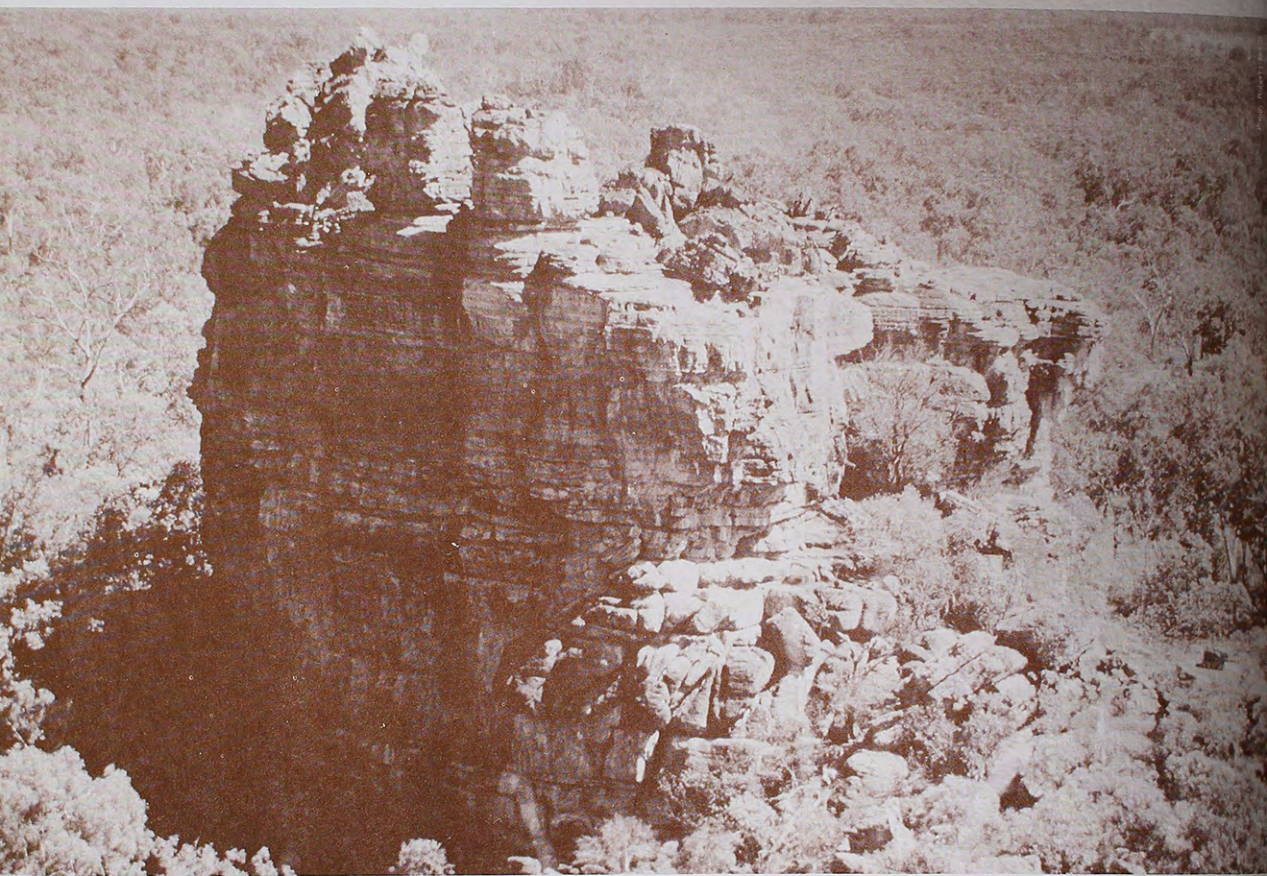
To Aborigines, there is no ethic in 'the ethics of conservation' of academics or politicians in Australia today.

Overleaf: Residual outliers of the Arnhem Land plateau are often honeycombed with rock shelters and caves. These afforded protection for Aborigines during the summer wet season which brought up to seventy inches of rain in much of Arnhem Land. (Alligator Rivers region, Arnhem Land)

Introduction of European tools and weapons was recorded in Aboriginal galleries throughout Australia. Steel axes and hand stencils are often superimposed on earlier art styles.

Robert Edwards







Leg-
endary
heroes of
the Aboriginal
Dreamtime. Archaeo-
logical excavations
in a rock shelter nearby
show that these sites have
been occupied by Aborigines
for over ten thousand years.
(Ingaladdi, Northern Territory)

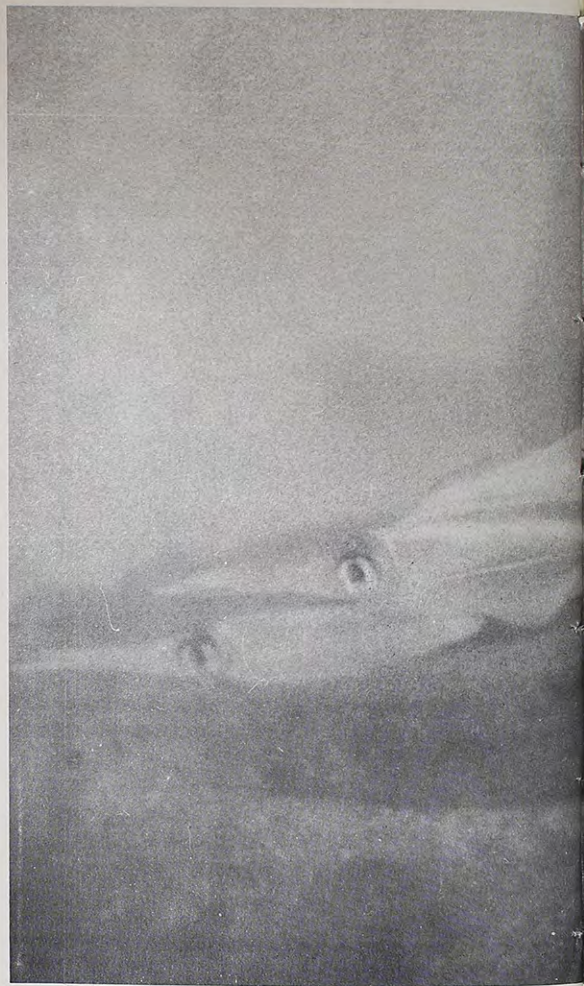
CHANCE ENCOUNTER ON A RUBBER

BY B.C. RUSSELL

Quite by chance, while routinely censusing the fish population of an artificial reef off the coast of New Zealand, I observed egg-laying in a group of Broad Squid (*Sepioteuthis bilineata*). This squid is common in the coastal waters of northern New Zealand and southern Australia during the summer months. Its clusters of rubbery white egg capsules attached to the base of finger sponges (*Callyspongia ramosa*) or to the stipes of brown seaweed (*Ecklonia radiata* and *Carpophyllum*) are often seen by divers. The Broad Squid, though, is a shy animal—difficult to approach closely—and spawning had never before been observed in this species. Indeed very few observations have been made of the behaviour of cephalopods in their natural environment.

The artificial reef had been established to study the development and dynamics of a small fish community and lay on a sandy bottom at a depth of 20m, off Goat Island near Leigh, north of Auckland. It was built from old car tyres bolted together and ballasted with a heavy mooring chain. Tubeworms and barnacles had settled on the rubber tyres and large numbers of hermit crabs and snails as well as several species of fish, inhabited the reef. During the summer I had noticed the appearance of several clusters of squid eggs attached to clumps of dead seaweed which had become entangled in the chain and tyres. Then one afternoon in February 1970, a group of six adult squid were seen.

A heavy swell on the surface of the sea had stirred up the bottom sediments and underwater visibility was reduced to less than four metres. The translucent white bodies and fins of the squid blended well with the light background of the bottom and only the large dark pupils of the eyes were conspicuous as they hovered in close formation over the sand near the artificial reef. Two of the squid were about 35cm long and were larger than the other four which were about 25cm. Each squid held its eight short arms together directly in front of the body, the two longer tentacular arms which are used in prey capture being kept retracted and invisible. Movement of the



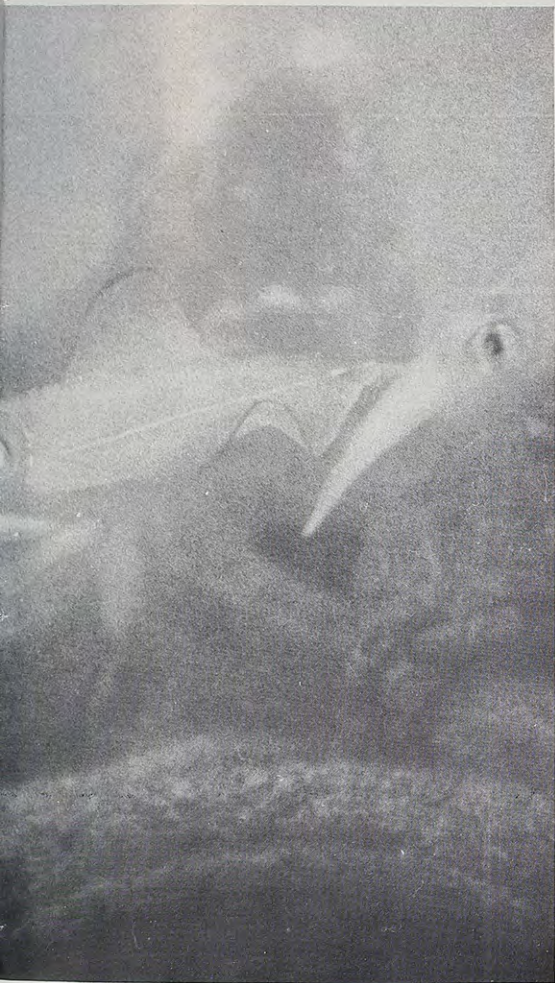
B. C. Russell

group was co-ordinated and they manoeuvred slowly backward and forward by an undulating motion of the long lateral fins. For faster movements, when frightened or for travelling more than a few metres, they used jet propulsion by squirting water through the funnel.

Despite the proximity of my companion and myself, the squid were obviously interested in

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BER REEF



folded the four lower short arms down and back. The remaining upper short arms were kept close together, pointed forward and forming a cone with the apex toward the centre of the mass of capsules. These upper short arms were plunged briefly into the capsule mass, being withdrawn after about two seconds as the squid reversed away leaving a new capsule attached in the centre of the mass. During the brief period of capsule placement, the squid exhibited a colour flush over its entire body, changing from the normal translucent white to a light golden brown. As it withdrew, a jet of water from the funnel was directed at the egg capsules.

Subsequent events proved that the smaller individuals were females and the larger ones, males. Each of the smaller squid in the group placed a capsule in the same cluster, being escorted each time by one or the other of the two larger individuals. The remainder of the group waited closeby while the two individuals involved in egg-laying were separated from them. When the four females had each deposited a capsule the group withdrew from the artificial reef, hovering above the sand about ten metres away. They remained away for about four or five minutes and then approached the reef again and repeated the capsule-laying procedure. This behaviour was observed for a total of thirty minutes until our diminishing air supply forced us to return to the surface. Two hours later, however, another pair of divers watched a group of nine squid placing egg capsules in the same cluster. The following day a lone female squid was also seen attaching egg capsules, this time to a completely new cluster.

This cluster was marked with a piece of plastic tape and subsequently observed. It consisted of about 200 egg capsules, each of which contained between two and six eggs. The eggs were placed in a row end to end and were separated from one another within the capsules. The capsule sheath containing the eggs is formed by the secretion of the nidamentary glands as the eggs are shed from the oviduct into the mantle cavity. The capsule is then moulded as it passes through the funnel to the arms. The material is an elastic protein which hardens on contact with sea water, and it may be that the purpose of forming

Broad Squid undulate their lateral fins to manoeuvre forward and backward. This group is swimming over the artificial reef.

one of the clusters of egg capsules and passed close to it several times. As the group hovered two to three metres away, one of the smaller squid swam directly toward the cluster of capsules. Immediately, one of the larger squid broke away and escorted the smaller one. Remaining close behind and slightly above its partner it blocked the approach of the others with aggressive movements and sudden threatening flushes of chocolate brown colouration. When about 50cm from the egg capsules, the smaller squid

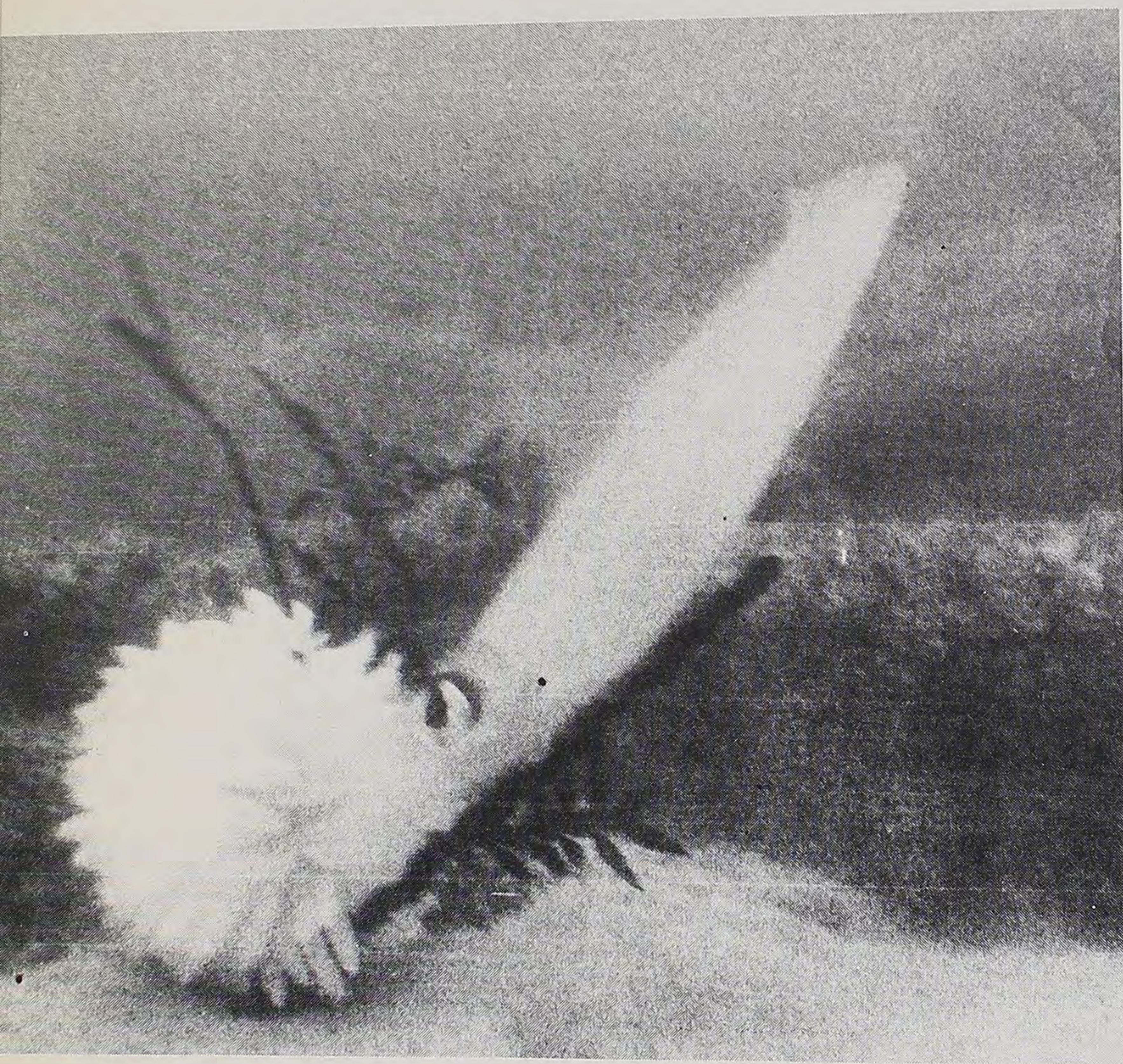
This female squid, approaching a cluster of egg capsules, holds her arms forward and down toward the centre of the cluster.

M. F. Lacombe



Thrusting her arms into the cluster, she attaches a new capsule to the centre of the mass.

B. C. Russell



As she backs away after depositing a capsule, she jets water onto the cluster.

M. F. Lacombe



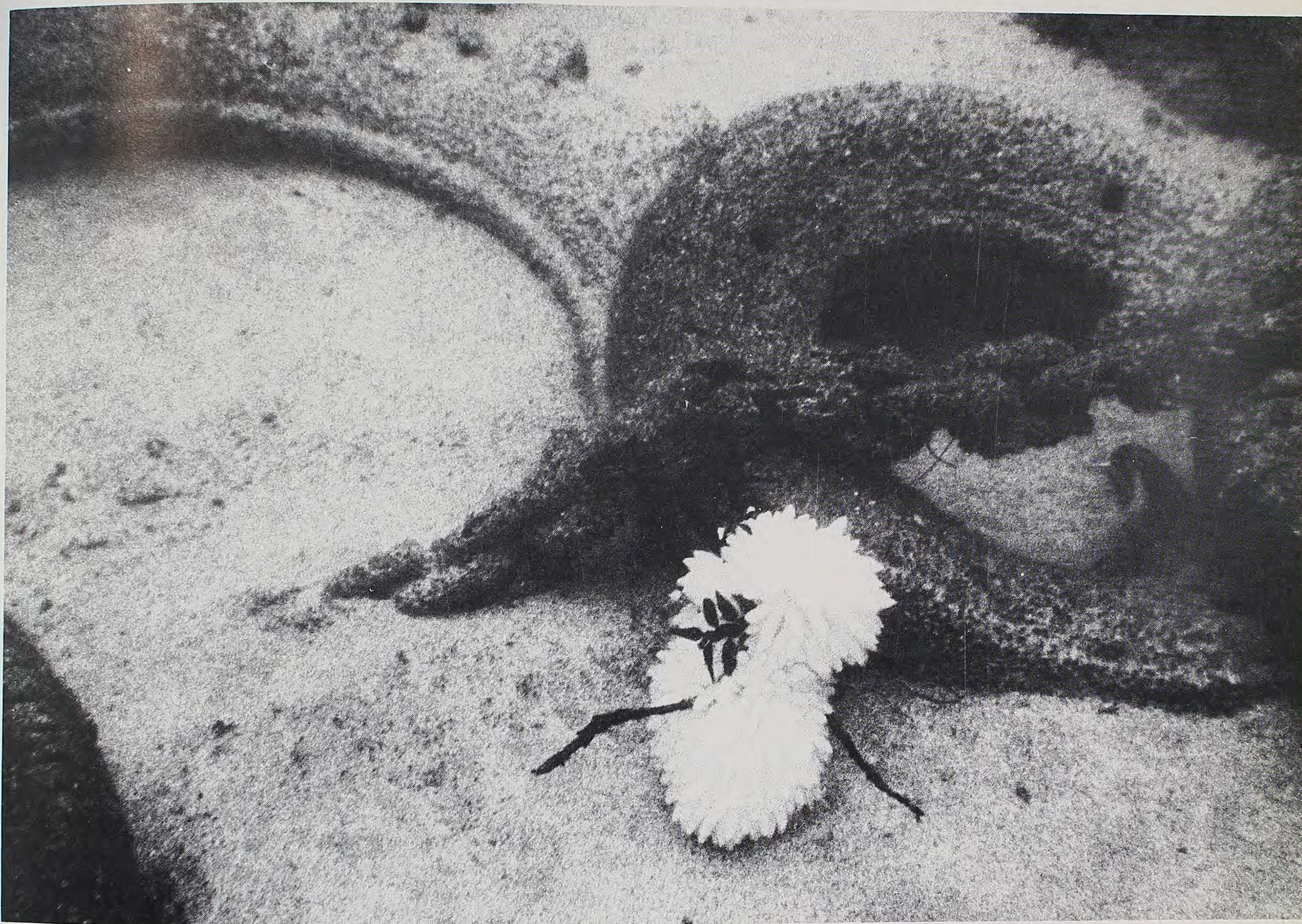
This cluster of egg capsules (opposite) is attached to a clump of dead seaweed which has become entangled in one of the ballast chains of the artificial reef.

the upper arms into a tight cone during capsule placement is to prevent the adhesive attachment portion of the capsule from coming into contact with water and so hardening prematurely. Once it is placed in position, however, the capsule is difficult to remove, and it seems likely that the female's action in jetting water onto the capsule immediately after it is placed may serve to hasten the hardening process and thus ensure that the capsule adheres properly.

Newly laid, the capsules are smooth and a translucent white colour, but as they mature they

which have to be faced as soon as they hatch.

Little is known of the post-larval life history of the Broad Squid, but they appear to grow rapidly and may reach maturity in as little as six months. The Broad Squid, like other loliginid cephalopods, probably has a one year life-cycle and moves offshore after hatching, to return when mature the following summer to lay its egg capsules in shallow water. In other squid such as *Loligo opalescens* in southern California, these in-shore migrations are often associated with the formation of large spawning aggregations and



B.C. Russell

become opaque and discoloured. The outline of the eggs also becomes increasingly apparent as the eyes and the chromatophores develop, and after about four weeks the embryos begin to hatch. Newly-hatched squid are about one centimetre long and are able to swim immediately, progressing with short rapid jerking movements produced by mantle contractions. They are also capable of sudden evasive action using the funnel, and can release ink clouds. This probably helps the tiny squid avoid the many predators

mass egg-laying activity. The Broad Squid, however, seems to differ from other known species, coming together to spawn in only small groups and laying its egg capsules in comparatively small clusters.

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LOCUST PLAGUES AND



Locusts and grasshoppers are among agriculture's most serious insect pests. Colloquially, all these insects may be called 'grasshoppers' but in fact locusts are species of grasshoppers capable of forming dense, migrating swarms. The difference is largely one of behaviour, and locusts are the more destructive because of their gregariousness and migratory habit. When they

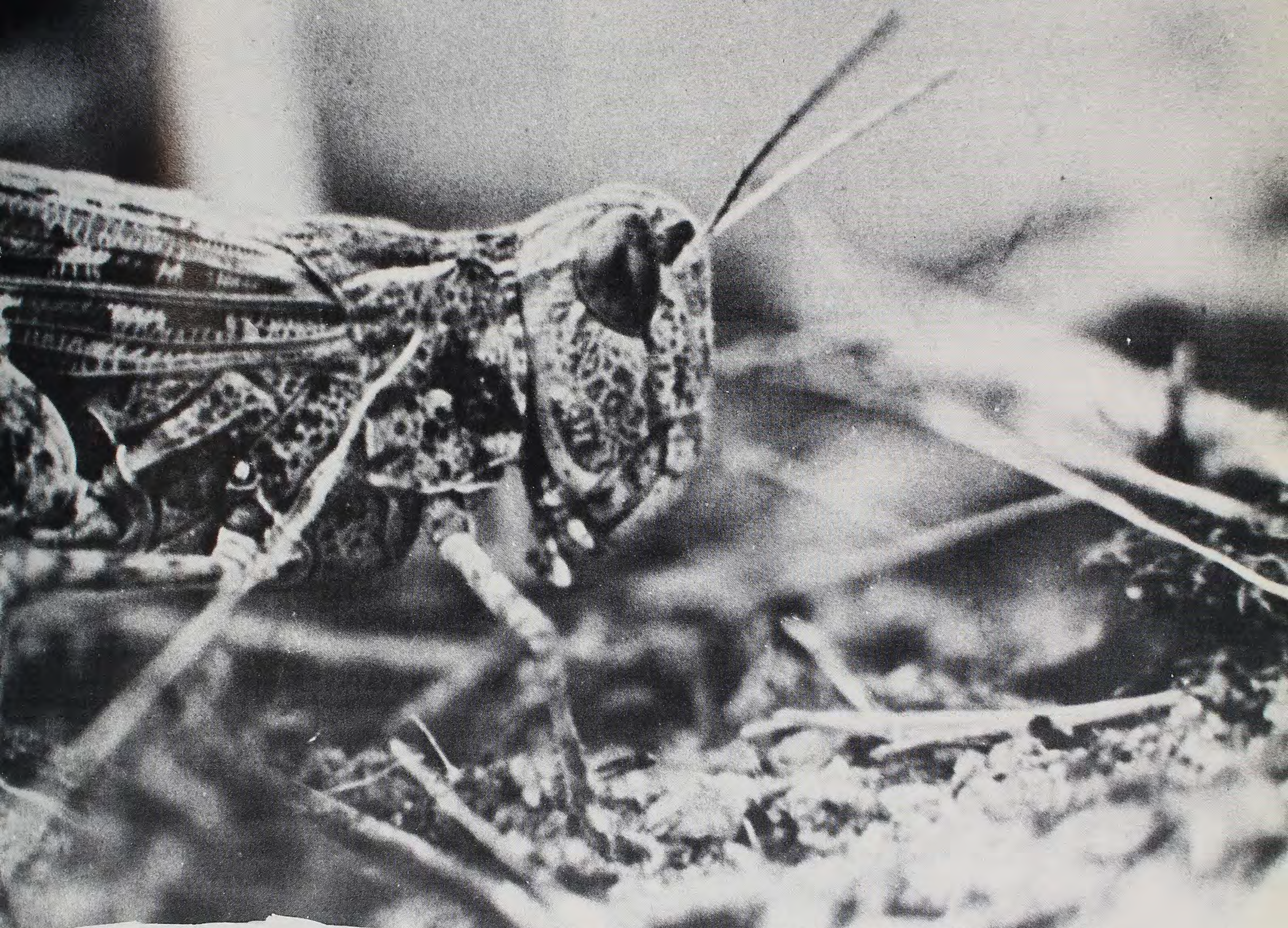
attain pest numbers, grasshoppers tend to be a localised problem, but locusts may affect whole regions and cross national borders.

Most of the world's land masses support one or more important locust species but the best known are the classical large species such as the Red Locust in Central Africa and the Desert Locust in North Africa and Asia. These have

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PLAGUE LOCUSTS

BY MAX CASIMIR



caused tremendous damage to crops during plague cycles. The Desert Locust was known in ancient times and the well-known reference to locust plagues in the Old Testament applies to this species. It remains one of the most devastating of our insect pests despite great advances in the techniques and organisation of control methods.

Locust outbreaks occur periodically throughout eastern Australia. There are several true locust species in the northern parts of the continent and these occasionally extend into New South Wales

but by far the most important in this State is the Australian Plague Locust (*Chortoicetes terminifera*), a native species which has been recorded as a pest since Australian agriculture first moved away from the coastal fringe. The following graphic account appeared in a letter written by the police Magistrate at Deniliquin in 1891: "We are now suffering from a great plague of grasshoppers, lately hatched from eggs deposited last March in the hard red clay of the plains. The young ones . . . are hopping along in countless thousands, devouring everything in

The female Australian Plague Locust deposits an egg-pod in a hole in the ground.

Immature locusts are called 'hoppers'. Newly-hatched, they are only about 5mm long and are wingless until the adult stage is reached.

their way . . . In some parts of the district the ground is perfectly black with them, and the Edward River and creeks are covered with their bodies, emitting a fearful stench".

Major breeding areas of the Australian Plague Locust are located in the pastoral areas of New South Wales and the largest plagues may involve almost all of the state west of the Great Dividing Range, and also the Hunter River Valley. Queensland, South Australia and Victoria are also liable to infestation, the more southern areas sometimes being invaded by swarms from the north. During plague cycles swarms have been known to travel as far south as Melbourne and to reach Kangaroo Island, south of Adelaide. Large numbers of scattered individuals appeared in northwest Tasmania following large swarm flights into Victoria from New South Wales in late 1973 indicating that locusts had crossed Bass Strait. Similarly, swarms have travelled as far east as the outskirts of Newcastle and there is a record of large numbers of locusts being washed up on Manly Beach, Sydney. These examples clearly illustrate the capacity of the Australian Plague Locust to migrate distances of the order of several hundreds of kilometres, given favourable conditions. Under these conditions the potential for damage by locusts is very high

'Hoppers' go through a series of moults (usually five) on the way to adulthood. This takes five to six weeks.

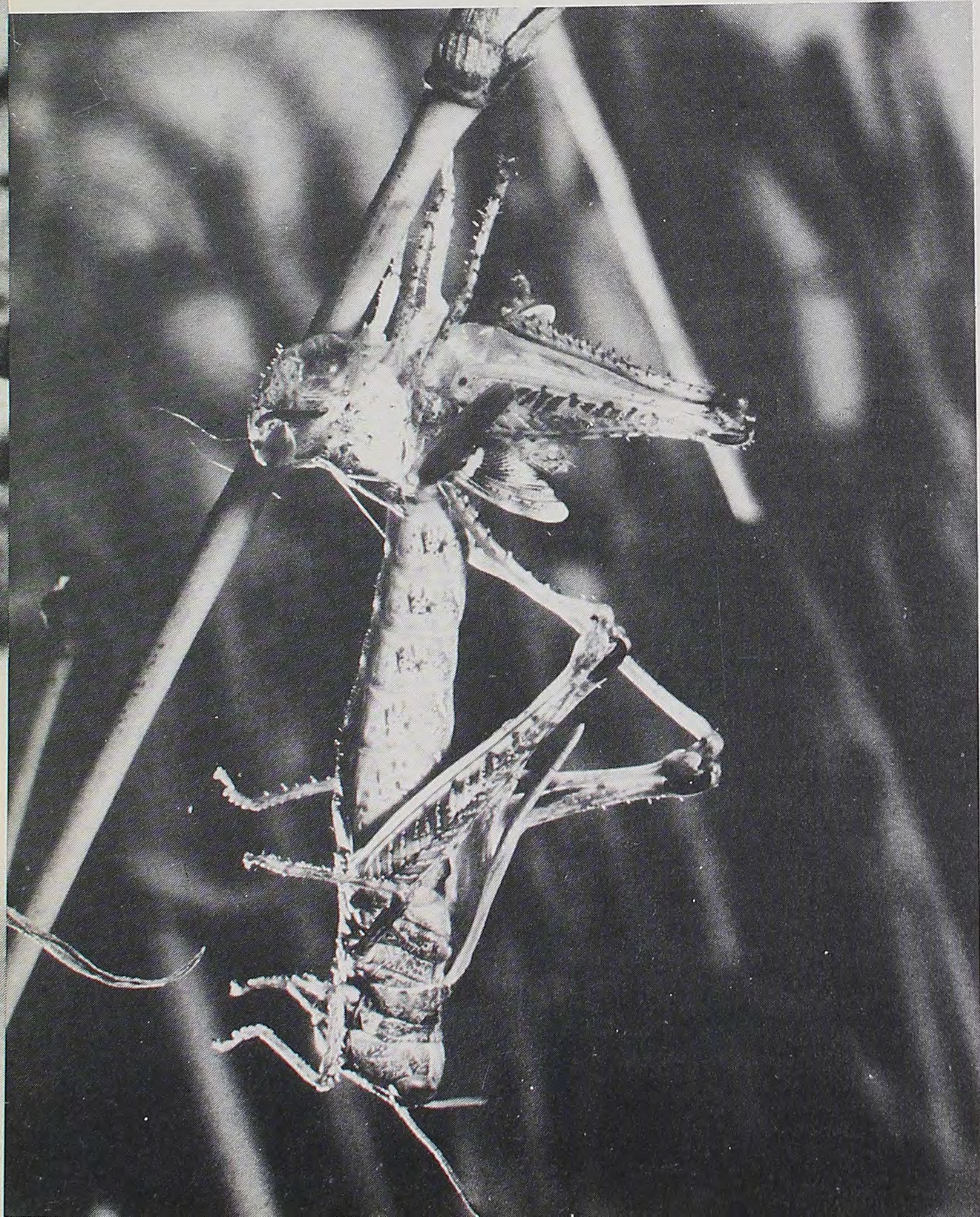
Howard Hughes/Australian Museum



because they are moving from the unimproved, pastoral areas into the intensive, high-value agricultural areas. At the same time locusts control presents a number of difficult problems that can only be solved by costly, well-organised community campaigns and, even then, only after a great deal of information has been accumulated on the habits and behaviour of the insect itself.

The life cycle of the Australian Plague Locust is similar to that of other locusts which are adapted to temperate regions. The female lays a batch of eggs, usually thirty to forty, in a hole drilled in the ground. A frothy secretion from the female serves to hold the eggs together in what is termed an 'egg-pod' and a single female may lay one or several such pods. A concentration of egg-pods is called an 'egg-bed' and these are usually located in bare patches of soil. They may vary from a few square metres to many hectares in size and are scattered irregularly throughout an area. The eggs require both warmth and moisture for development and hatching, which occurs in about two weeks under favourable conditions. It has been recently shown, however, that eggs laid in late summer and autumn often enter a resting stage or diapause in response to lower temperatures and decreasing day length. This diapause is only broken by exposure to a period of cold weather in winter. The mechanism has obvious survival value for the species.

The young insects or 'hoppers' make their way to the surface of the soil after hatching from the egg. They grow through a series of moults from the minute first stage which is about 5mm long, to the adult during a period of five to six weeks. There are usually five stages or 'instars'. All are hopping or crawling insects since the wings are





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present only as incipient buds until the adult stage is reached. The adult is rather slender, brown or green in colour, and from 25 to 40mm long. The species can be readily recognised by the distinct black tips of the otherwise transparent hind wings and by the bright scarlet colour of the shanks of the jumping legs.

First hatching of the season is usually in September or October. Eggs from a single egg-bed may hatch simultaneously giving rise to dense hopping bands and later to flying swarms. A second generation of locusts starts hatching in late December or January from eggs laid by the previous generation and usually by this time the parents have died. This second generation of adults in February and March often causes extensive damage to summer forage crops, pastures and autumn-sown wheat and oat crops. In very favourable conditions a third generation may be produced and be present until late May or early June, but eggs laid in autumn usually overwinter in the ground and hatch the following spring.

This description indicates a straightforward situation of two or three locust generations per season. The situation in the field is, in fact, more complex—especially in warmer areas where a small proportion of eggs hatches at the end of autumn or in early winter. The resulting hoppers develop very slowly during the colder months and mature in early spring. They lay their eggs when the first major spring generation is emerging from overwintering eggs, resulting in a complicated situation with overlapping generations later in the season. Occasionally, drought conditions will result in the death of a high proportion of locusts in one generation. If locusts in the overlapping generations are in a less susceptible stage, i.e.

eggs in the ground, they can subsequently make up previous losses. This is of considerable survival value in areas of erratic rainfall.

Another factor affecting the length of a locust generation is that female locusts require specific mechanisms to initiate sexual maturity. Green food is necessary to mature eggs, but the sharp drop in temperature commonly associated with frontal weather systems also appears to influence the onset of sexual maturity. Thus, in the absence of appropriate climatic triggering mechanisms adult locusts may remain sexually immature for periods as long as eight to twelve weeks. In this state they are able to exist on relatively poor, dry food. Locusts that have already developed eggs have a much shorter life.

Some locust species have a completely different type of life cycle. These are the species adapted to more tropical conditions. One such species—the Spur-throated Locust (*Austracris guttulosa*)—appeared suddenly in large numbers throughout northern New South Wales in late 1973 from its normal habitat in Queensland. The adult females laid many eggs which hatched in January and February 1974. The young hoppers were favoured by heavy summer rainfall and lush pastures (corresponding to the wet season in the tropics) and they developed into adults in

This young locust, having shed his last skin, unfolds his adult wings for the first time.

Howard Hughes/Australian Museum





Don Kennedy/NSW Department of Agriculture

Spur-throated locusts sometimes cluster in trees in such density that their weight breaks off large branches.

February and March. They formed very dense swarms which passed through the winter period, often clustered in and feeding on trees. At times the densities formed were such that large branches snapped under the weight of locusts. At the time of writing (August 1974) the locusts surviving the winter, are expected to carry through into late spring when eggs will be laid. This species therefore has only one long-lived generation per year in contrast to the Australian Plague Locust which may have two or more.

Swarm formation by the Australian Plague Locust prior to an outbreak was once thought to be restricted to well-defined areas (outbreak areas), having a mosaic of soil and vegetation types. Approximately twenty such areas were mapped in eastern Australia. The total area involved is approximately 390,000 square kilometres, although the most important and frequently active outbreak areas are located in central-western New South Wales covering an area of about 52,000 square kilometres. In the classical sequence of events, multiplication begins amongst the scattered locust population in one or more outbreak areas due to favourable conditions, particularly rainfall, and concentration into swarms takes place. These swarms move about within the outbreak area and merge, creating much larger swarms which eventually migrate and invade agricultural regions. This sequence has been observed in many outbreaks but it is now apparent that locusts are also capable of surviving over vast tracts of coun-

tryside outside the defined outbreak areas.

Locusts scattered over large areas may be concentrated into swarms under the influence of prevailing winds or they may be transported to other more favourable areas. Significant displacement appears to be mainly downwind. For a small species such as the Australian Plague Locust, flying speed is about eleven kilometres per hour (in still air). The distances travelled by swarms are highly variable and depend on a number of factors including prevailing wind and weather conditions. Sometimes they cover only a few kilometres although distances of 80 to 160 kilometres are common. Occasionally, large swarms have been thought to travel more than 800 kilometres. They may fly by night and both scattered locusts from low density populations—which are rarely seen to fly during the day—and locusts in swarms are known to fly after sunset. Large displacements of locusts occur in this way.

During outbreaks locusts are capable of causing widespread and severe damage to pastures and crops, including wheat, oats, and summer crops such as sorghum and lucerne. A large flying swarm may occupy an area of several square kilometres and can consume up to 80-100 tonnes of plant material per day. Hundreds of swarms may be present in a district at one time.

Locusts are potentially devastating pests. Damage by locust swarms can result in serious economic setback for whole communities. It is therefore necessary that some action be taken to

protect pastures and crops. Nowhere in the world has it been possible to achieve satisfactory control without the use of insecticides. Organised campaigns, usually involving the use of aircraft, have been necessary. In New South Wales swarm activity by the Australian Plague Locust sufficient to require treatment has been recorded in thirty-three of the last forty years. Twenty-four of these are classified as moderate to heavy outbreaks involving a significant part of the state while the plagues of 1933-34 and 1953-54 are among the worst on record.

The ability of locusts to form dense swarms and the mobility of these swarms mean that their invasions are sudden and spectacular. At the same time the occurrence of separate swarms allows control measures to be concentrated against the main aggregations of locusts rather than applied as a blanket to large tracts of countryside. Ecologically, the former is much more acceptable when using toxic chemicals, and economically the returns in terms of locusts killed per unit cost are much greater. It is possible to apply treatments in critical areas and at a critical time in the locust's life cycle provided there is detailed information available on locust behaviour and on the influence of weather.

At present research is being carried out on (1) the factors operating when no swarms are present and locust populations are scattered and sparse, in an attempt to provide basic information on the critical, early stages of swarm formation; (2) the possibility of forecasting well ahead when swarms are likely to appear; (3) the respective roles of predators, parasites and weather in controlling locust numbers; and (4) the possibilities of restricted treatments applied at an early stage instead of large-scale campaigns when a plague is already fully developed.

Insecticidal treatment of locusts will be required into the foreseeable future but studies of the complex of factors which combine to regulate numbers of locusts in the field are leading to a better understanding of the insect and, in turn to more precise methods of control. Advances in the organisation and technical aspects of control campaigns are related to findings of research into the ecology and behaviour of locusts. Insecticides with lower mammalian toxicity and with fewer problems from undesirable residues, are being developed. New aerial spraying techniques involving the use of minute volumes of highly concentrated insecticides per hectare have allowed recent findings on swarm flight behaviour to be put into practice.

The approach to the locust problem in New South Wales now involves a continual development in organisation, including a patrol and reporting service, the testing of new control techniques, and the investigation of the behaviour and ecology of the locust. There is no doubt that eventual success in the control of swarming populations will depend on the proper integration of all three aspects.

FURTHER READING

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Locust swarms are a familiar and unwelcome sight to farmers all over the world.



FOCUS ON ABORIGINAL ARTS

BY PATRICIA M. McDONALD

THE AUSTRALIAN ABORIGINAL HERITAGE, AN INTRODUCTION THROUGH THE ARTS, edited by Ronald M. Berndt and E. S. Phillips; *Australian Society for Education through the Arts in association with Ure-Smith, Sydney, 1973; 320 pages, 300 colour and black and white illustrations, 25 colour transparencies, two 12-inch records; \$27.50 (educational institutions), \$31.04 (individuals).*

This production represents a milestone in the teaching of the Aboriginal arts. Its multi-media presentation of book, colour slides, and records is not new on the educational scene but in this subject area it provides a most successful avenue for combining the various art forms of the Australian Aborigines into a meaningful whole. The two editors—anthropologist and educationist—have integrated the scholarly contributions from both disciplines into an educational tool designed for the use of students, members of the general public, Aborigines and non-Aborigines and all those who are interested in the arts.

The introductory chapters explain the aims and ambitions of the project and, in general terms, the basis and functions of the various art forms. Following these, the major portion of the book is divided into six parts, each with an introduction or 'connecting link' by Professor Berndt. Each part is written by a different author or authors and this has naturally produced differences in style in the final text and some repetition of material. However, as it is apparently intended that any one section may be read independently of the others, this duplication may be an advantage. Certainly in a book of this size, some circumscription of the contents is essential.

Part One deals with the social beginnings of the arts and descriptions are given of various children's games and a *mamu* ceremony at Yalata. Many of these games could be played by students in a classroom and could well form the basis of much creative work in this field. *Part Two* concerns oral literature and the problems of communication both through persons and through time. The theme is illustrated with many stories from the myths and legends. *Part Three* deals with rock art; the materials and techniques of

painting and engraving, the Wadjina figures of the Kimberleys and the rock art of the Cape York Peninsula. This Part also includes one of the few references to the arts outside the northern parts of Australia—the rock art of the Hawkesbury area. *Part Four* covers sculpture and bark paintings with a wide range of examples given. Although the illustrations throughout the book are excellent, special mention should be made of those of *Parts Three* and *Four*—the visual arts. The authors have chosen as their examples many of the famous figures as well as recent and therefore less well known paintings and this, combined with superb reproduction qualities, makes these illustrations an outstanding contribution to our knowledge in this field. *Part Five* concerns music and dance and this section of course relates to the two records. For the music student, this would be a most valuable chapter as it details so carefully and thoroughly the musical styles and accompanying dance movements. *Part Six*, on the future of the Aboriginal arts, is a most thought-provoking analysis of the interaction between European (or white Australian) and Aboriginal arts and the developmental trends influencing production of the various art forms.

The two records, with their accompanying text, give a range of tribal songs, children's songs, didjeridu playing and modern influences on Aboriginal music. In the reviewer's copy, side 2 of both records was flawed and the needle stuck in the grooves. Compared with the illustrations in the book, the 25 colour transparencies (which duplicate those in the text) were not of such a high standard of colour reproduction. The slides are numbered but not named and this may limit their usefulness in the classroom if the accompanying folder is mislaid or, as it also contains the notes for the records, is being used by another group.

In spite of these minor flaws, this combination of text, slides and music represents a valuable educational resource and should be warmly welcomed by those interested in studying the Aboriginal arts.—*Patricia M. McDonald, Education Officer-in-Charge, The Australian Museum.*

A photograph of the Eight-rayed Sea Star (*Patiriella calcar*) was included in error in our June, 1974 issue. This species has not been recorded from Lord Howe Island.



1



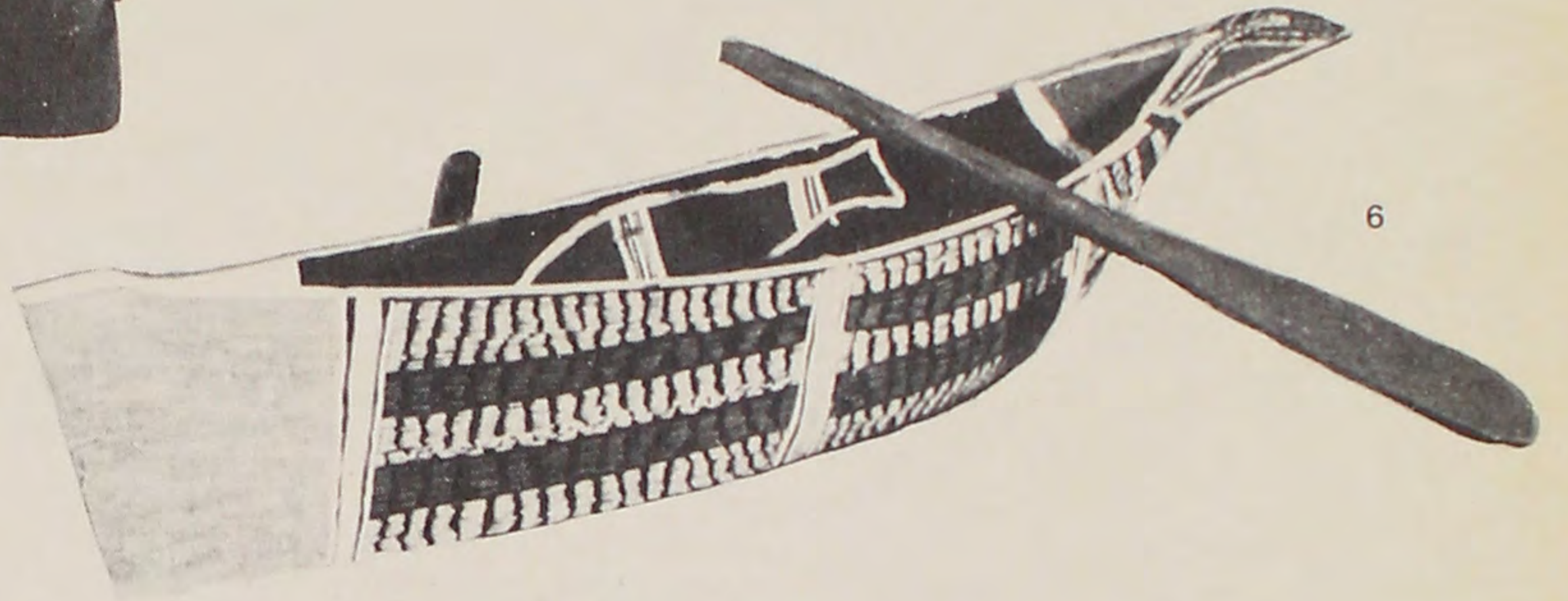
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