AUSTRALIAN NATURAL HISTORY

JANUARY–MARCH 1977 VOLUME 19 NUMBER 1 $1*

CELEBRATION '77

The Australian Museum is celebrating its 150th Anniversary with special exhibits and events throughout the year. The programme for the first six months includes—

HISTORY OF MUSEUM EXHIBIT

31 March-26 June 1977

This exhibition portrays The Australian Museum's contributions to scientific research in the fields of evolutionary zoology; environmental studies and anthropology over the past 150 years. One display recreates part of the Museum as it was a hundred years ago. Two audio-visual shows tell its story. Various stages of the Museum's construction are illustrated by old plans (some of Museums which were never built) and by a model of the Museum building as it may be in the future. Old documents dating back to 1836, from the Museum's archives, chart the history of legislation by which the Museum is governed. Other sections include a display of beautiful old microscopes and descriptions through old photographs and publications, of fieldwork and collecting and educational activities late last century.

DISCOVERERS' PAGEANT

Members of the Discoverers' Club and pupils from city primary schools will present a dramatic version of episodes from the Museum's colourful history, in the Hallstrom Theatre in March and April, dates and times to be announced in The Sydney Morning Herald.

NEW ARID ZONE GALLERY

Nearly two thirds of continental Australia is classed by geographers as arid or semi-arid. A new Arid Zone Gallery, to be opened shortly, will explore the origins of Australia's desert regions, their geological and physiographic features, and the wealth of animals and plants which have evolved adaptations for survival in these dramatically harsh regions.
Other exhibits in this gallery will look at the history of exploration of arid Australia, the impact of Aboriginal and European man on the desert environment, and an audio-visual programme to illustrate the rich scenic diversity of Australia's desert interior.

TAMS ACTIVITIES

The Australian Museum Society has a full calendar of events for the Museum's Sesquicentennial year. Special anniversary activities include a Celebration Dinner on 30 March (members only) to be attended by the Governor, and a family day at the Museum, Celebration Saturday (members only) on 2 April, with clowns, music, a pageant and guided tours of the Museum with historical commentary. Tours are also available to members on 31 March, 1 and 3 April. Other events include lectures and films, and field trips led by staff scientists. Write to TAMS or ring 33-5525 (mornings) for the current programme brochure. New members welcome.

DANCING IN MARTIN PLACE

Ethnic dance performances in the amphitheatre at Martin Place, 12pm—12.30pm and 1.00pm—1.30pm.

28 March—Indonesians
29 March—Summer Hill School
30 March—Hibiscus Entertainers (Tonga)
31 March—Mornington Island Dancers
1 April—Polynesian Association

MAN, A PECULIAR PRIMATE

Merrylands 14 February-12 March
Windsor 14 March-3 April

This exhibit is the pilot project of a planned series of travelling displays to be circulated in Sydney's outer metropolitan regions.
The exhibition deals with primates and the evolution of man, the nature of man and man's place in nature. Composed of twelve panels and seven showcases it is to be set up in space provided by the recipient communities. As well as attractive graphics the display will include specimens of modern-day primates, high quality casts of skulls of early man and genuine stone age implements.

SCHOOL HOLIDAY ACTIVITIES

During the May vacation, the Museum's educational activities for children will be centred around marine animals—fishes, shells, crabs, turtles. Specimens will be available for handling and close examination. Films will be shown. For further information telephone Education Section—339 8111.

AUSTRALIAN NATURAL HISTORY

published quarterly by The Australian Museum, is a popular magazine on natural science, and anthropology subjects. A special issue, commemorating the Museum's Sesquicentenary, presents an historical view of scientific research in Australia.
Other recent issues include articles on fossil birds, fish mimicry, Balinese shadow puppets, animals of Australian deserts, satellite photography, sea anemones, insect migration, the Rofaifo people of Papua New Guinea, a new volcanic island and many more fascinating topics. Special supplements on Mining in Australia and on Urban Man's need for natural areas are also included.
Single copies ($1) and subscriptions ($4.50) are available from the Museum Bookshop or by writing to The Australian Museum.

GALLERY HOURS
Sun & Mon 12noon-5pm
Tues-Sat & Holidays 10am-5pm
Closed Good Friday and Christmas Day

the australian museum
6-8 College Street **sydney**

AUSTRALIAN NATURAL HISTORY

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INDEX TO VOLUME 19

JANUARY-MARCH 1977 – OCTOBER-DECEMBER 1979

CONTENTS

AUTHORS AND TITLES

SUBJECT MATTER

AUSTRALIAN NATURAL HISTORY

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PRESIDENT, MICHAEL PITMAN DIRECTOR, DESMOND GRIFFIN

VOLUME 19 NUMBER 1
JANUARY—MARCH 1977

A. Burrows

COVER: The Red Junglefowl *Gallus gallus*, ancestor of the many breeds of domestic fowl today. From *Illustrations of Ornithology Vol 3* 1835, by Sir William Jardine and Prideaux John Selby. (Photo: Gregory Millen/Australian Museum).

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FROM THE JUNGLE TO THE FARM

BY WALTER BOLES

Few birds are as familiar to so many people as is the domestic fowl or chicken. It is known to have been domesticated in civilisations for more than 4000 years and has since appeared throughout most parts of the globe, including many remote islands and among primitive societies with limited outside contact.

The junglefowls, a distinctive group of pheasants, are the ancestors of the modern domestic fowl. Four distinct species of junglefowl occur through the warmer parts of south-central and southeastern Asia and into Indonesia—Red Junglefowl (*Gallus gallus*), Ceylon Junglefowl (*G. lafayetti*), Sonnerat's Junglefowl (*G. sonneratti*) and Green Junglefowl (*G. varius*).

There is a close resemblance between the domestic and wild junglefowls. The male, or cock, has a single comb on top of the head and two wattles under the bill. The tail is compressed with two long curving central feathers. These elongated feathers and the strong spur found on the legs of the male are missing in the female.

Wild birds are very timid but have adapted to living near villages despite heavy hunting as a food source or in retribution for their fondness for farmers' grain. The ranges of the four species are generally exclusive except for an overlap between the Red and Green Junglefowls in a small section of Java. Although captive birds freely hybridise, no interbreeding has been reported in the wild.

Most authorities agree that the Red Junglefowl is the ancestor of modern poultry, although some ancestry of the other species has been claimed. The Red Junglefowl is the most widespread of the wild species, occurring from western India through to Indochina, Malaysia, Sumatra, and parts of Java. Its spread from its wild state in its native environment to the domesticated bird found throughout the world has an intriguing history. In addition to providing an interesting puzzle in itself, the study of the development and introduction of the domestic fowl has provided some valuable information towards the understanding of early civilisations and their movements. When attempting to trace the spread of the domestic fowl through history, three major lines of pursuit prove helpful. The uses of and attitudes towards the chicken, its names in the societies, and its physical characteristics are often indicative of the bird's ancestry.

Modern poultry has been selected for its flesh or egg producing quality. Gastronomic considerations, however, have not always been the primary concern. Evidence shows that religious and sporting aspects of the fowl were of far greater importance in early cultures, and its food potential was not developed until much more recently. As cultures spread, some of the customs that moved with them were those relating to the chicken. Therefore, if there were two possible sources of introduction of the fowl to an area, a comparison of the cultural uses often provides a valuable clue to its origin.

Related to the selection for culturally desirable characteristics is the development of distinctive physical traits. Cocks for fighting would have been bred for pugnacious temperament and physical strength, while food birds would have emphasised quality and quantity of meat and eggs. Many early religions required white chickens for sacrifices and thus birds would be chosen for colour. The different physical attributes resulting from this selection can serve to illustrate the lineage of the breeds of poultry. Two major groups of domestic fowl exist—the Mediterranean breeds and the Asiatic breeds. The former are characterised by such traits as large single combs, small bodies, and white egg shells as opposed to pea combs, heavy bodies, and tinted eggs in the latter.

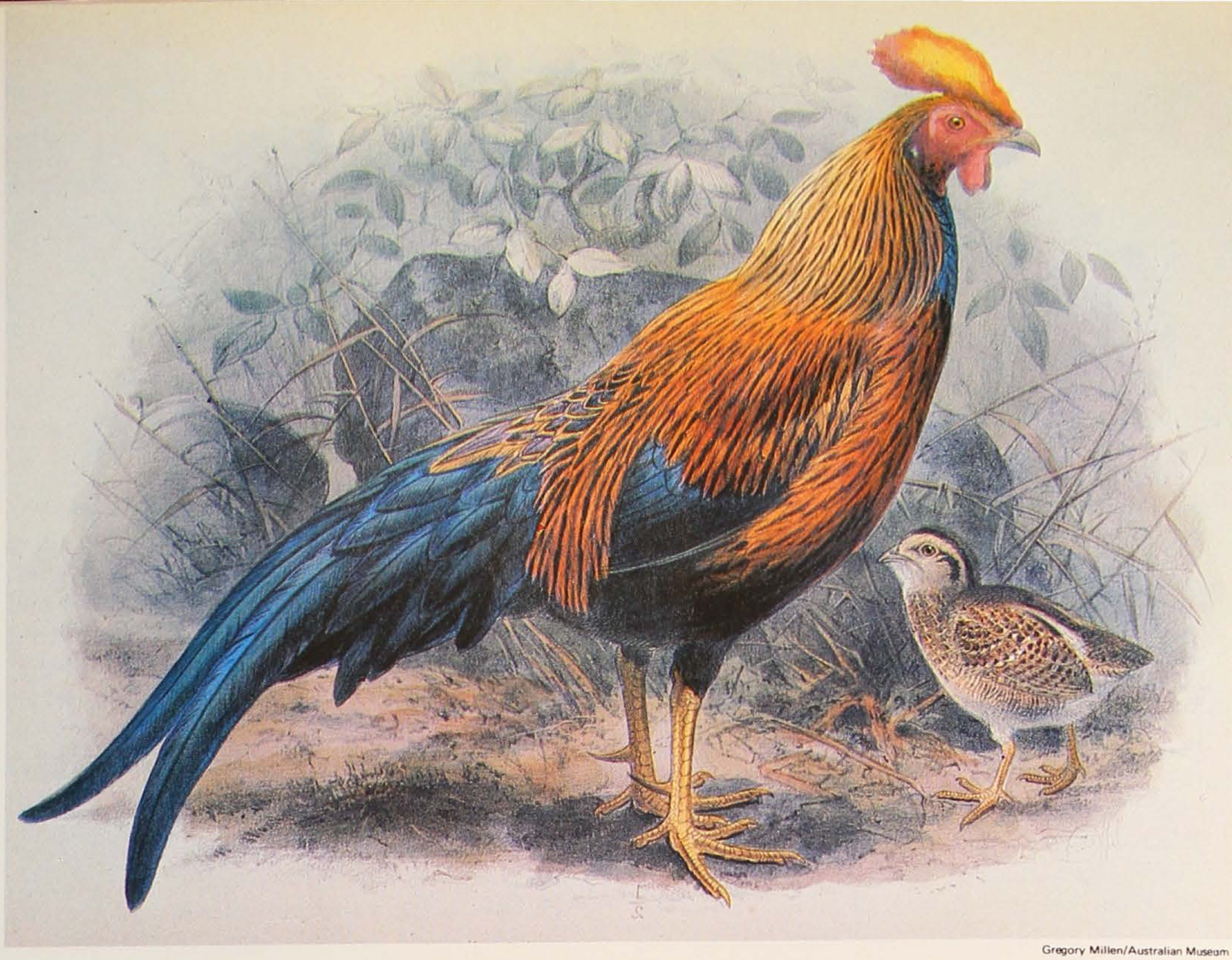
A picture from the tomb of Tutankhamen in Egypt (ca. 1350 BC) illustrates a cock with the characteristic comb of the Mediterranean breeds, suggesting descent from birds originating in northwest India.

A knowledge of the ereditary relationships of the various traits is also useful. The Asian breed character of pea comb is dominant over the single comb of Mediterranean breeds. If the Asian breeds had reached Europe, their pea comb feature would have eventually replaced the recessive single comb trait. As displacement of single combs did not occur, this may be considered evidence of the absence of Asian breeds in Europe.

The third valuable source of information on the domestic fowl's dispersal is the linguistic study of its names in different cultures. The greater number of names in use usually indicated increased importance or greater antiquity of the bird in the society. Where the chicken was well established, each sex and age

The farmyard fowl, *Gallus gallus*, bred for whiteness, is the same species as the Asian junglefowl (see cover photo). This rooster is of the Mediterranean race.

WALTER BOLES is a Technical Officer in the Department of Ornithology, The Australian Museum.



Gregory Millen/Australian Museum

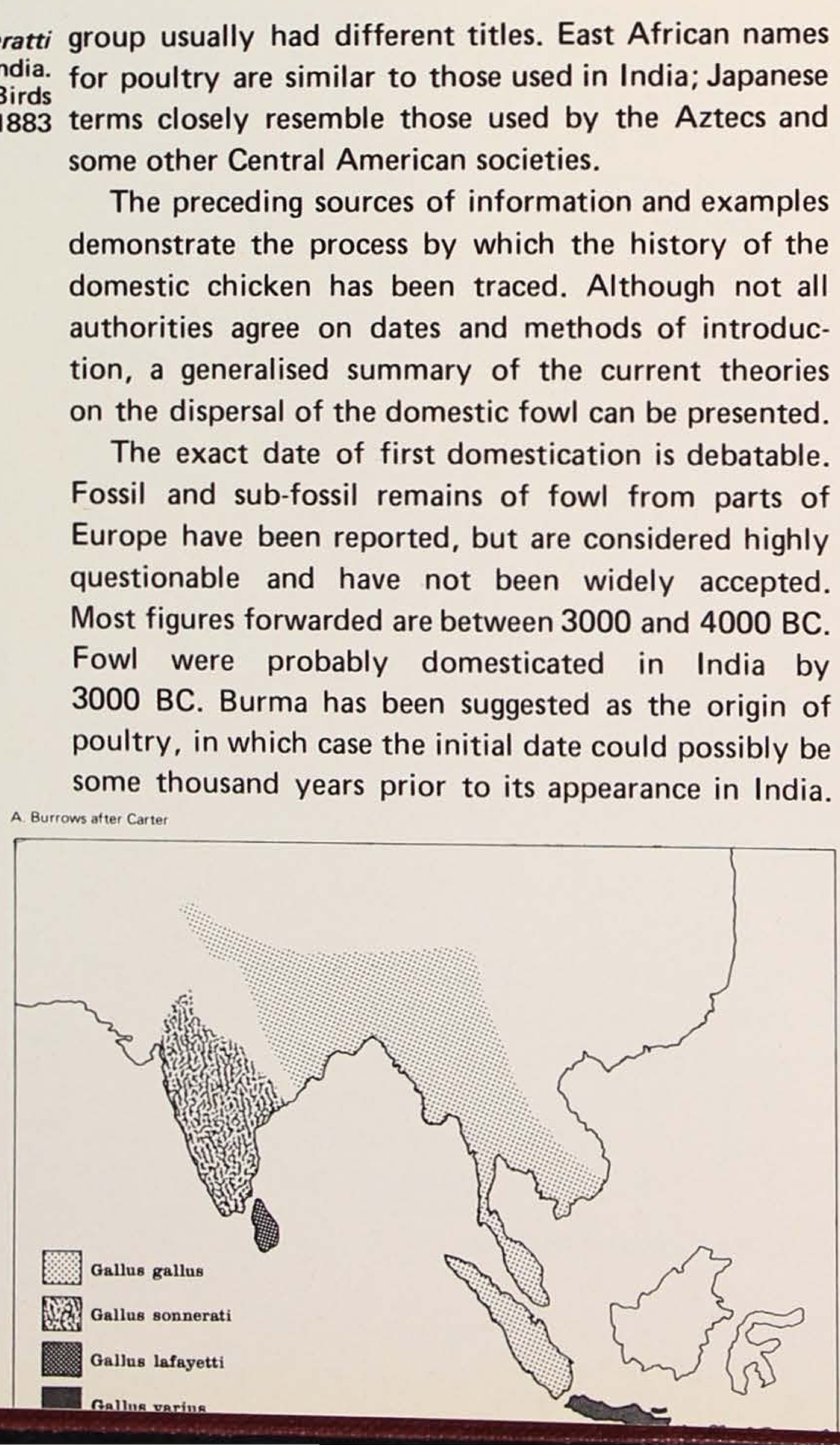
Gallus sonneratti (male) from India. John Gould's Birds of Asia, 1883

group usually had different titles. East African names for poultry are similar to those used in India; Japanese terms closely resemble those used by the Aztecs and some other Central American societies.

The preceding sources of information and examples demonstrate the process by which the history of the domestic chicken has been traced. Although not all authorities agree on dates and methods of introduction, a generalised summary of the current theories on the dispersal of the domestic fowl can be presented.

The exact date of first domestication is debatable. Fossil and sub-fossil remains of fowl from parts of Europe have been reported, but are considered highly questionable and have not been widely accepted. Most figures forwarded are between 3000 and 4000 BC. Fowl were probably domesticated in India by 3000 BC. Burma has been suggested as the origin of poultry, in which case the initial date could possibly be some thousand years prior to its appearance in India.

A. Burrows after Carter



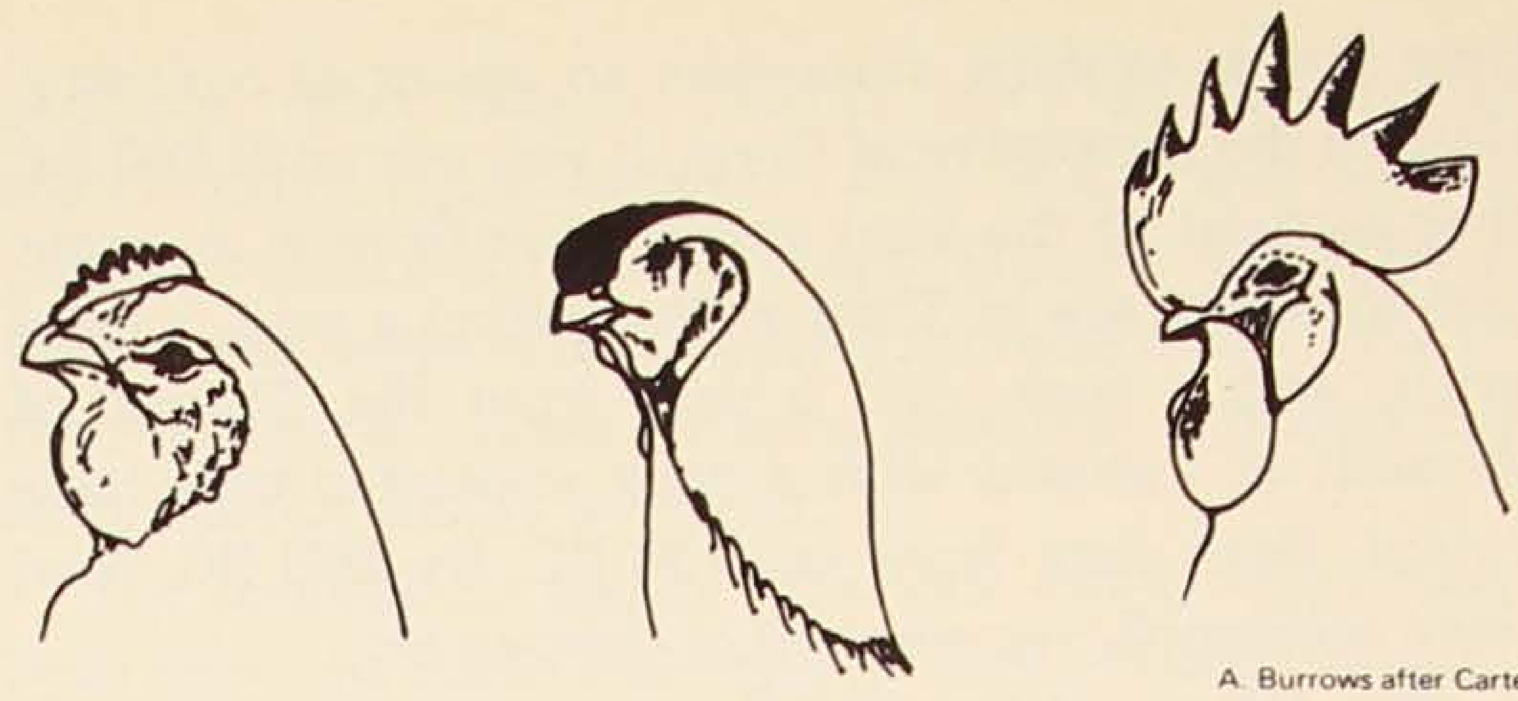
Documentation for the presence of domestic fowl in the Indus Valley Civilisation places its occurrence around 2350 BC. Trading between the Indus Valley and Mesopotamia (ca. 2300 BC) has lead to the suggestion that the chicken reached the Middle East by 2200 BC. Certainly, it was well established soon after. Active sea routes would have resulted in a relatively rapid introduction, although a longer overland path through Afghanistan is a possibility.

The primary purpose of poultry in Mesopotamia was for sacrifices. The birds were kept in large numbers at temples as festival offerings to the goddess Bau and were referred to in the omen texts. The fowl became an important element in the Zoroastrian religion in Persia and later in Greece and Rome. In the religious literature between 2000 and 700 BC, it was called the 'Herald of the Dawn' and occasionally 'Bird of Light'. It was said that God created the cock to crow, thereby fighting the demons of idleness and the hosts of evil which were harboured by the darkness. Ancient writers such as Virgil and Pliny commented on the attitudes towards crowing, considered in Rome to be a favourable omen. Selection for this habit no doubt occurred and today crowing in domestic birds seems to have no real biological significance. In parts of the Middle East, crowing contests are still held.

Prior to 2000 BC, considerable domestication of other birds—ducks, guinea fowl, and even pelicans—as a source of eggs, had been practiced in Egypt. No evidence of the fowl is found during this period and it was not until the commencement of trading with Mesopotamia that the chicken made its appearance in Egypt. A graffito on a Thebean temple, the first definite evidence, placed the date near 1850 BC. Other unquestionable illustrations of cocks were found on the tombs of Rekhmara (ca. 1500 BC) and Tutankhumen (ca. 1350 BC), discussed earlier.

Under the leadership and military prowess of Thutmosis III of the XVIII Dynasty (1504-1450 BC), Egypt's borders reached their greatest extent. Among the tribute received from conquered countries were four birds. It is described in the Royal Annals carved in stone on the walls of the Great Temple of Karnak that "they bring forth every day", i.e. they lay eggs every day. This capacity for increased productivity in egg-laying is a selected characteristic in domestic birds not found in their wild ancestors. It is agreed that this reference is to the domestic fowl. The name of the source of the tribute was broken from the wall, but from a reading of the remainder of the text, this has been shown to be between Syria and Babylon.

A major subject of controversy was the 'chick hieroglyph', a frequently inscribed figure in tombs, which, if it was indeed a young fowl, would have placed the arrival of poultry in Egypt before 4000 BC. Many interesting theories about the symbol's identity were put forth. One author suggested it represented a now extinct flightless partridge formerly endemic to Egypt. Others considered a very early introduction



A. Burrows after Carter

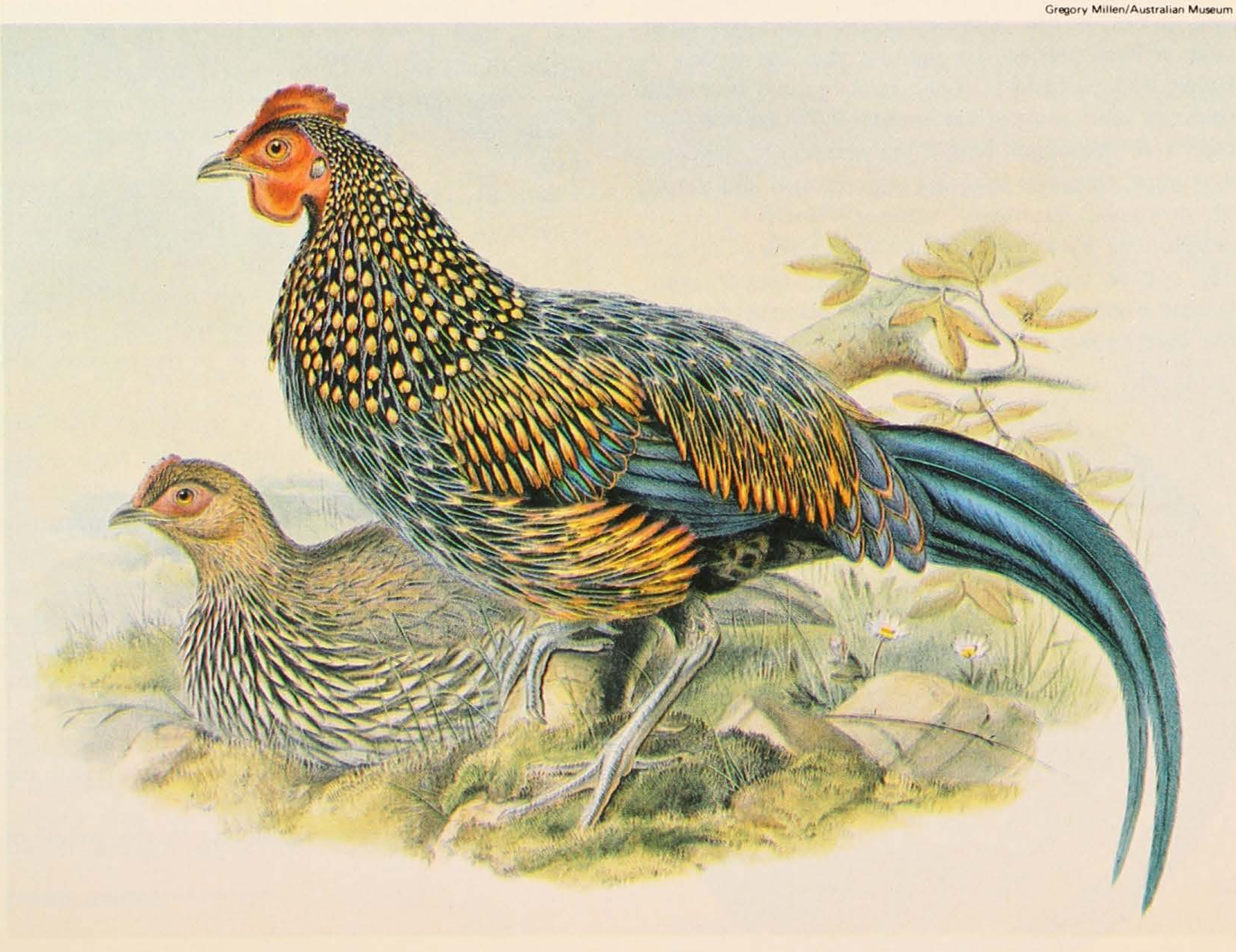
Physical characteristics, suc as comb type, can often give a clue to origin. The strawberry comb (left) is of the Mala race, the pea comb (centre) is of the Sinitic race and the single comb (right) of the Mediterranean race.

(ca. 4600 BC) of the fowl by Mesopotamian invaders (an invasion for which no other evidence has been found) to be the explanation, or that religious and/or aethestic sanctions on picturing the adult allowed only the chick which was "elegant and pleasant in appearance" to be shown. It has now been concluded that the hieroglyph, which remained unchanged from dynasty to dynasty, represented the appropriately named Pharoah's Quail *Coturnix coturnix*. Two statuettes of a wattled bird from 4400 BC are almost certainly guinea fowl.

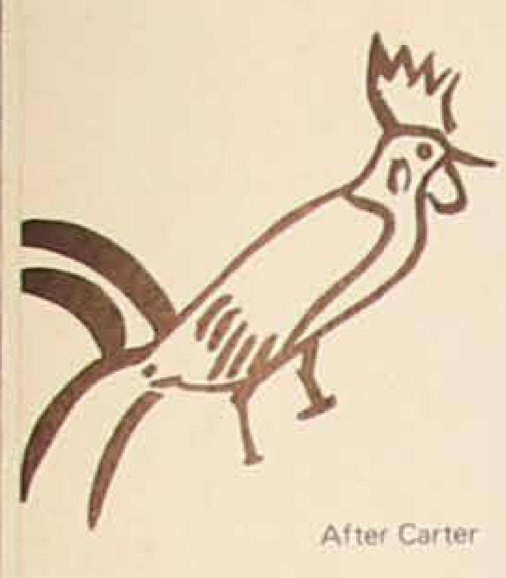
Other notable Egyptian findings featuring the chicken are a description in the 'Hymn of the Sun' inscribed in the tomb of Ay (ca. 1355 BC) and a silver bowl originating during the reign of Seti II (1200-1194 BC). The five centuries following Seti II saw a decline in external contact with an accompanying recession in trade. No mention or traces of the fowl have been discovered in this period.

Soon after the fowl had reached Egypt it had also appeared in Crete (ca. 1550 BC) by way of Mesopotamia. It may have been known in Italy at this

Gregory Millen/Australian Museum



Ceylon Junglefowl, ***Gallus lafayetti*. Th** female is in the foreground. Capt. W. Vincent Legge's Birds of Ceylon, 1880.



After Carter

The cock drawing from the tomb of Tutankhamen (ca 1350 BC). Compare the comb type with those illustrated on the previous page.

time but as nothing more than an object of curiosity. Despite the proximity of Crete, it was not until 800 BC that pictures of the fowl appeared in Greece. A jasper seal from a grave in Tharros illustrating a man, a lotus plant, and a cock, and a coin from the Temple of Artemis at Ephesus with a cock imprinted have been found. Both date from ca. 700 BC. By 600 BC, fowl were commonly represented in Grecian art.

The failure of the Old Testament to speak of fowl has led some authors to conclude that the bird was absent in Palestine during this time. They fix the time of its introduction in the second century BC. Recent archeological excavations near Jerusalem, however, have revealed pieces of pottery with figures of both male and female fowl. A double spur in one picture suggests an emphasis on the fighting abilities of the bird. Cocks are shown on two seals from Jerusalem (ca. 587 BC), one for Yaazanjahu, 'the Servant of the King', and one for Yaachazjuhn, 'the Son of the King'. Chickens were not used as food and one authority attributes this reluctance to the bird's position as a sacrificial object in Persia at the time.

Following the Persian conquest of Egypt in 525-524 BC, the fowl once again became an important part of the culture. A seal showing a hen defending her chicks and clay vessels in the form of cocks are among the variety of ways this bird was incorporated into the art. In the Greek and Phoenician colonies around the mouth of the Nile, it was a favourite subject of artists in their terracotta work.

By 200 BC, poultry had assumed a very significant role in Roman life. Although Pliny, Varro and other later writers praised the fighting abilities, it was in Rome that husbandry of the fowl reached its highly complex level. Specialised breeds and rules for their care were developed. Within the vast poultry industry that grew, specialist branches were formed and details of economic problems outlined. Ancient scribes' descriptions portray stocks similar to those of present day and as equally prolific as egg layers. Chickens formed a conspicuous part of the Roman diet. Possibly the best known reference at this time is the Biblical narrative of the cock crowing thrice following Peter's denial of Christ.

An Italian coin, circa 268-240 BC, from the private collection of P. Boland.

Charles Turner

Gregory Millen/Australian Museum

Several pathways of introduction into Europe are currently accepted. One is that from Egypt to Crete and from there to Greece and Italy. Another is a route through eastern and central Europe, eventually converging with the first introduction in northwest Europe. When the Romans invaded Europe, they discovered fowl as part of the Celtic society in 100 BC and in Britain in 43 BC. In Cornwall and Scotland, legends suggest that the Phoenicians brought the birds, which if true, raises the possibility of the existence of a sea route.

With the fall of the Roman Empire, the chicken's importance diminished. It was raised for food on a farm to farm basis but did not reach the magnitude that it had earlier. The breeds were genetically strong, however, and were thus maintained with little conscious effort. No large scale resumption of the industry was made until the nineteenth century.

In the opposite direction of the Middle East and European introduction, domestic fowl were transported from India to the Orient. Domestication of poultry in China was practiced by 1400 BC, primarily for religious and fighting purposes. During the Chou Dynasty, 11th to 3rd centuries BC, chickens were used for sacrifices. Although the record is not as well documented as the westward dispersal, it is known that the fowl was introduced to most east Asian societies and the development of the Asian breeds began.

The nearest relatives of a breed found in East Africa seem to be those in India, which is consistent with the idea of a direct introduction by sea.

The role of European explorers in the arrival of

Athenian drinking cup picturing two cocks and four men. Circa 550-530 BC. Nicholson Museum, University of Sydney

fowl in the New World was debated for many years. Had Spanish introductions been the initial ones or were earlier trans-Pacific ones responsible? Cabral brought chickens to Brazil in 1500 AD. Nineteen years later, Magellan found them 1000 miles to the south of their original landing spot. Within forty years, they were present over most of South America. These stocks were well differentiated from European breeds. Poultry were important in the lives of most South American tribes, yet no Spanish names were in use.

The argument of pre-Columbian versus post-Columbian chickens was carefully researched by George F. Carter. Comparing the rates of diffusion in the Old World with those implied by the post-Columbian concept, he showed that in the New World this rate would have to be higher by several orders of magnitude. Setting the value to that of the Middle East, he arrived at a figure of 1500 BC.

Using the methods of study discussed earlier, Carter found information consistent with that from his diffusion rate study. American birds had pea combs and other Asian traits unknown to Europeans. Tribes seldom ate the birds or eggs, instead valuing for their fighting and decoration; again, an Asian-like, non-European pattern. Perhaps the linguistic aspect is the most revealing. Non-Spanish names were used even for Spanish birds. It was also found in the Philippines that the older name remained in use to the exclusion of those introduced by a new culture. Throughout the New World, the names were of Asian origin; different ones seemed most closely related to Indian, Chinese, or Japanese.

From this Carter concluded that although the Spanish brought some fowl, multiple Asian introductions from several sources were of far greater significance. Trade between Asia and tribes on the coasts of Peru and Ecuador was of greatest importance. Carter also suggests that Central America at the time of the Aztecs was visited by early Japanese, although this theory is not widely accepted.

The journey to South American shores must have been from the Asian mainland or large offshore islands. Little appears to have been transmitted by way of the intervening Polynesian islands, for establishment of poultry in Polynesia did not occur until relatively recently—ca. 1300 AD. The distribution of chickens throughout Polynesia is patchy; they appear on some islands but are absent on others. On those islands to which they were introduced attitudes and uses of poultry followed the general Asian pattern, although with individual variation. The differences in stocks throughout Polynesia suggests multiple introductions. In Hawaii, white chickens were important in necromancy. An ancient Tahitian legend tells that chickens have been there as long as man. Henhouses for sacrificial fowl have been found on Easter Island. European explorers reported poultry on Bougainville, New Hebrides, and several other islands.

After Carter

The famous chick hieroglyph, the identity of which was debated for many years. Had it been a young fowl rather than a quail, it would have indicated an arrival of poultry in Egypt before 4000 BC.

Australia stands out as somewhat of an anomaly. No evidence of pre-European fowl have thus far been found despite numerous potential sources.

With few exceptions, every recent society has come into contact with the domestic fowl in one context or another. Regardless of the purpose to which it is put, the chicken should continue as the most important bird ever domesticated by man.

FURTHER READING

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Gregory Millen/Australian Museum

Greek terracotta plaque in the shape of a cock. Early fifth century BC. Nicholson Museum, University of Sydney.

PHARMACOPOEIA NOVA

AN UNDERSEA SEARCH

BY JOE BAKER

For many decades Australians regarded the sea as an ideal recreational facility, without seriously considering its potential for scientific or economic development. This attitude, which so markedly contrasts with that of Asian and Pacific Island countries, began to change in the late 1950s and early 1960s, particularly in consideration of the economic role of Australian fisheries and in recognition of the scientific need for a greater emphasis in Marine Science.

Government support came in the establishment of the Australian Institute of Marine Science (AIMS). Universities introduced additional courses in Marine Science and these courses have attracted an increasing number of students. However, apart from the example provided by AIMS, the number of openings in State and Commonwealth Agencies employing Marine Scientists has not increased in anything like the same proportion, and specified Government support for Post Graduate Research in Marine Science at this time, is grossly inadequate.

Australian commercial and industrial organizations have been slow to enter new fields based on the potential of the marine environment, due to the current paucity of detailed knowledge about marine organisms and their environment and to the high cost of the equipment needed to harvest and utilise marine organisms. The technology associated with this equipment lags seriously behind that of comparable equipment for the use of terrestrial resources. Even with extensively used resources such as fish, prawns, cray-fish, abalone and scallops, the application of commercial farming methods is little more advanced than laboratory scale.

The first major commercial commitment to the potential of the Marine environment as a source of biologically active substances came from the Swiss firm of Hoffmann-La Roche in the establishment of the Roche Research Institute of Marine Pharmacology (RRIMP), on April 20th 1974, at Dee Why, Sydney.

The objectives of RRIMP were summarised as:

(i) to isolate and characterize chemical components of marine fauna and flora;
(ii) to investigate the activities of these compounds in microbiology and pharmacology in order to test the compounds for suitability for therapeutic uses in medical and veterinary applications;
(iii) to provide such biologically active natural compounds as models for laboratory synthesis;
(iv) to co-operate with other institutions in carrying out research in marine science.

RRIMP is unique in Australia. In other countries only the Russian Institute of Marine Bio-organic Chemistry at Vladivostok appears to have similar objectives.

Now, a little over two years since RRIMP was opened, some progress can be observed, but the time is far too early to unambiguously assess the often asked question, "Will the marine environment provide new materials with biological activities that can be used for the betterment of human and animal health or for the improvement of agricultural crops?" Prolonged testing of potentially interesting leads will be required before any one of the diverse components of that question can be answered.

JOE BAKER, Director of the Roche Research Institute of Marine Pharmacology, is a Trustee of the Australian Museum and of the Museum's Lizard Island Research Station. His research interests include insect gland constituents and colouring matters and biologically active substances from marine organisms.

RRIMP

Jellyfish are particularly common on the NSW coast and in Pittwater thousands can be seen on any summer Sunday afternoon cruise. Many jellyfish have associated with them trace amounts of chemical substances which can cause skin irritation or even acute discomfort. Despite the fact that these are in general more than 98% water, they are proving a species worthy of detailed study.

The variety of features of Australian beaches, mangroves, headlands and sea beds necessitates a range of collecting methods from the simplest forms of intertidal collecting to scuba diving and trawling.

A major consideration in collecting marine organisms to determine their chemical constituents, to ensure that opportunities for enzymatic breakdown of the natural constituents are minimized during transport of the samples to RRIMP. The most common methods used are to place the specimens in an appropriate extracting solvent such as isopropanol or ethanol immediately on collection, or to transport them to the laboratory frozen and store at $-20^{\circ}C$ until required for extraction by the chemists. What may appear in nature as an attractively coloured submarine display may lead to pure chemical substances. Marine organisms provide new classes of natural substances, but large quantities of these are not needed for further testing. The required amounts can be synthesised. Certainly marine organisms have yielded completely novel classes of natural products—never found from terrestrial sources and unlikely to be thought of by man as molecules to synthesise.

Due to the inadequate knowledge of taxonomy of Australian marine species, and to the variety of novel compounds from marine organisms already recorded in the literature, the most obvious results of RRIMP's first two years of work, come from the Biology and Chemistry sections.

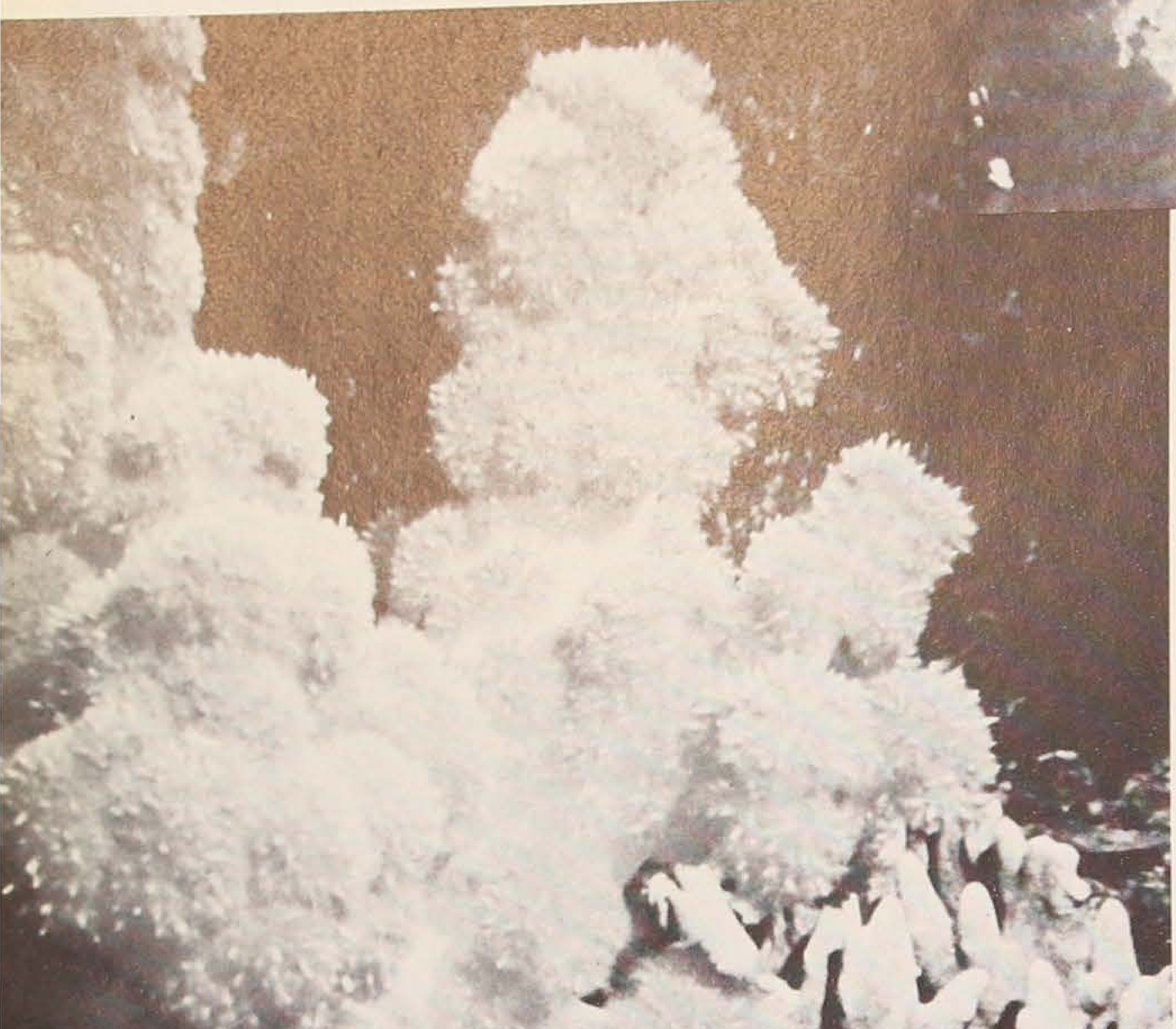
Results from the Pharmacology and Microbology sections depend upon the establishment of a wide range of tests which must first be established on pure, known drugs before the unknown marine materials can be evaluated. In Pharmacology, the major tests are for substances active in the central nervous system, active

Right: *Caulerpa* sp., green alga (right side of photo) has given rise to a perhydro Vitamin A derivative — the first time that such a compound has come from a plant source — either in the sea or on land. *Laurencia elata* a red alga (left side of photo). The *Laurencia* are among the most complex of the algae. They are chemically interesting because they possess a wide variety of halogenated substances.

Below Centre: A typical underwater scene of benthic invertebrates as found off Sydney. Large numbers of sponges such as these are rare on the Great Barrier Reef.

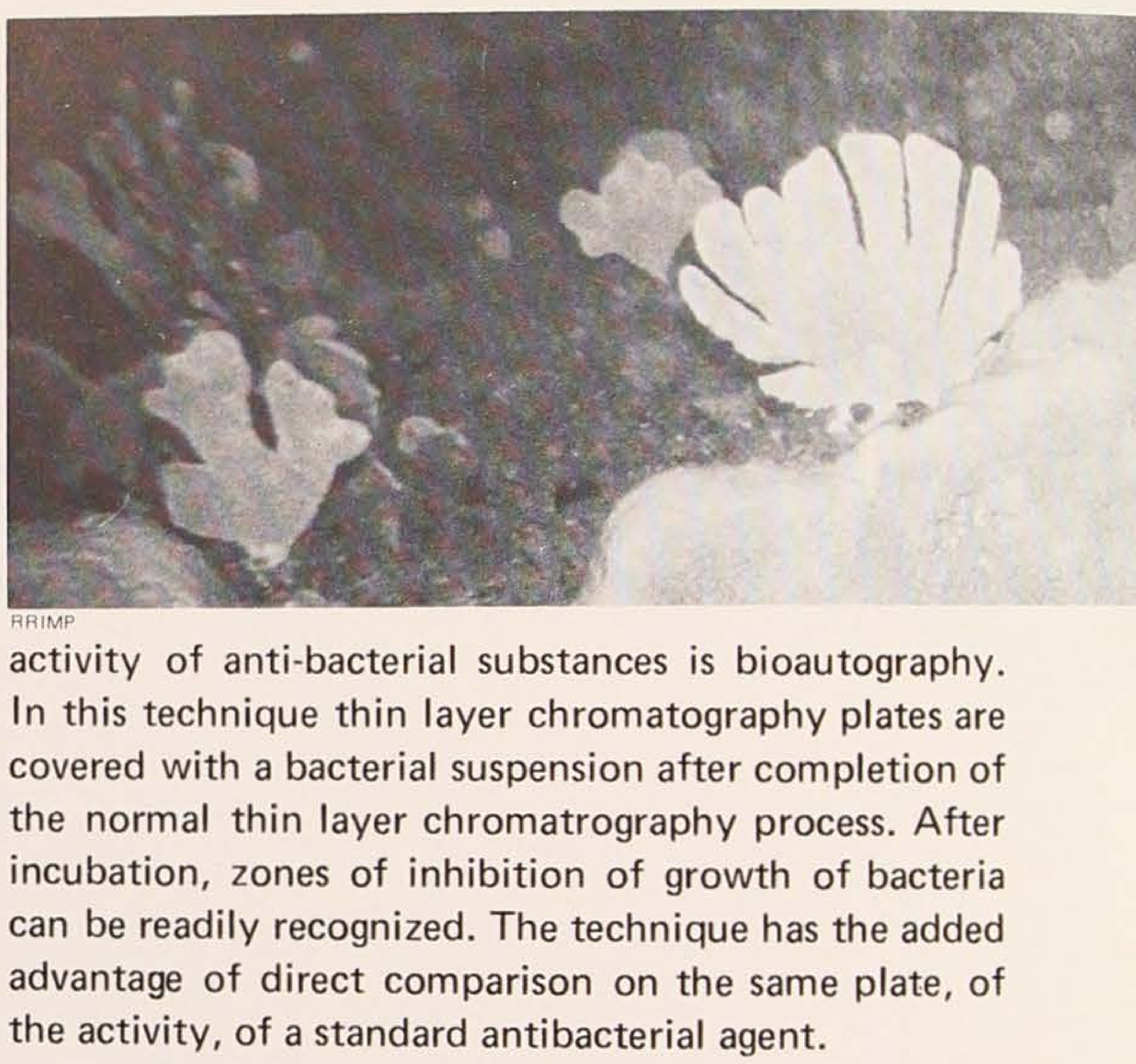
Below: Soft corals such as this bright red *Dendronepthya* abound in the waters of the Barrier Reef and extend into NSW waters. Soft corals have provided interesting macrocyclic substances. The green one (right side of photo) is another soft coral — a *Lobophyton* sp.

RRIMP



on blood pressure or active as anti-inflammatory or analgesic agents. In Microbiology, the interest centres on tests for anti-bacterial and anti-fungal agents. Both sections have completed the majority of their tests against standards, and routine screening for activity of marine substances will soon be operational.

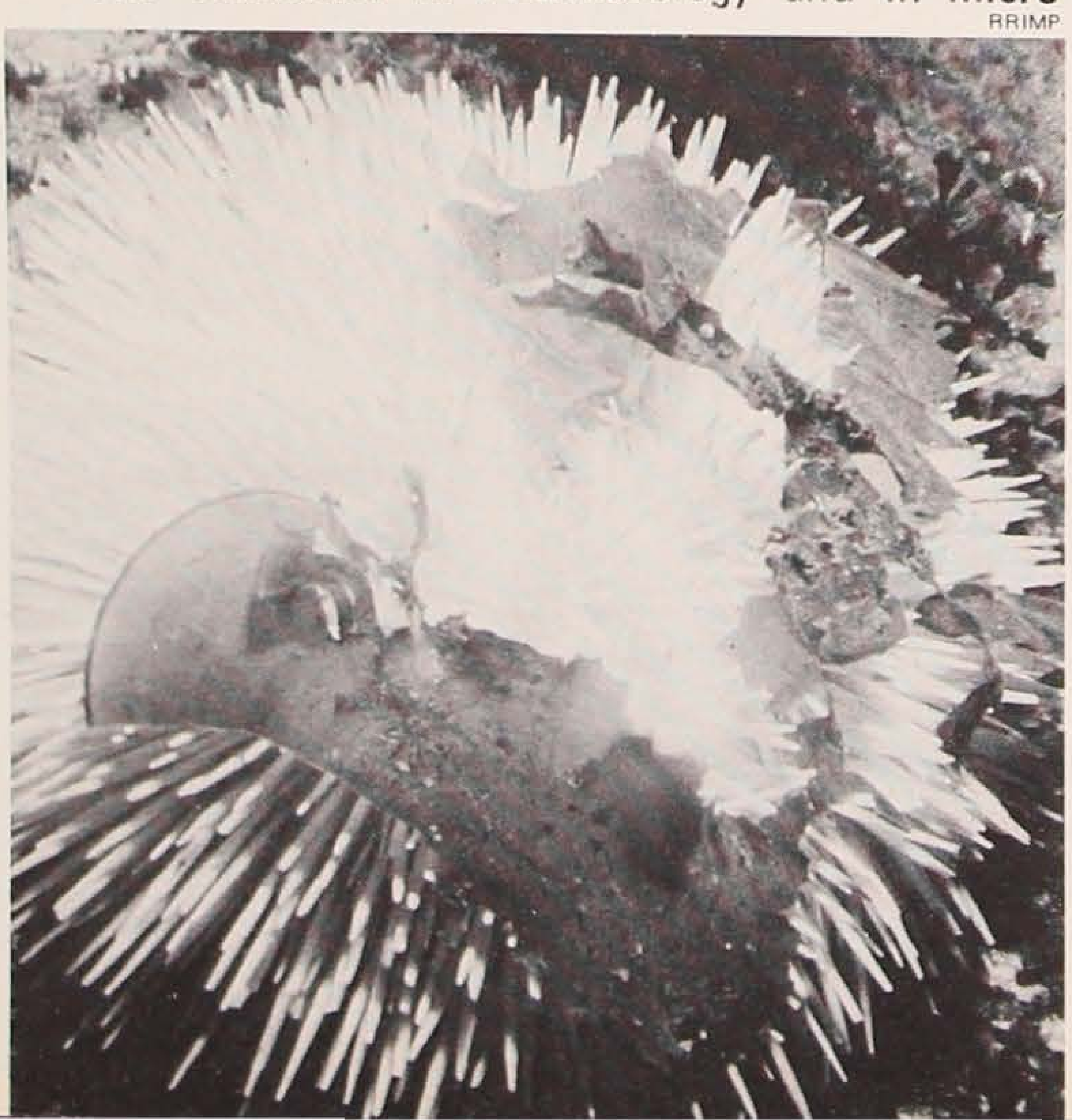
Tests conducted in Pharmacology and in Microbiology will be either away from *(in vitro)* or on live animals *(in vivo)*. Within the Microbiology section, classical methods are followed in the screening for activity against eight different bacteria and two fungi. A further method available for determining the *in vitro* activity of anti-bacterial substances is bioautography. In this technique thin layer chromatography plates are covered with a bacterial suspension after completion of the normal thin layer chromatrography process. After incubation, zones of inhibition of growth of bacteria can be readily recognized. The technique has the added advantage of direct comparison on the same plate, of the activity, of a standard antibacterial agent.



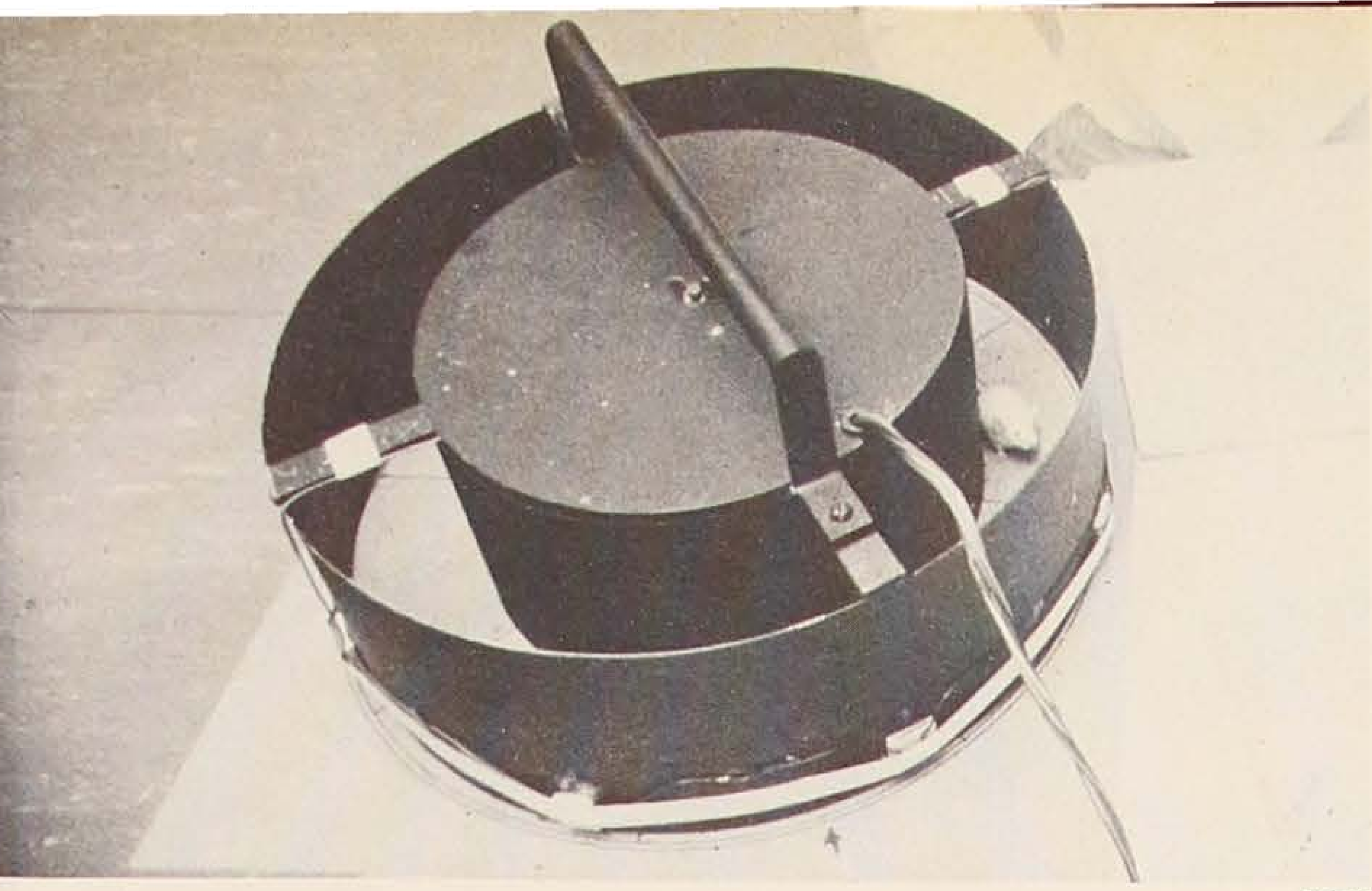
RRIMP

The *in vitro* tests must be followed by *in vivo* tests in animals carrying specific bacterial infections. Such tests are conducted in isolated laboratories and strict safety measures are practiced. Some of the equipment used has been developed within RRIMP. One such example is the mouse runway apparatus used in the Pharmacology section, in which the *in vivo* effect of a substance on the locomotion activity of mice can be assessed as the mouse passes through a series of infra-red light beams, the interruption of which is recorded electronically. In many ways the apparatus relies on a principle similar to a light beam that triggers a mechanism when broken, to open a door or to set off an alarm. In the mouse runway apparatus, the interruption of one of the light beams records a sinyle pass on a

RRIMP



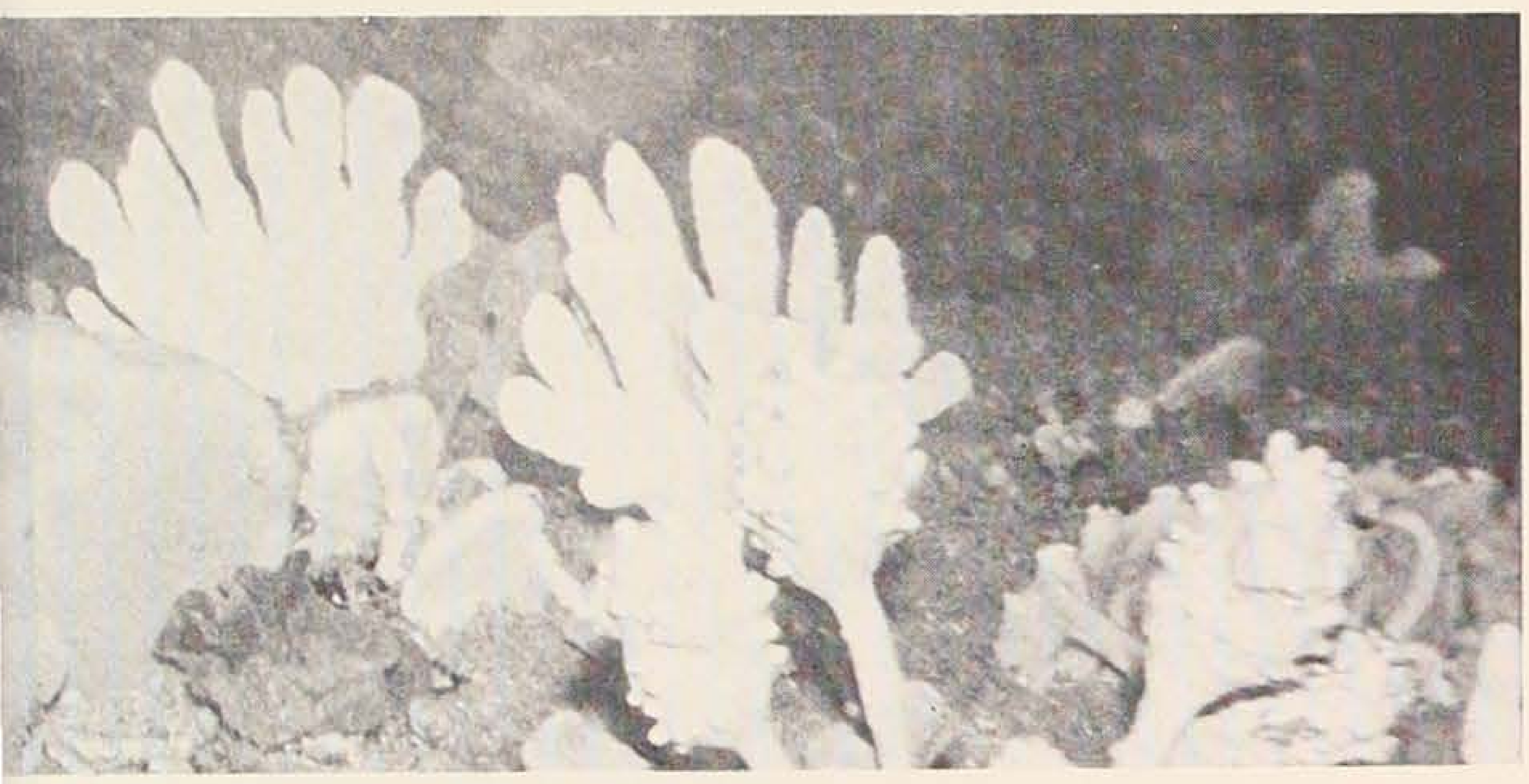
This sea urchin can be found around the Sydney area and is very common on the Great Barrier Reef. It is a common occurrence for sea urchins of this type to have floating pieces of seaweed attached to them, which is said to be a possible protection for the sea urchin against the sun.



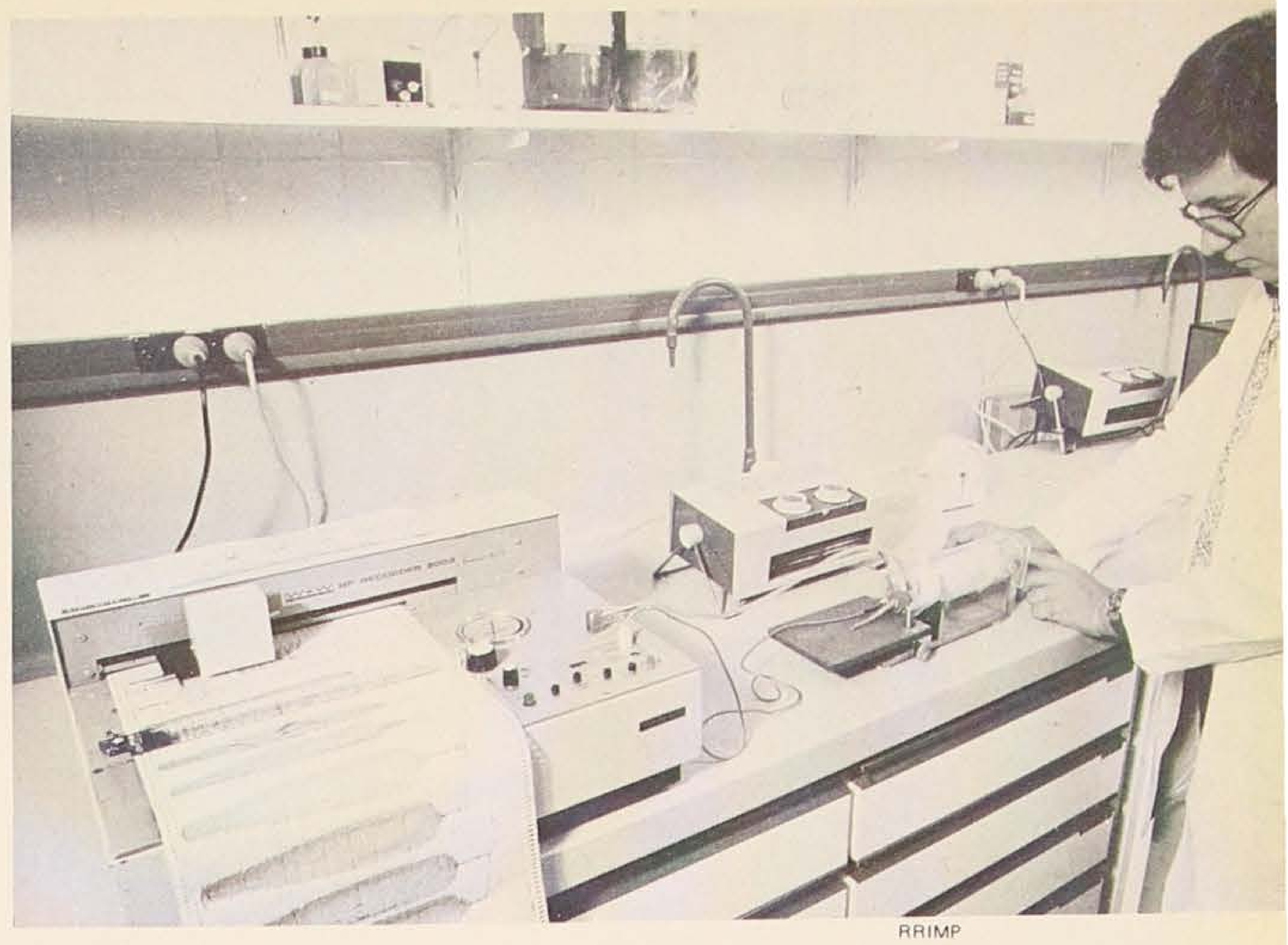
RRIMP

read-out instrument and the circuitry is adjusted so that continuous back and forward motion through the same beam does not result in multiple recording of a pass through that beam. The adjacent beam must be crossed before the first one records.

The effect of marine substances on the circulation system of the rat, in particular the influence on heartbeat and blood pressure, is also routinely studied. Heartbeat may vary either in force or in rate, or both, under the influence of certain chemical substances, and such substances may eventually prove valuable aids in



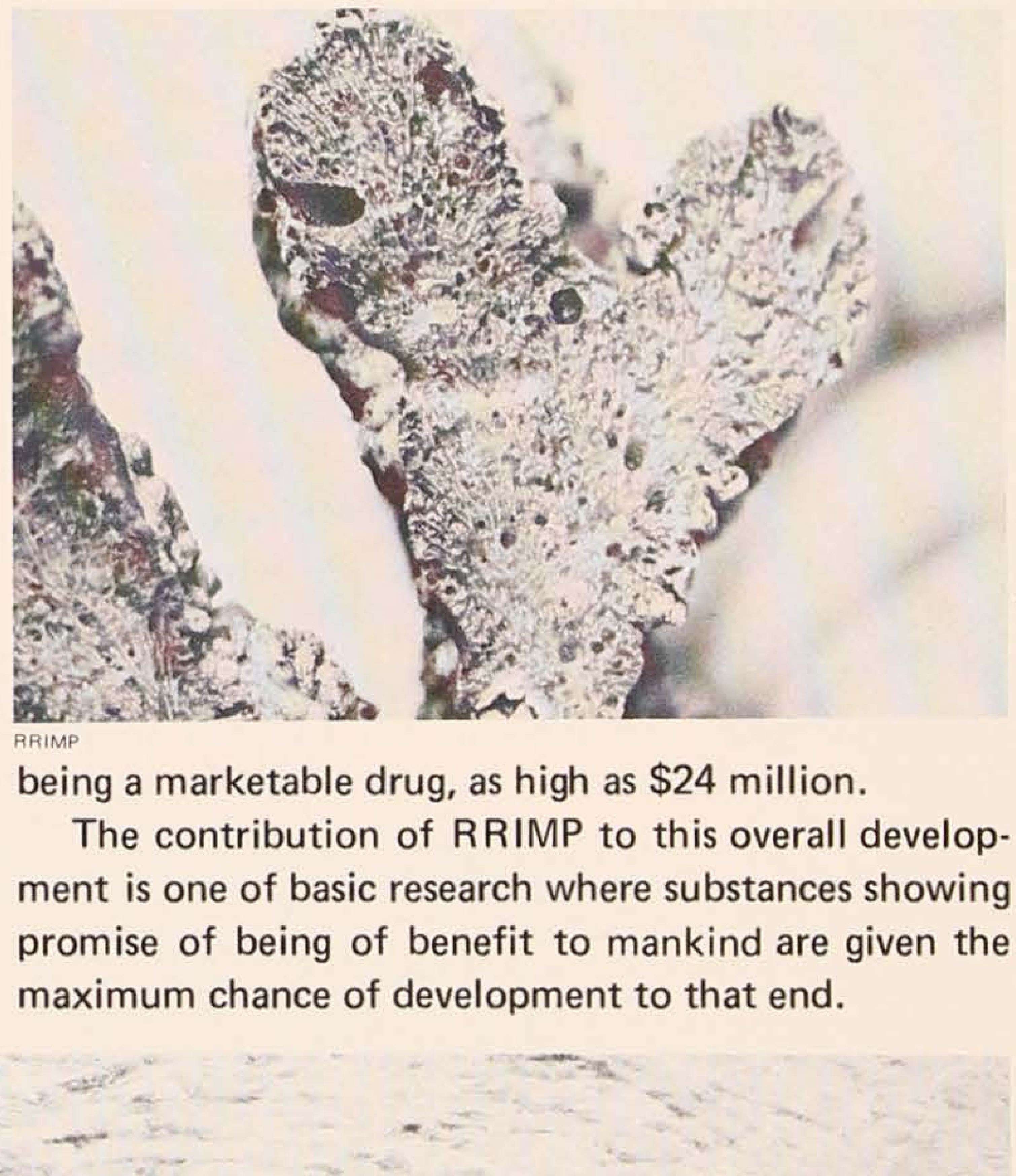
heart surgery. With blood pressure measurements, we are searching for substances which either increase blood pressure (hypertension) or lower blood pressure (hypotension). Other experiments are designed to determine anti-inflammatory and analgesic properties of test substances and where activity is demonstrated in any of these tests, detailed studies on the mechanism of action are conducted. Many more tests must be conducted on promising substances before they could be considered for commercial application.



RRIMP

Laboratory techniques include the mouse runway apparatus (left) and special equipment for measuring the mouse's blood pressure.

Before a substance can be proposed for human application, tests additional to those available in RRIMP must be conducted in other Roche centres. In the search for new biologically substances, RRIMP enjoys the very real advantage of having available the extensive screening facilities of Roche worldwide. The time required for such tests is estimated at 6-10 years, the cost of developing a new substance to the stage of



RRIMP

Cross section of a sponge collected off the NSW coast. Under the ocean it is red in colour with an overall fan type shape and in this example is covered by a colonial anemone. Sponges have given rise to totally new series of compounds.

being a marketable drug, as high as $24 million.

The contribution of RRIMP to this overall development is one of basic research where substances showing promise of being of benefit to mankind are given the maximum chance of development to that end.

RRIMP

A diver in the shallow waters of North Queensland. Note large numbers of soft corals.

LIFE AMONG THE ASHES

BY E. BALL

Newly-created islands seem to interest almost everyone, but they hold a special interest for the ecologist because they provide him with a ready-made laboratory for studying biological colonization and succession. In 1969 Jean-Marie Bassot and I discovered such an island, which the local people call Motmot, about 3km from the nearest shore of Lake Wisdom, a large freshwater lake which fills the central caldera of Long Island, Papua New Guinea.

From the sea, Long Island appears as a long, low-lying land mass connecting two peaks, so it is quite logical that William Dampier, who sailed by in 1700, named the island as he did. In fact, however, the island is a nearly circular collapsed volcano and steep cliffs 200-300m high surround most of the crater containing Lake Wisdom. The vegetation of Long Island varies from open savannah just back from the coast to rainforest on the crater walls and moss forest on the mountain peaks.

The whole of the island is scenically spectacular and it is presently under consideration as a National Park. It has an abundance of animal and bird life, mostly because of low hunting pressure from the relatively small human population (approximately 700), who live in five villages on the seashore. The low human population is the result of slow recolonization following a large eruption which apparently devastated the island sometime between 1700-1750 and killed all those islanders who hadn't fled in response to the initial rumblings. The islanders are basically subsistence farmers although they also do some hunting and fishing. They only go up on the crater rim to hunt and very seldom go to Lake Wisdom.

One digression would appear to be worthwhile before we consider the evolution of the flora, fauna and physical features of Motmot: this is, to stop and consider what information we can hope to gain from such a study. We have been handed a natural experiment and all we have to do is let time pass and observe, while interfering with the course of events as little as possible. The things that we want to know can be summarized by two questions: (1) What gets to the island and how? (2) What succeeds (i.e. survives and reproduces) and what does not and why? The first portion of each question can be answered just by visiting the island at regular intervals and recording what organisms are present. The how and why parts of the questions, however, are considerably more difficult and require a knowledge of the biology of the organisms involved and a certain amount of detective work before they can be answered. With this background, let us now proceed to examine the evolution of Motmot and its plant and animal life.

An island first appeared where Motmot now stands in 1943, but it had apparently been eroded away to a shoal by the early 1950s. A new series of eruptions began in 1953 and activity continued intermittently until June 1955, leaving an island approximately 400m x 100m. Wind and waves gradually eroded this island until by 1968 it had been reduced to a ridge and two small islets. In March 1968, eruptive activity began again and at the time of our first visit in 1969, there were two islands separated by a channel 1-2 metres deep.

When we first arrived on the shores of Lake Wisdom in October 1969, we had the good fortune to find a canoe which had been built in anticipation of the arrival of a party of geologists. Using this canoe we were able to reach the two islands in Lake Wisdom which, we found, differed considerably from each other. The north end of the large island contained a small crater pond and was separated by a saddle from the slightly higher south end, which reached a height of approximately 30m. The large island presented rather unfavourable conditions to any potential colonists due to having either very steep slopes which were constantly being eroded and collapsing onto the beach or hot, highly mineralized water which had to be crossed to reach those areas with more gradually sloping beaches. In addition, the large island was very porous so that it was extremely dry everywhere except on the beaches and around the crater pond.

The only mature plants in 1969 were two clumps of sedge. Aside from sedges there were only three or four immature plants on the entire remainder of the island above beach level and a total of 68 seedlings on the two small areas of beach that combined a relatively gentle slope and moderate water temperature.

Black ducks were present on and around the island and there were two nests containing eggs in crevices

A telephoto shot of Motmot erupting at 9pm on 26 October, 1973.

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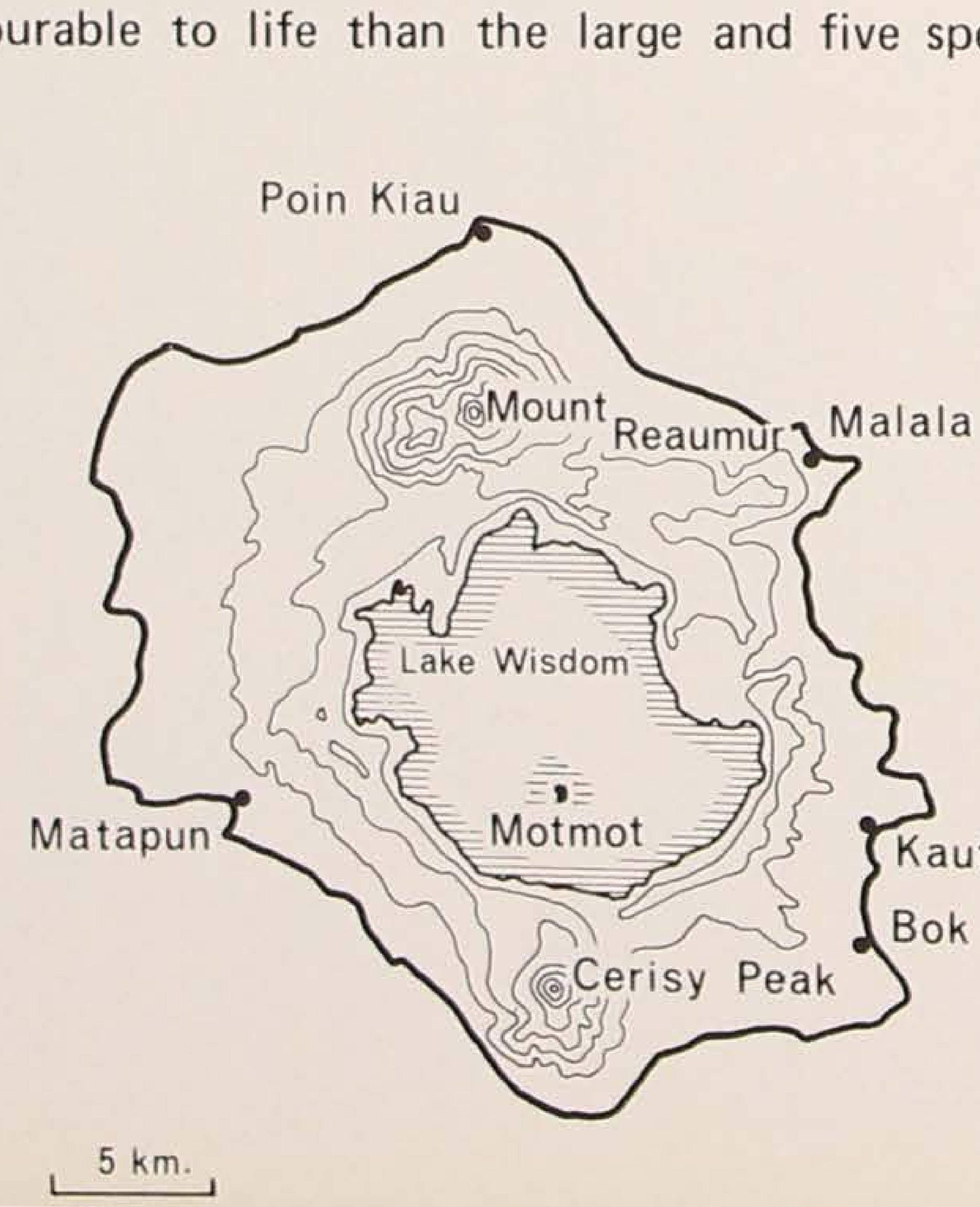
Bureau of Mineral Resources/Photos by permission of the Royal Society

Stages in the development of Motmot. The top and centre photos show eruptive activity in 1968. The bottom photo was taken in November 1969 at the time of the author's first visit.

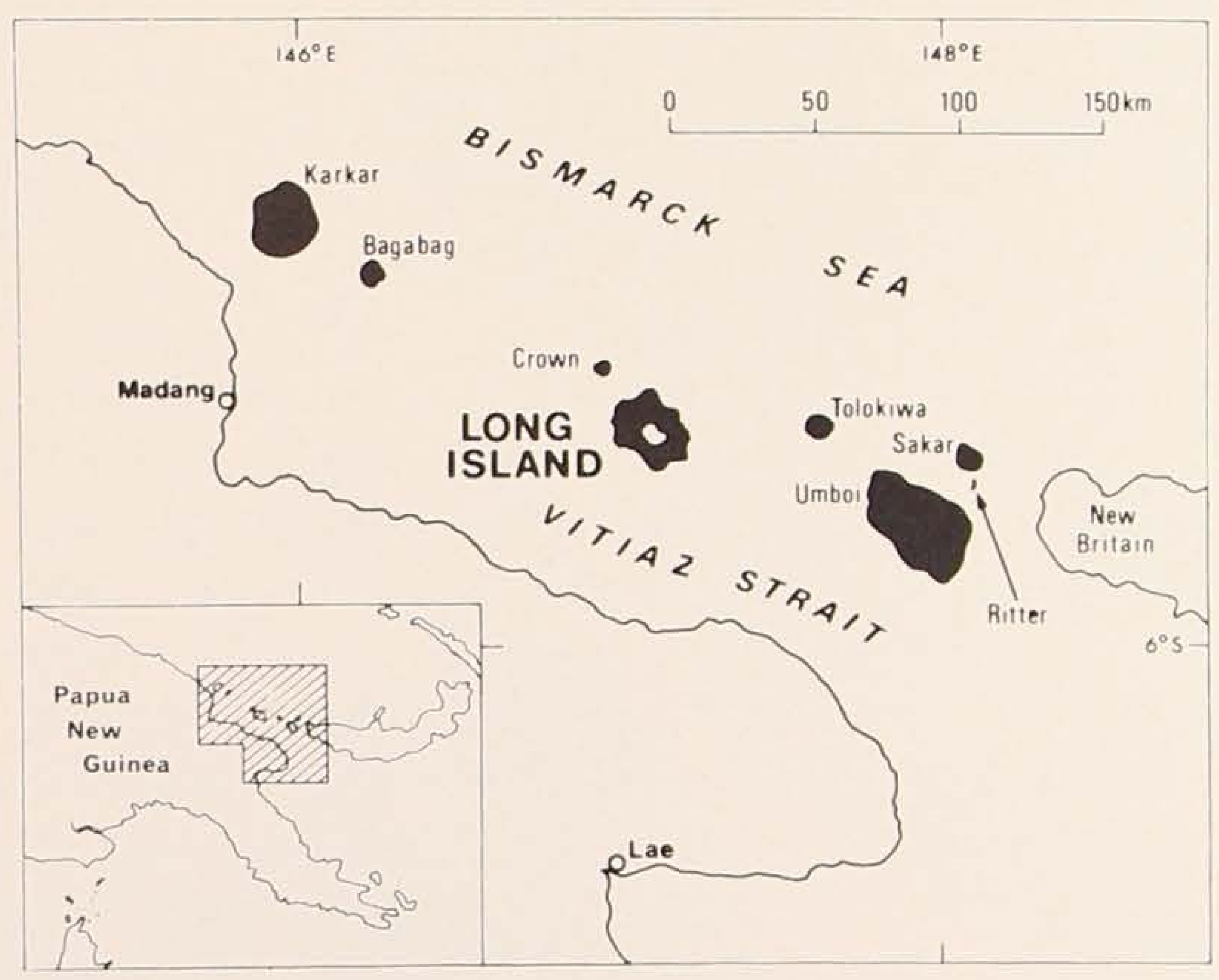
near the crater pond. Swallows were also flying around the island but no nests were seen. Four large lycosid spiders, from the dry ridges above the crater pond, were the only invertebrates found.

The small island had physical conditions much more favourable to life than the large and five species of plants and 22 species of invertebrates were already established there. However, sometime during the following year, this smaller island was reduced to a totally submerged shoal and has remained submerged ever since.



Due to other work, I was unable to return to Long Island in 1970. However, by good fortune Dr. R. W. Johnson visited Motmot during a geological expedition in September 1970, and from his photos it is apparent that sedges were getting started around the small crater lake at this time.

In 1971 Joe Glucksman (PNG Fisheries Research) and I were dropped off on Long Island by the administration boat *Koro* with the promise that it would return for us in about a week. We had hoped to use the canoe that had been built on Lake Wisdom in 1969 to reach Motmot but, on our arrival at the lake, we discovered that this had rotted and we found ourselves sitting on the shore of Lake Wisdom still separated from our goal by 6km of water. We thought about swimming to Motmot, but this would have meant that we couldn't take any equipment with us, so we hired some of the islanders to build us a canoe. This they did over the next few days, making very clever use



of vines, pegs and woods of different hardnesses. However, when we tried the canoe, which was made of green wood, we found that it sank under the weight of any one of us.

As we were running out of time we decided to try to reach the island by using the canoe as a raft for our cameras and other equipment and kicking it out to the island. This worked out fairly well with Angus, our camp boss, who was the lightest of the three, sitting on the main log steering while Joe and I lay on our backs and kicked with swim fins while holding onto the outrigger support. In this fashion we managed to reach Motmot in about 4 hours. We spent the remaining hours until dark hurrying about taking photographs and measurements and collecting specimens. That night a storm came up but we slept relatively comfortably on the volcanically heated sand

E. Ball

Jean-Marie Bassot photographing a spider on the rim of the crater on Motmot.

beach. The next day we continued our survey of the island from sunup until about noon and then kicked our raft back to our camp on the shore, arriving just before dark.

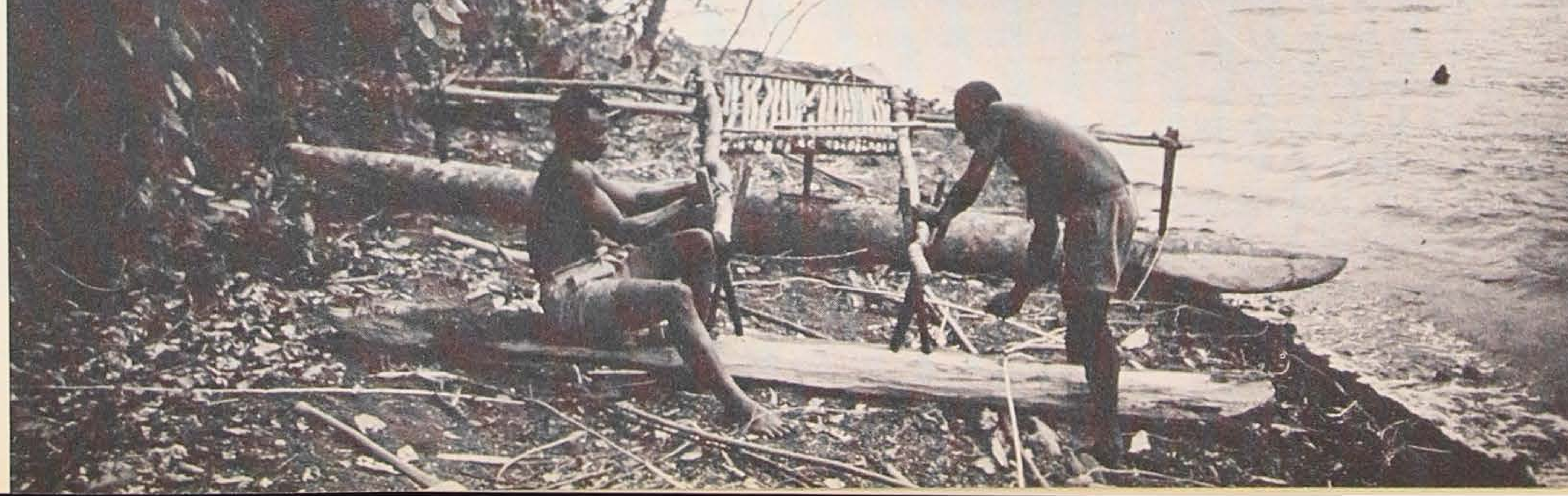
On Motmot we found that the number of plants had greatly increased since 1969, both in number of individuals and in number of species. The plants had flourished best around the pond, but there were also scattered individuals on the drier crater walls. None of the seedlings which had been present on the beaches in 1969 had survived, but there was a new crop in 1971. Sedges were by far the most successful plants with a few individuals of other species also present.

The large lycosid spiders found in 1969 were now present everywhere on the island, but other invertebrates, including earwigs and small beetles, were limited to the beach. Ants were found on the beach and around the crater pond. Black ducks and swallows were common and both were nesting on the island.

On the basis of our 1971 visit, we decided that we wanted to do a more complete survey of Motmot and of the flora, fauna, and physical properties of Lake Wisdom. So in 1972, with the support of the National Geographic Society, Glucksman and I returned to Long Island for a month. This time we went well prepared with a folding aluminium boat and a motor, which made our work much easier. When we arrived at Long Island we found that it was suffering from the worst drought in the memory of the islanders. The effects of the drought were very apparent on Motmot for, although both species diversity and number of plants had increased compared to 1971, many plants either had died or were close to death from lack of water.

Motmot underwent some fairly extensive physical changes between our 1971 and 1972 visits. During the rainy season, heavy wave erosion had cut through the thinnest portion of the crater wall thus connecting the crater pond with Lake Wisdom. By the time of our visit, however, the water level had fallen so low that the two lakes were separated by an exposed sill. In addition, a vent, probably caused by a steam explosion, had opened above the crater.

E. Ball



Angus and Salong putting the finishing touches on the outrigger canoe near camp on Lake Wisdom.

E. Ball

Sedge was one of the two mature plants on Motmot in 1969, by 1972 this founder plant has seeded off several hundred progeny in all directions.

Invertebrate life also increased on Motmot between 1971 and 1972 and the organisms then present can be divided into a few major groupings:

(1) beach insects such as beetles, ants and true bugs which were supported either directly or indirectly on organic material originating outside the island;
(2) ants, which were living among the vegetation around the crater pond;
(3) lycosid spiders and earwigs, which were found in all stages of development almost everywhere on the island, and
(4) staphylinids (rove beetles) and collembolans (tiny primitive insects) associated with the algal crust of the crater pond.

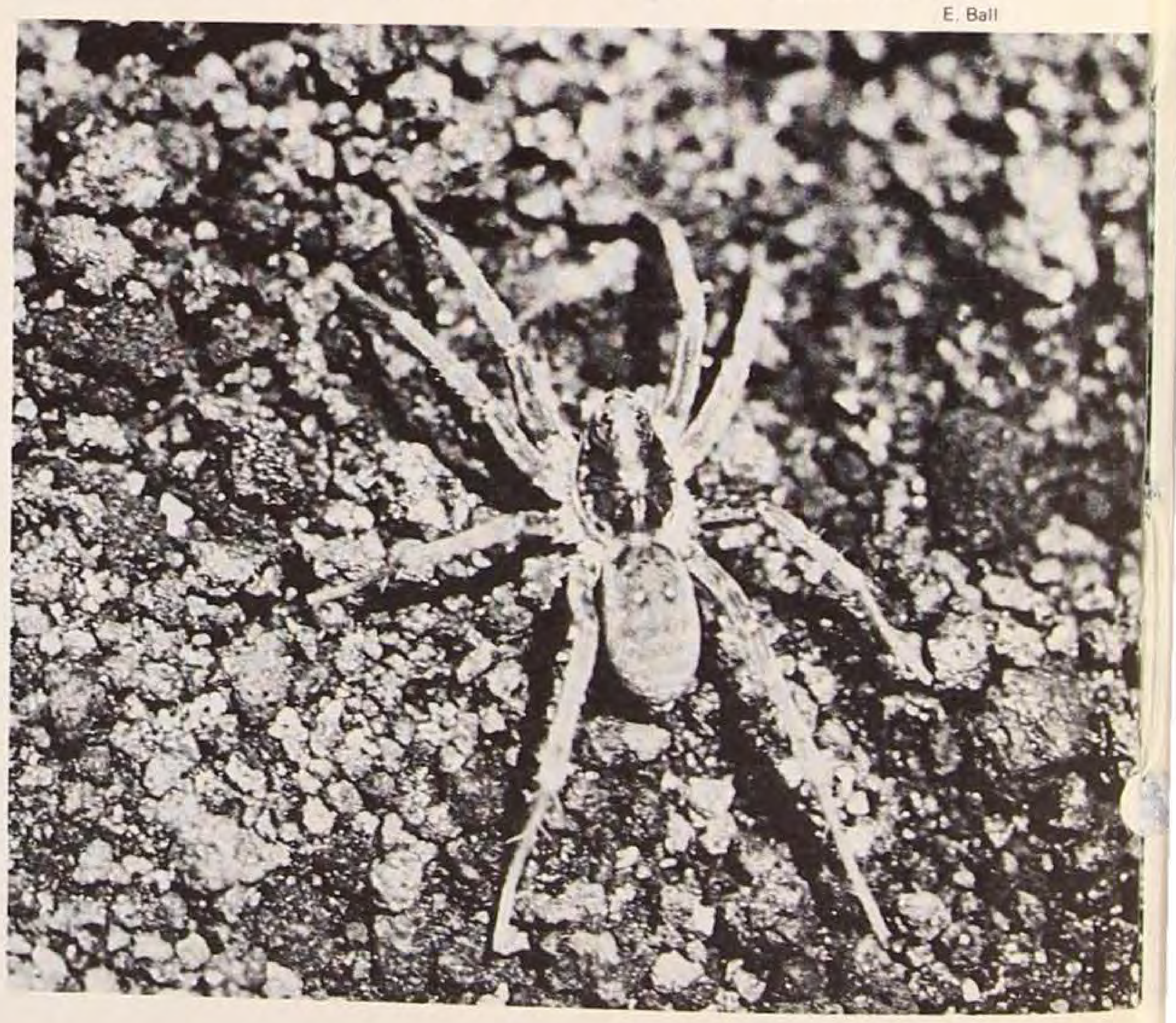
Black ducks and swallows were again abundant on and around the island, and both had active nests there. The usual activity pattern of the ducks was to arrive at the island for several hours after sunset, spend the night either on shore within the crater or in the crater pond, and then fly off again in the hour or two preceding dawn.

In May 1973, Motmot erupted and destroyed essentially the entire plant community, so the biota present in 1972 represented the maximal development of life on Motmot up to the present. Through 1972, Motmot had shown a fairly steady sequence of development with number of species of plants (1969-1, 1971-13, 1972-17) and invertebrates (1969-3, 1971-8, 1972-20) and the area covered by these steadily increasing. Sedges were by far the most successful plants regardless of the measure of success. Mosses were also present in all years and covered large parts of those areas not subject to heavy wind erosion. The other plant species that survived from 1971 to 1972 were all 'weed' species typically found in such disturbed or unstable habitats as sand bars or gardens. Every year the beaches of Motmot had a new crop of seedlings sprouted from seeds that had washed in, but the following year these seedlings had always disappeared, apparently having been killed by either rising water levels, wave erosion, or material falling onto them from the slopes above. Only the plants within the crater and on the crater walls survived from year to year. The distribution of plants on the island makes transport by water or wind unlikely and leaves the ducks as the most probable seed carriers. The Black Duck is a dabbling duck which dredges for food from mud bottoms, strips seeds from plants growing in the water or on shore, and filters seeds from the surface of the water. The CSIRO has made studies of the gut contents of the Black Duck in the Northern Territory and there is remarkable agreement between the genera of plants identified in these studies and the plants found on Motmot. However, ducks grind their food very fine, and it seems unlikely that a seed could survive passage through a duck. Therefore, the ducks probably carried seeds to Motmot either in their feathers or in mud which adhered to feet or feathers.

Although the majority of the plants that survived probably arrived on Motmot on ducks, some almost certainly came by other means. For instance, mosses and ferns both have very light spores which are widely distributed by the wind. Another likely means of seed transport is inside the small birds carried to Motmot by falcons. The very first plant to reach maturity on Motmot, a sedge, was high up on the crater rim beneath a rock where falcons sometimes sit while eating their prey.

Several of the invertebrate species on Motmot may have arrived there more than once and by more than one method. The lycosid spiders probably arrived either by aerial rafting of juveniles on webs or on floating vegetation. For the earwigs, transport by means of floating vegetation seems most likely and, during our 1973 visit to Long Island, we found a floating log, which had already drifted past Motmot, carry-

E. Ball



A lycosid spider, *Varacosa sp.*, and earwigs have been the most successful colonists of Motmot. Within a week after volcanic activity lycosids and earwigs were already invading the new ash fields.

ing two species of ants, two species of spiders and one species of earwig. Beetles, bugs and ants could have reached the island by some combination of flying and being passively carried or as either eggs or adults in floating vegetation or associated soil. Both dragonflies and flies would have reached the island by a combination of flight and wind drift.

It is relatively easy to explain the survival of some of the intervebrates on Motmot. For example the beach fauna of small beetles, ants, earwigs and bugs is either living directly on plant or animal material which washes in or on smaller organisms which are utilizing this material. The ant species from around the crater pond are general scavengers or feed on small insects.

Lycosid spiders are strict carnivores, but they were already present in 1969 before we found other invertebrates on the island. It is possible that our search for other organisms was inadequate but, since lycosids are known to survive for more than six months without food, it seems likely that they were existing on insects that were occasionally blown to the island and on midges that periodically hatch out there. Also, once the earwigs became established they would have contributed to the spiders' diet.

The earwigs first became established on the beaches and then gradually moved inland. Their gut contents included the remains of earwigs and spiders but they may have been feeding on smaller invertebrates and some vegetable material as well.

A new, high cone at the north end of the island where the crater pond had been and a lava flow (Motmot's first), which considerably increased the island's area, were the main results of the 1973 eruptions. At the end of the eruptive period, three clumps of sedge were the only higher plants remaining alive on the island. The beach fauna, which was richest at the south end of the island, was relatively little affected by the eruption and although large numbers of lycosids and earwigs were certainly killed, many survived and some of these survivors were already recolonizing the new ashfields within a week of the end of the volcanic activity.

When we returned to Motmot in 1974, we found that a new cone had been created on the east side of the island since our last visit. In addition, the south end of the island had heated up considerably and this had killed many of the beach invertebrates. The few sedges that had survived the 1973 eruption had reproduced and a few other plants were again getting started on the higher parts of the island. The lycosids and earwigs were still flourishing although they were now more abundant at the north end of the island due to the heating at the south end.

The general impression in 1974 was that the position of life on Motmot was more precarious than at any time since 1969 and we have not been back to Motmot since our 1974 visit. However, in the past


E. Ball

Rising steam from Lake Wisdom — the new hot area on the east side of Motmot

Motmot has always settled down to an extended period of quiescence following a year or two of activity. In addition, the extensive lava flows of 1973-74 mean that Motmot will not be rapidly eroded away this time, so it will be interesting to follow the changes in the biota of Motmot in the coming years.

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SURVIVAL IN AN ARID LAND

BY W.V. MACFARLANE

The desert is a place of extremes, with intermittent deficiencies of water and food, excessive solar radiation and salt, and even frost in winter. Mammals have evolved various adaptations to allow survival in arid regions.

The three main principles underlying desert adaptations are structural, physiological, and behavioural. To illustrate how these principles work, it is useful to consider a series of contrasting pairs of mammals embracing both marsupials and placentals. The first pair comprises a large and a small mammal each evolved for desert conditions.

The desert mouse and the camel are two of the more effective desert mammals. Desert mice (genus *Notomys)* evolved in Australia and are small (20-30g), active, communal seed-eaters. They escape the sun and hot winds in air-conditioned burrows (temperature 25-28°C).Their food seeds have a high energy content but very little moisture so water is derived mainly from burning the hydrogen of fats and starches. They do not need to drink because water is saved by their powerful kidneys which produce the most concentrated urine so far recorded. Water is also conserved by the production of dry faeces, the absence of sweating and a very low metabolic rate which prevents respiratory water loss. The low metabolic rate saves on food but this low rate

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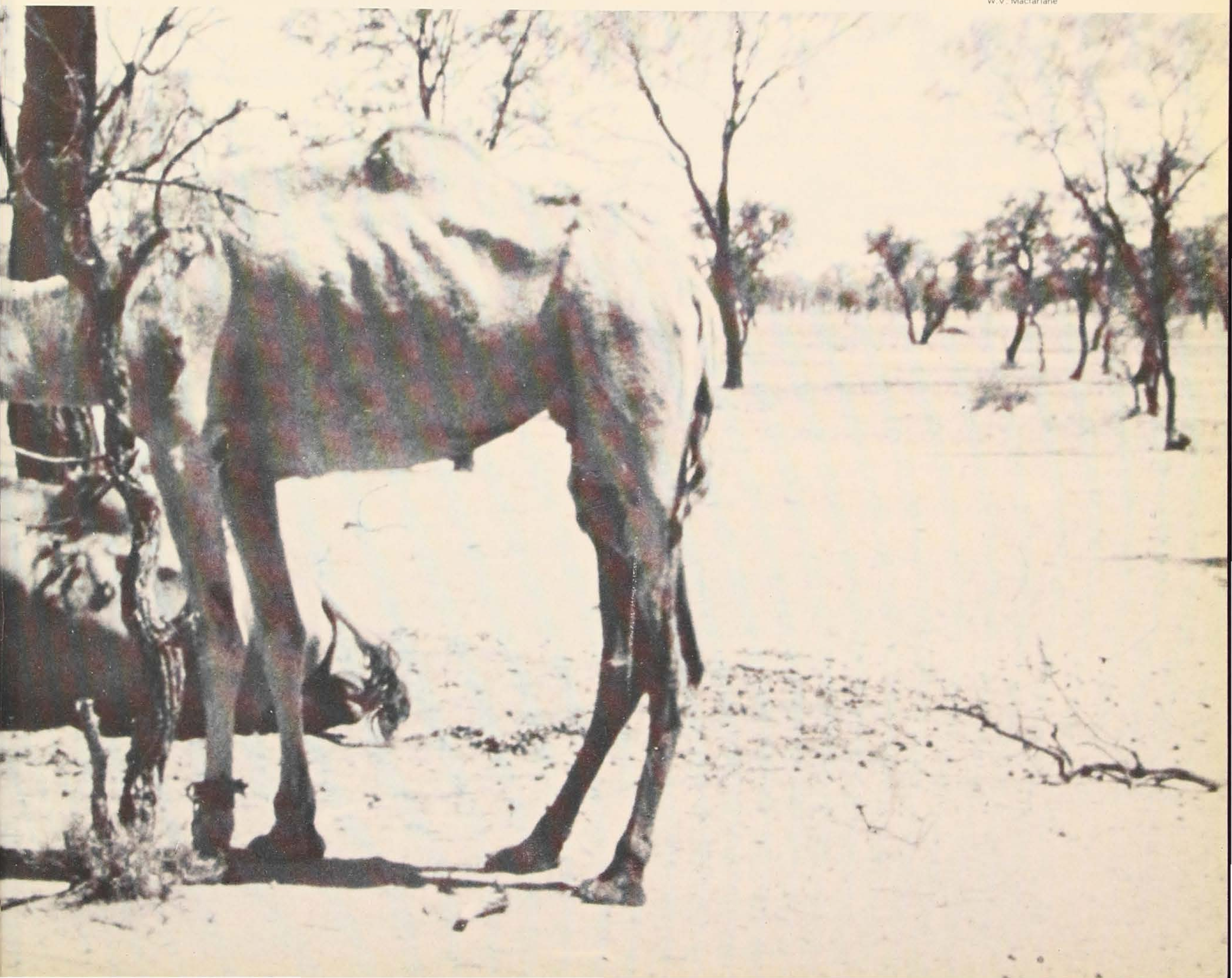
of energy use does not mean that the *Notomys* are sluggish, in fact they are extraordinarily active and efficient. Their burrowing and nocturnal behaviour make water-cooling mechanisms unnecessary. This is a function of size since small mammals escape heat rather than use water for cooling.

Camels are too large (500-700kg) to escape the rigors of the desert. They evolved in the dry west of the USA (Dakota) and migrated three million years ago to Asia and then to Africa. Dromedaries in Australia respond to seasonable change in day length by shedding their thick matte winter coat in spring and growing a sleek shining summer coat under the influence of longer days. The surface temperature of winter coats in the sun can reach 65°C but the smooth summer coat reflects heat, and rarely rises above 46°C. Equatorial camels do not shed their coats but retain a smooth, reflecting surface throughout the year. Like most desert mammals, the camel's skin is dark so that even if it did receive ultraviolet radiation there would be little sunburn.

In 1907, camel's were brought to Western Australia where veterinary officers noticed that body temperatures were high in the evening (41°C) and low in the

His major research interest is the ecophysiology of Australia's arid regions.

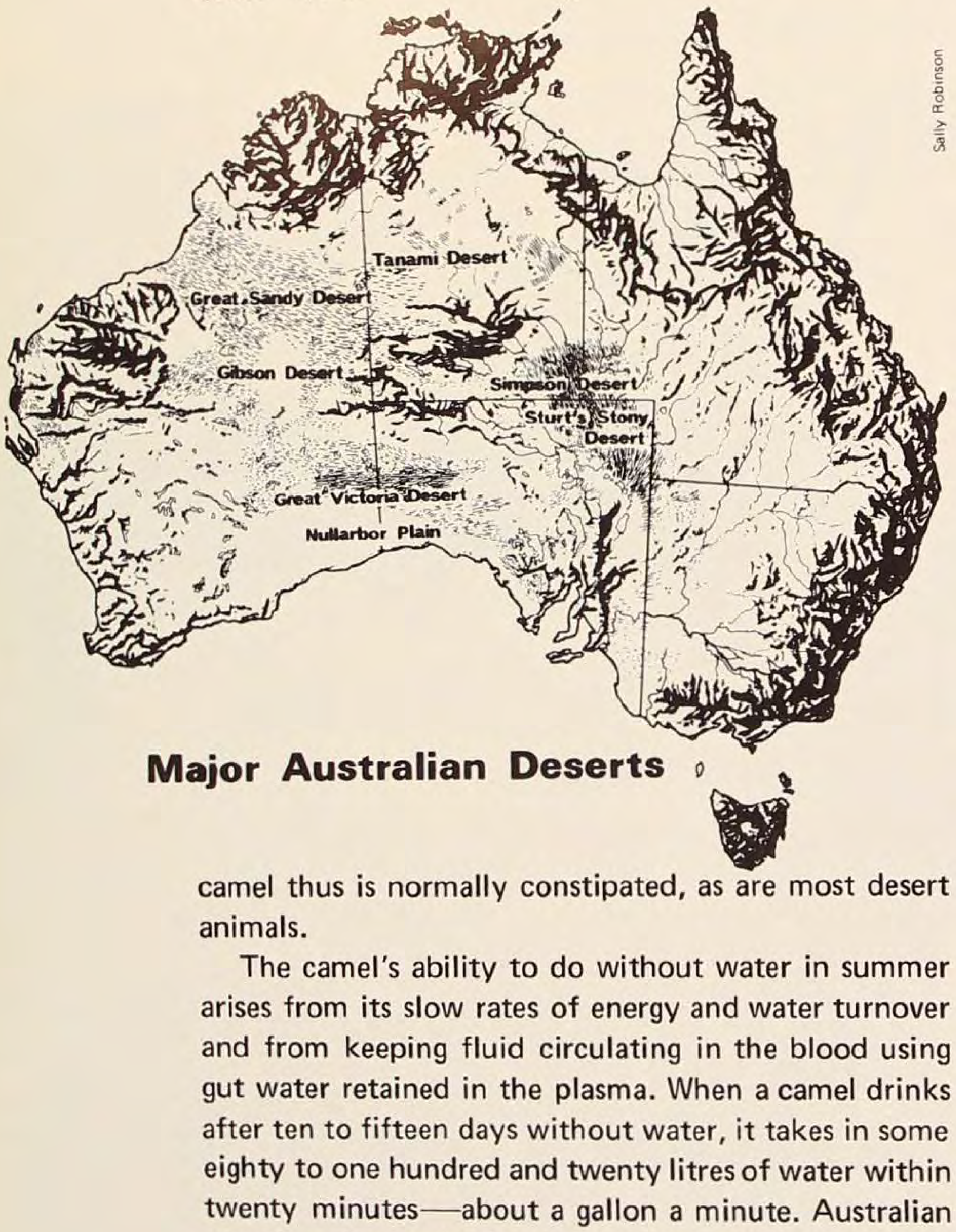


W.V. Macfarlane

In central Australia during the long drought of 1958-1966, lactation was an added strain on camels. These animals had lost most of their humps, but continued to feed their calves up to two years.

morning (37°C). In effect, the camel stores heat by day, and loses it during the night by convection and conduction, rather than by expensive sweating. When a camel is dehydrated it has a greater morning to evening temperature (Schmidt-Nielsen 1964). Camels adapt to solar heat behaviourally, sitting all day on the same patch of sand, which remains cool at 45°C under them (while the desert around is 70°C or more). The camel also moves with the sun so that it catches the least amount of heat, its head pointing east in the morning, and west in the evening.

Water is saved by various devices. Camels have thick skin and do not have a wet muzzle. The nose is covered with soft hair. Nostrils are closed by sphincters for two-thirds of the time, opened two seconds for a breath, then closed to keep out dust and flies. As it is not a panting animal, the camel loses little water from the nose, trachea or lungs. The colon of the camel is an extraordinarily good water-absorbing mechanism. The faecal pellets are dried to only forty-five percent water whereas cattle faeces contain sixty-five percent water. The camel thus is normally constipated, as are most desert animals.



Major Australian Deserts

The camel's ability to do without water in summer arises from its slow rates of energy and water turnover and from keeping fluid circulating in the blood using gut water retained in the plasma. When a camel drinks after ten to fifteen days without water, it takes in some eighty to one hundred and twenty litres of water within twenty minutes—about a gallon a minute. Australian camels replace only about sixty percent of water loss in the first drink, so two to four drinking periods at about twelve hour intervals are needed for full replenishment. Although *Notomys* can concentrate urine dramatically, camel's urine is considerably less concetrated yet interestingly, the daily amount of urine lost by a camel without water is only one one-thousandth of its body weight, compared with a urinary loss of one two-hundredth of body weight in dry sheep. The kidney filtration of camels can be reduced during dehydration to as little as one fifth of the normal. This means that urea and salt are retained in the blood, then re-used after the camel drinks.

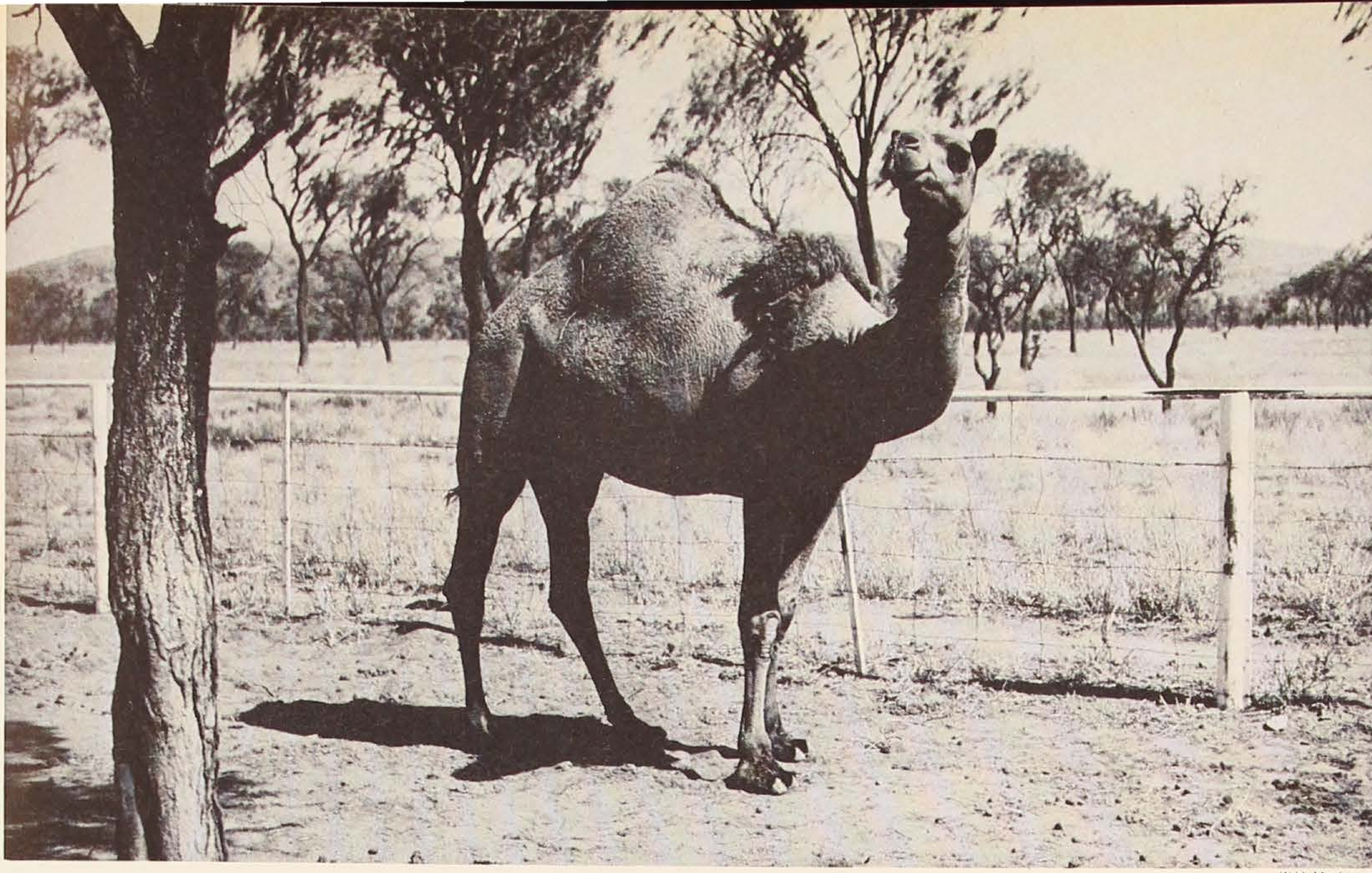
The camel kidney responds one hundred times more readily to the water-saving hormone, vasopressin, than do the kidneys of cattle. Vasopressin encourages water reabsorption, but in camels it causes potassium secretion across the tubule wall, short-circuiting the renal filter. Potassium is thus moved into the urine, while sodium and water are retained. Potassium is a danger because it reduces blood pressure, and in excess, the heart beats irregularly. On the other hand the tissues of the camel are not adversely affected by high concentrations of urea. Camel nerve cells are extraordinarily tolerant of salt which can be readily pumped out of cells.

The camel will select more than one hundred species of plants from its wide feeding range and prefers dry rather than succulent pasture; it likes salty plants. It can walk long distances, up to four-hundred kilometres over fifteen days between watering places during summer in its relentless search for food. In winter it does not need to drink at all, since it derives sufficient water from its food.

The camel also keeps on eating beyond its immediate needs. A five-hundred kilogram camel can store two-hundred kilograms of fat in the hump which can provide enough food to keep the camel alive for about six months without eating. During droughts it may disappear completely. The hump, composed of yellow fat interlaced with blood vessels and fibrous tissue, also prevents the insulating properties of fat from interfering with cooling. By keeping the insulation on the back, the belly and underparts of the camel are free of fat insulation, so that more heat can be lost to the sand or air.

The surface of arid Australia comprises many areas which look as though there were ringworm on the land. These are the salt fringes of water holes. Chenopod saltbushes which grow in these regions are eaten by camels, taking advantage of the valuable proteins of this plant. Camels are also able to drink water containing over five percent sodium chloride, a higher salt concentration than sea water, without ill effect. Mammals tolerate salt in inverse proportions to the amount of water passing through them. The lower the water turnover, the greater the salt tolerance; the camel is probably the most capable salt-handler of all mammals.

Amongst the marsupials, differences in ecophysiology can be illustrated by contrasting two insectivorous dasyurids. *Sminthopsis crassicaudata* is a small marsupial that can live in the desert. It has, like cattle, high metabolic water turnover rates so that it dies in about



W.V. Macfarlane

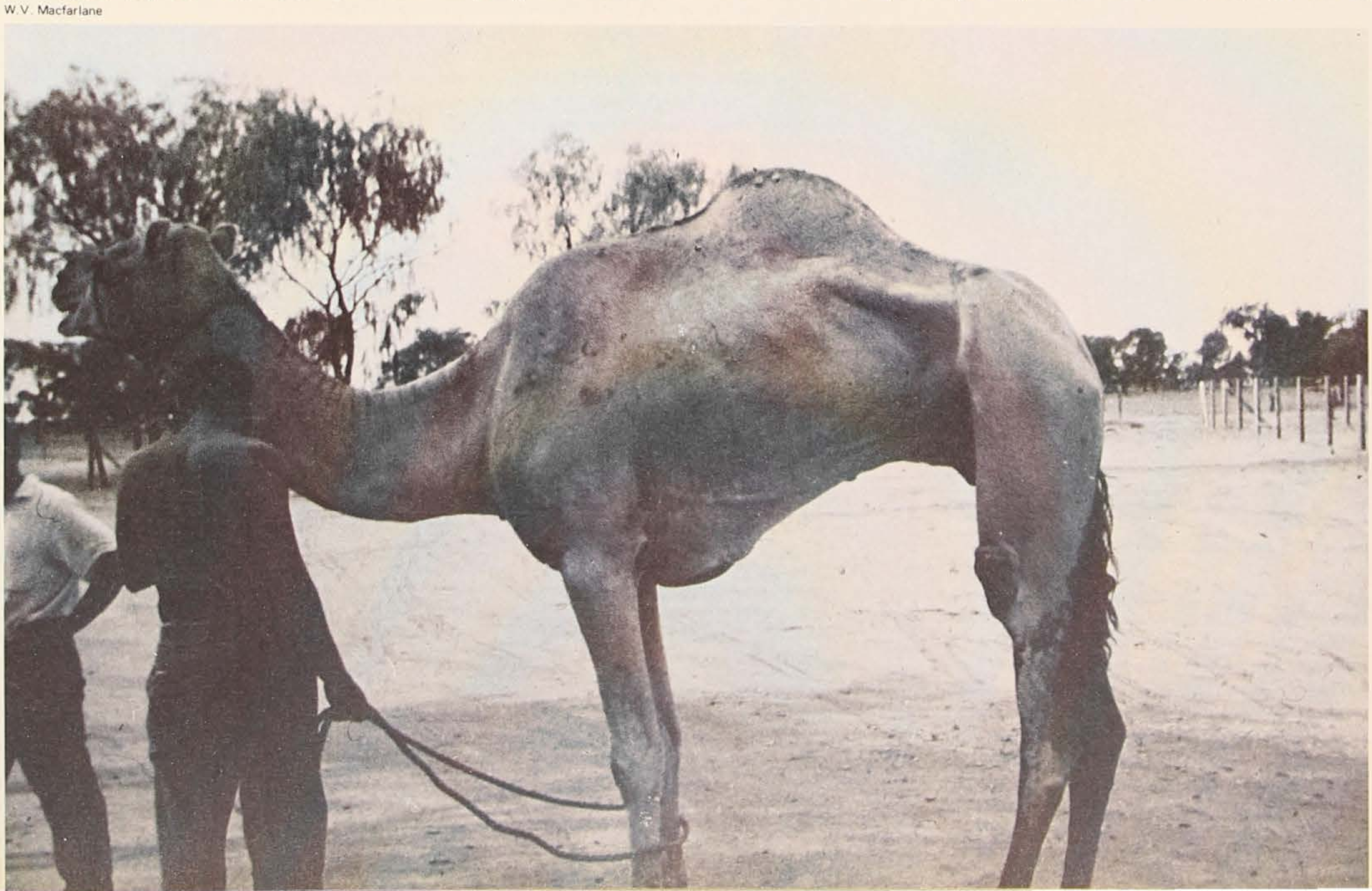
After the drought broke in 1965, the camels ate persistently over the next three years and put away 200kg of fat, ready for the next famine. This fat could feed them for at least six months.

five days without water. *Dasyuriodes* and *Dasycercus* are slightly larger but they originated in the desert, like the camel. They have low rates of metabolism and water turnover, and need not drink if they can catch insect food. *Sminthopsis* does not burrow, but lives under logs or rocks. It is found up the great river system of the Murray-Darling and as far into the desert as Oodnadatta. By contrast *Dasycercus* has its heartland in the central desert where it makes deep burrows, forages for insects at night and lives away from water. Both types of marsupial go into torpor if food supply is low. Body temperature falls to 12-14°C and with it, of course, the energy and water demands. The animals are fairly easily roused, then they search for food or, in the case of *Sminthopsis,* for water.

Sminthopsis and *Dasycercus* look alike. They both grow fat tails during good seasons but, interestingly, *Sminthopsis* turns over water and energy three times faster than *Dasycercus* and so dies quickly without food or water. *Dasycercus* is extremely active yet its rate of use of water and energy is low. It can live at least three times longer without food and water than *Sminthopsis. Sminthopsis* populations seem to die out during long droughts but can re-invade dry country afterwards since a nuclear population is maintained in cool wet areas. In contrast *Dasycercus* or *Dasyuroides* sit out the dry periods. Desert insects are still numerous during drought so food containing water is still available.

Among the grazing marsupials, the hairy-nosed wombat is physiologically nearest to the camel. It has

W.V. Macfarlane

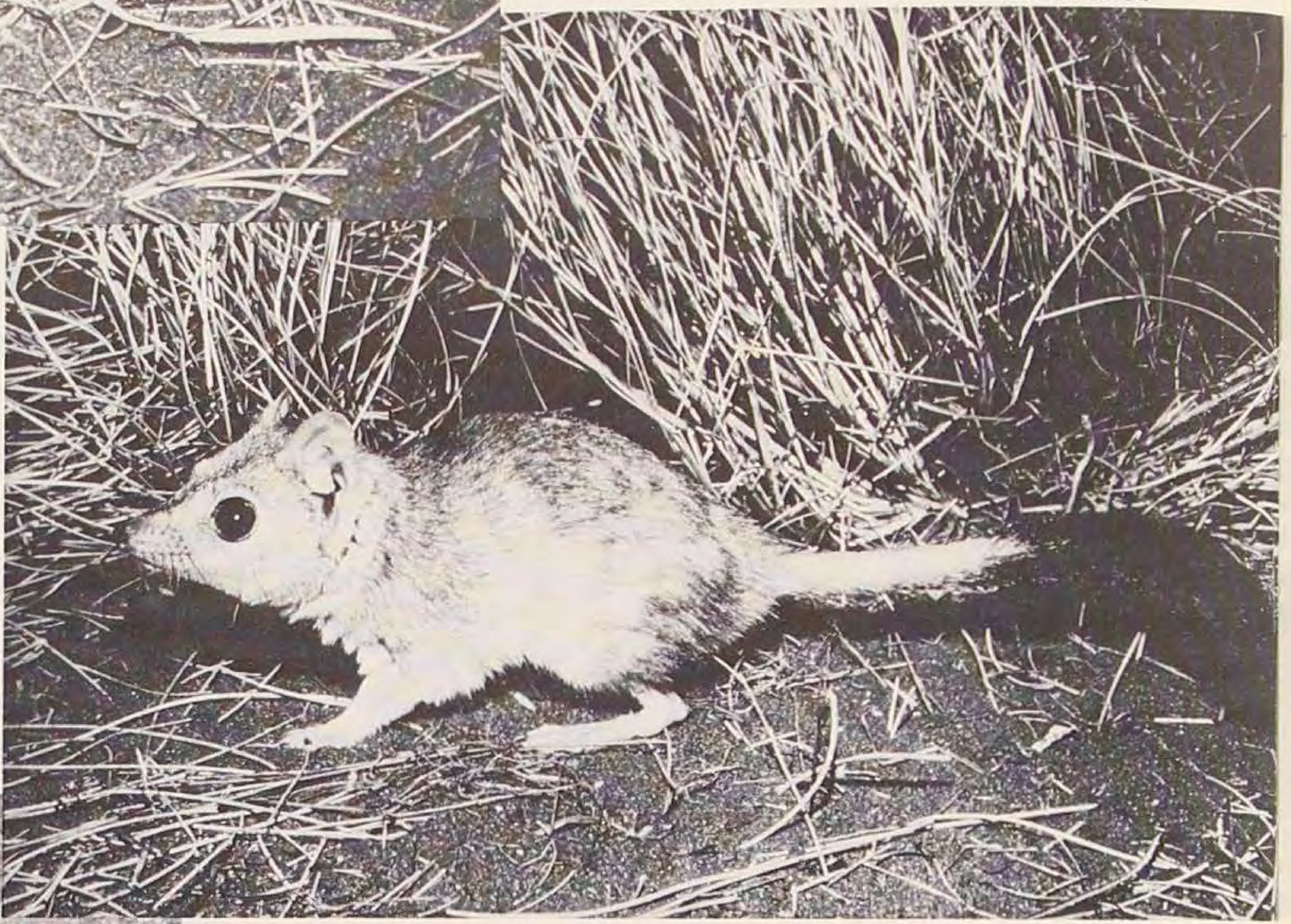


This Australian camel was nine days without water with daily temperatures of 40°C. The main sign of its dehydration is the retracted adominal line. Near Alice Springs, latitude 24°S, the effect of day length on the coat is to leave a rougher, longer fur than is seen in equatorial camels. The toenails of the camel show clearly on top of the feet. Camels walk on the soft pads of their fingers and toes. The hard, dry, faecal pellets of the camel are scattered over the ground.

Left: This Australian mouse, *Notomys alexis,* eats seeds, does not need to drink water and lives in burrows, foraging at night.

W.V. Macfarlane

W.V. Macfarlane



Right: By living in burrows and eating insects, this marsupial, *Dasyuroides byrnei,* can live in the desert without drinking. It has a very low rate of use of both energy and water, and yet it is extraordinarily active in catching insects.

Left: By storage of fat in the tail and slow use of this reserve, *Dasycercus,* can survive famine when its insect food is not available. This marsupial has a very low rate of use of energy and water, and fat is used from the tail more slowly than from other places. It does not need to drink in the desert. The entrance to its metre-deep burrow is seen.

W.V. Macfarlane

Right: Although these marsupials, *Sminthopsis crassicaudata,* belong to the same family as *Dasycercus* and have fat storage in the tail, they survive only five days without water. The rates at which they use water and food is three times greater than that of *Dasycercus* or *Dasyuroides.* They belong in well-watered country, but live in the desert like cattle, near their water supplies.

very low rates of use of water and energy which fit it both for the desert and for life in its protective burrow.

In the arid areas, it is useful to contrast wallabies and kangaroos, sheep and goats on the one side, with cattle and humans on the other. Sheep and kangaroos are intermediate in metabolic rate and water turnover between the low-rate camels and high-rate cattle. Sheep can survive eight days in summer without water and, like kangaroos, they lose it at the rate of about four percent each day. Goats are rather more drought-resistant than sheep and the euro or hill kangaroo is better at desert living than the grey kangaroo but the differences are not great. These animals function between cattle and camels also in urinary concentration and faecal water content and show some differences in the ways of desert living. The Merino sheep for instance has an insulating coat which becomes extremely hot (90°C) on the surface, but the wool prevents the heat reaching the skin. Kangaroos have a more reflecting coat which does not become much hotter than 55°C. Merinos stay out in the sun on the treeless plains whereas Kangaroos prefer living in scrub country, seeking the shade of bushes in creek beds. Wallabies use rock shelters to escape the sun and graze at night. Kangaroos graze the greener plants but sheep will eat dry grasses. When a sheep is without water, it loses fluid from the gut as well as from the plasma. Plasma volume falls to about half in ten days and yet the sheep is able to maintain circulation with this unusually low volume. It is far less tolerant of salt than is the camel—1.8% of salt in the drinking water causes staggers and usually death. Kangarros have a similar physiology.

On the other hand, cattle, pigs and humans have high rates of water turnover and are not really adapted to desert living. At 40°C cattle will die in four to five days without water, losing seven to eight percent of body weight each day. Humans are even less adequate and, without water, Aborigines die within two days during summer exposure. Europeans walking in the desert sun with no water often die within four hours. This is because man is the greatest sweater of all animals (up to 3 litres per hour). On a desert walk, he would lose over one litre an hour, straight from the blood. Soon circulatory shock sets in.

The Aborigines, in spite of desert living and forty thousand years in Australia, produce nearly twice as much sweat in a day as Europeans and, accordingly, they drink twice as much water. This probably relates to their origin in the wetter parts of southern Asia where water was plentiful. They are not really desert peoples, but rather they have adjusted behaviourally to living near desert water sources. Like kangaroos they lie up in the shade by day, then travel at night. Neither man, pig nor cattle beast is tolerant of salt. About one percent of salt in the drinking water is enough to produce neurotoxicity.

Cattle in the arid areas are similar to Aborigines in their response to heat. They seek shade and water; they sweat, but not as exuberantly—at a rate less than a third that of man. They develop thin, shining coats which reflect the heat of the sun and as a second defense they evaporate water from the turbinals of the nose. In the desert, however, they still retain jungle equipment. The muzzle of a cow is covered with glands, which secrete a dilute salty fluid with mucus, which protects the nose from excoriation during swamp grazing. In the desert it still loses water rather pointlessly among the dry grasses.

In all these contrasting approaches, there are hierarchical functions. Evolutionary processes have selected proteins of particular types for each sort of environment. The energy-water-protein turnover hierarchy has its high point in jungle animals (cattle, pigs, deer or man) and its low points in the desert (camel, goat, wombat) with intermediate rate functions in sheep, kangaroo, and wallaby. The desert animals are the most tolerant of salt and those most intolerant derive from the jungle.

Reproduction presents a similar set of contrasts. The camel, as a desert animal is an opportunistic breeder. After two months of good food, its pituitary turns on hormones leading to oestrus, rut, mating and the conception of young. These are born eleven months later, when there should be further rain and food. The delayed implantation and cessation of breeding during drought, common in macropods, is also a desert defense mechanism.

Animals which adjust to the desert behaviourally, in spite of inappropriate, high rate-functions are much more vulnerable to heat and drought and lack of food and water than are those which have evolved with the full machinery of desert ecophysiology. For the desert, low rates of turnover, high salt tolerance, heat escape, heat storage mechanism, water economy, plasma volume maintenance in dehydration and opportunistic breeding are functional advantages. If living organisms originated in water, the desert animal has come furthest from it and has reached the peak of evolutionary adaptation.

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Charles Turner

TRACING PATTERNS OF INSECT FLIGHT

BY COURTENAY SMITHERS

To speak of migration in some animals, such as birds, is now quite commonplace and evinces no reaction. Bands placed on the legs of birds by thousands of enthusiastic naturalists have established in some detail the long distance routes taken each year by whole populations of many species.

To speak of migration in insects, on the other hand, still causes surprise amongst most people, even naturalists. Insects are traditionally thought of as small, delicate creatures, buffeted by the elements and living for a short while. In reality, despite their small size (in relation to Man, that is) they are tough animals. They have evolved as the most successful group of animals in a highly competitive world. They have evolved complex bodily structures in their moves to exploit their environment and they have developed senses of such acuity as to be quite incomprehensible to us. Along with these physical attributes have evolved specialization and complexity of behaviour patterns. As a group, the insects are essentially opportunists, taking advantage of situations as they arise. Because of their small size individuals are able to flourish on relatively small quantities of resources and it is essential for them to be able to seek out and take advantage of these resources as they become available. At the same time an ability to breed rapidly enables them to develop relatively high populations during those periods when food is plentiful; they are adapted in one way or another to overcome the difficult times. From time to time insects move en masse. Population movements or migration can be seen in many orders of insects, and it is not only the larger species which do so. These are not random phenomena; the movements are part of the regular behaviour pattern of the species, but it is only in comparatively recent times that insect migration has been intensively studied. There are certain inherent difficulties in such studies. It is only natural that the larger migrant species have come in for most attention because they are easiest to see and study in the field and migration study is essentially a field operation. As a result of this, more is known about migration in butterflies, some of the moths, some beetles and few pest species, although the phenomenon is widespread in other insect groups. Those species which migrate do so regularly although sometimes their population levels may be low and their movements may not be at all obvious and must be watched for very carefully before they can be detected. On the other hand, when populations are high, dense swarms may be on the move at once, even to the extent that they may become a nuisance.

Helpful to any migration study is the ability to identify the species easily in the field and here, again, the butterflies have an advantage in that many of the species are easily recognised in the field. With a little experience in observing insects going about their everyday business in the field, it is possible to recognise different kinds of behaviour and, with a little practice, one can recognise the flight of a migrating individual as being somewhat different from that of a non-migrating one. At most times, a butterfly will merely flit about in a rather haphazard way, flying around obstacles it may meet, feeding on the nectar of flowers or resting on the ground or on foliage. Butterfly collectors very quickly learn to recognise the characteristic flight of certain species. The fast erratic flight of the skippers is very characteristic and the lazy, flapping, leisurely flight of the large swallowtails is equally so. When migrating, the individual takes on a somewhat different kind of flight. The flight path tends to be much straighter, more 'determined' in appearance and although the butterfly will often stop to feed, when it sets off once again it will set off in the direction in which it was previously flying. Stops are short and are for feeding, not resting. There is a very strong tendency to fly up and over an obstacle rather than to go around it and migrating butterflies will frequently fly towards a building, fly up the wall, across the roof and down the other side rather than skirt around the building. There is also tendency to maintain a certain height above the ground and this is often characteristic for a species. Some fly high; others maintain a fairly low level of flight, sometimes little more than a metre or two above the ground.

Most butterflies normally settle down and refuse to take flight when wind speeds increase to the point where direction of flight is affected. When migrating, however, the wind speeds which are tolerated are much greater

A mass of wanderers gathered together during winter in the coastal area of New South Wales. Scattered through the Sydney Basin and Hunter Valley, enormous numbers wait for the advent of spring.

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The life-cycle of the Caper White Butterfly *(Anaphaeis java teutonia)*. 1. Eggs on foliage. 2. Eggs (enlarged). 3. Caterpillar. 4. Caterpillar (enlarged). 5. Pupa (enlarged). 6. Pupa on leaf. 7. Upper surface of butterfly. 8. Under surface of butterfly.

Plate XIX.—LEPIDOPTERA.

From Froggat, 1907

Wanderer butterflies migrate from inland areas to the coastal region where they gather into clusters at certain localities to pass the winter as a fairly non-active, non-reproducing population. In spring they set off to areas in which the females can find plants suitable as food for the next generation of caterpillars.

and a migrant butterfly will insist on flying in winds which would normally force it to settle down and seek shelter on some shrub or tree. This peculiar insistence on flying in high winds frequently means that the insect is blown off course; in fact, it is not unusual to see butterflies flying into a headwind and actually being blown backward! The fact that migration continues under such conditions frequently means that migrant butterflies end up in areas a long way from their point of origin, having been carried by wind as well as their own efforts. In the normal course of events, however, the direction taken by the butterfly has no relation to the wind at the time.

Some species take flight over a remarkably broad front. The Painted Lady butterfly (*Vanessa kershawi*) is known to eastern Australia over a front from the coast at least as far inland as Wagga Wagga. Even wider fronts have been observed in other species. Some species move in fairly narrow streams which seem to divide and link up again, leaving wide areas between the streams which are not occupied by the migrants in flight.

More than one species may be on the move at once in one area and they may move in different directions. In Sydney in November it frequently happens that Caper White butterflies (*Anaphaeis java*) are moving northeastward at the time Painted Ladies are moving southeastward. Concurrently, hover flies have been recorded as flying westward.

The density of the flying mass of insects varies according to the population levels of that season. In years of high population, hundreds of migrants of one species may be in view at once whilst at other times it may be necessary to keep a very close watch on each specimen and record its direction of flight before a migration can be detected. It seems that each individual is undertaking the migration independently of the others although in some insects, such as locusts, there is a strong influence of one specimen on another. In butterflies, it is not necessary for the individuals of a species, when migrating, to be in view of one another. When populations are low, only an occasional specimen may be seen, with intervals of perhaps an hour or more

An entomologist nets butterflies at Camden, NSW as part of The Australian Museum's butterfly migration study.

Charles Turner

A voluntary helper tags butterflies near Camden NSW.

between each, and yet during a migration period these will all be flying in the same direction. There is no possibility that one specimen is being visually stimulated to migrate by the movements of another as they would seldom see each other in such a flight.

The period of the season over which a species migrates is also more or less fixed. In Painted Ladies the migration may continue for several weeks; in the Brown Awl *(Badamia exclamationis)*, a butterfly which migrates between New Guinea and Queensland, the period may be quite short. The actual time of flight may vary from year to year, being a little earlier or later than average. This seems to be determined by climatic conditions.

The distances over which migration takes place also vary considerably. Many species are known to move from Victoria as far as Queensland, whereas others may move only a few miles.

It is very easy to overestimate the speed of flight of a flying insect and the only reliable way to ascertain its speed is to time the insect over a known distance. Even then, allowance must be made for the fact that the insect is not flying a straight course. Migrating populations sometimes change course at a more or less fixed point in their flight path. The reason for this is not known but presumably has something to do with the topography of the area over which they are moving.

The nature, extent, direction and duration of migration varies according to the species concerned; the details are geared to the requirements for survival of the species. Generalizations about migration are difficult and studies over the last few years suggest that what has generally been termed 'migration' consists in fact, of a great many different phenomena. Each species about which we have more than a smattering of knowledge seems to have features peculiar to itself and migration is an aspect of behaviour which fits into the biology of each species in a different way. In some of the army worm moths (e.g. *Persectania ewingii)* the movement of the population is into areas where the next generation will find conditions suitable for development whereas in the Wanderer, the autumn migration is into areas in which the butterflies can survive during the winter months in a relatively inactive state and from which they spread out the following spring to areas which would be suitable for egg-laying and survival of their young. Each species has evolved a pattern in response to environmental conditions which ensure survival of the next generation.

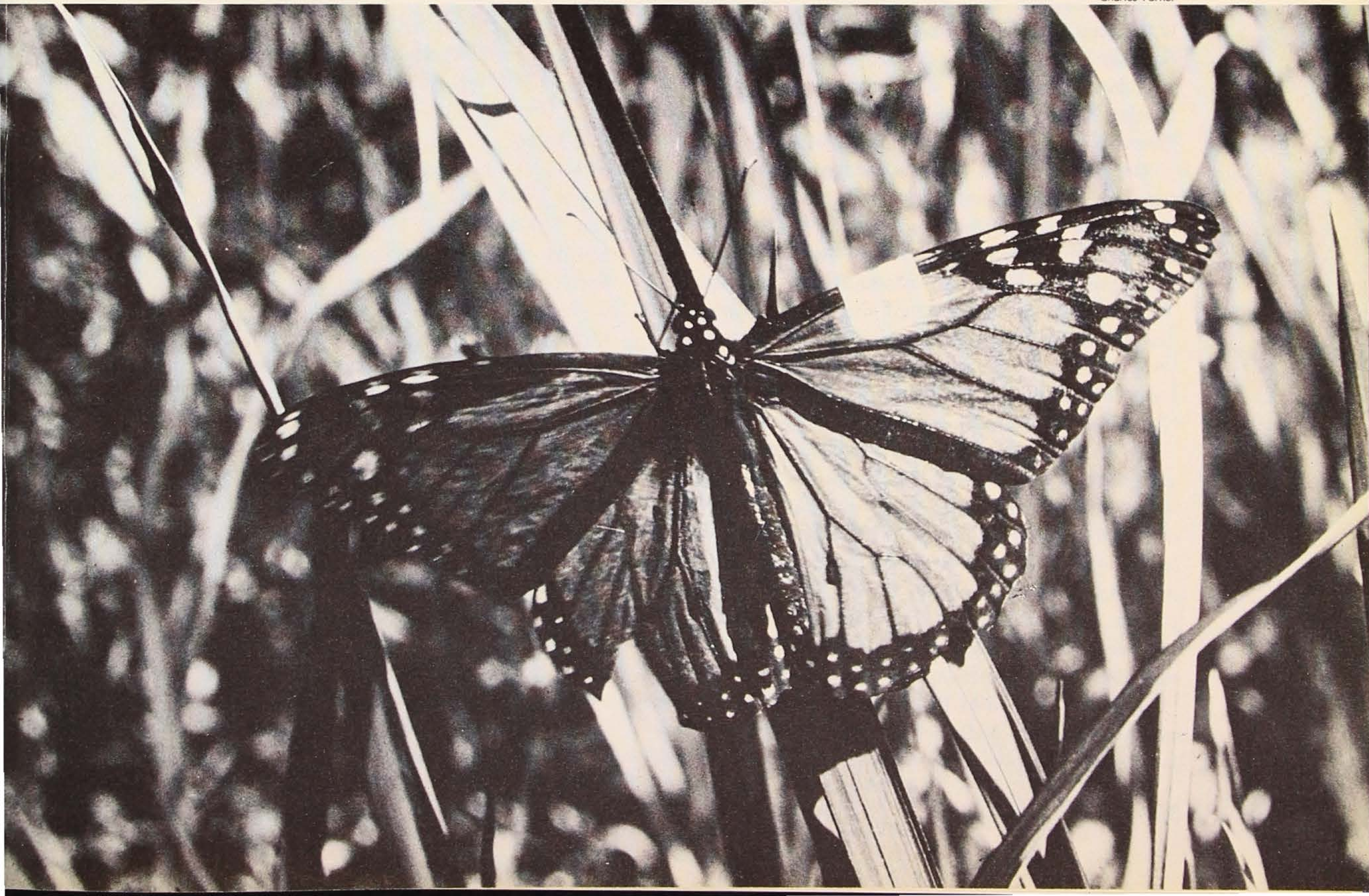
A great deal of time is required to accumulate observations on migration. A great many different techniques have been used to gather data on population movements of insects. If flight directions of individuals are recorded as they are seen, movements in even sparse populations can be detected. If this is done over a period, it is possible to determine when population as a whole changes from a static one, with individuals flying in all directions, to a migratory one in which all or most individuals are flying in the same direction. This gives information about one place only, however, and in order to obtain information on movement patterns, observations at many points are needed. In the case of dense populations, the migrations are obvious and counts of individuals moving across a line of known length in a given time will give a measure of the population on the move. In this way it has been calculated that literally millions of insects may move across a front of a mile in the course of a day. Specimens can be marked in various ways, one of which is to attach a small paper label to the specimen. Such specimens can be released in the hope that they will be recaptured elsewhere so giving some indication of the overall direction, distances and time of movement. This method is applicable only to reasonably large specimens. Radioactive marking with tracers can be employed but it is of limited application when long distances are involved, mainly because the marked indivuals are not obviously so to the casual observer, and special equipment is needed to detect a marked specimen. Radar equipment can be used to detect moving swarms and is particularly useful for studies of nocturnal species and those moving at heights. By using combinations of many techniques, scientists have gradually built up the present body of knowledge of insect migrants.

Although a regular part of the behaviour pattern, migration behaviour is adaptable to the changing needs of the species. An excellent opportunity to study this flexibility presents itself in the Wanderer butterfly. The movement of this species has been studied in Australia with the help of naturalists making observations all over the country. Almost five hundred co-operators have been making observations on this and other species, as well as being engaged in a mark-and-release programme which has been operated from The Australian Museum. The Wanderer is a native of North America where it undertakes annual migrations, sometimes of more than 2000 miles, to the south in autumn with northward extension of range over a series of summer generations. The Wanderer arrived in Australia late last century. It would be reasonable to expect a reversal of migration directions on such a change of hemisphere but, in fact, the observations made by the co-operators in the migration study scheme have revealed a remarkable change in movement pattern in adaptation to the Australian climatic regime especially with regard to movements of cold fronts. Instead of a north-south movement in eastern Australia, we find a movement from the inland areas towards the coast in autumn. In the coastal area, the population usually becomes restricted in winter to three areas. There is a northern, coastal continuously-breeding population from northern New South Wales to north Queensland. There is an isolated population which is mostly non-breeding during the winter in the Adelaide area, and, similarly a, mainly non-breeding winter population is isolated in the lower Hunter Valley, adjacent river valleys and the Sydney basin. From these three separate over-wintering zones, the populations spread out in the spring so that, by summer, the whole of eastern Australia is again occupied by a breeding population. The Wanderer has adapted its migratory pattern to suit Australian conditions with its different pattern of cold front movements and this has enabled it to colonise those areas of the continent in which there are plants suitable as food for its caterpillars.

Population movements, whether large or small, form an integral part of the behaviour of insects and are of importance in understanding the biology and ecology of any species. Such understanding enables us, in some cases, to predict where populations will rise and where they will fall and this is of some consequence to those who are responsible for restricting the depredations of pest species. The activities of migrant species throw some light on the physiological mechanisms involved in orientation of insects in flight, and the seasonal distribution and changes in distribution resulting from migration throw light on the way in which insects respond to climatic and other changes in their environment.

Waterproof paper tags bearing an Australian Museum serial number are placed on the butterflies wing. Specimens of Wanderers marked in this way have been recaptured up to six months later.

Charles Turner



SCIENTIFIC EXPLORATION: HISTORIC

SCIENTISTS IN NINETEENTH CENTURY AUSTRALIA, A DOCUMENTARY HISTORY by Ann Mozley Moyall, *Cassell Australia, 1975, 280pp, $5.95*

For the reasons that one would not expect to find a thriving *Academie des Sciences* on Devil's Island, it is not surprising that scientific preoccupation was rare among the first European settlers of Australia. As Ann Mozley Moyall observes:

> "For the first fifty years of the colony, Australia was a convict-emancipist society . . . Among the small professional community, scientists were few. In general the citizenry was antipathetic to science. More importantly, colonial governments, straining for economic and social stability, were indifferent—if not openly hostile—to the support of science. With a reluctant bureaucracy, the scientific enterprise hence devolved upon small groups of interested individuals." (p. 4)

These were remarkably few. I find it difficult to extend the list of prime movers in the first half of the century beyond the four Macleays, the Reverend W.B. Clark, Dr George Bennett, Sir Charles Nicholson, Captain P.P. King, and Governors Brisbane, Denison and possibly, Franklin. The astronomers Rünke and Dunlop could perhaps be included but they did not, like the others, create institutions and societies.

Dr. Moyall avoids such tendentious evaluations but they are implicitly supported by the selection of documents with which she illuminates the early development of Australian science.

> "With the exception of one or two speeches and official letters, most of the material was never intended for publication. Essentially they are private letters, extracts from journals and diaries; the informal expression of the working scientists." (p. 5)

These are connected by an unobtrusive, informed commentary, to create a work of such compelling interest immediacy that, having taken it up after dinner, I was unable to put it down until reaching the last of its 256 pages in the small hours of the following morning. We have, for the first time, a broad survey of the germination and first flowering of Australian science (anthropology and medicine specifically excluded), on the words of the men involved.

George Basalla has described three phases in the spread of science into a new territory. At first, the new land serves mainly as a source of data for scientists in the homeland; then the colonists, still concerned primarily with natural history, accept greater responsibility for interpretation of their data; finally the colonials create independent scientific institutions and train their own specialists. Dr. Moyall agrees that Australia conveniently fits into this scheme but does not force the point. It is this reviewer's pleasure to pick from among her riches some illustrative examples.

An early colonial situation involves remote control of science no less than political administration. Banks manipulated Flinders, Brown, Bauer, and his paid collector George Cayley to whom he wrote in 1804:

> "Our greatest want is to be acquainted with the manner in which the Duck Bill Animal and the Porcupine Anteater which I think of the same Genus breed, their internal structure is so very similar to that of Birds that I do not think it impossible that they should lay Eggs or at least as Snakes and some Fish do Hatch Eggs in their Bellies." (p. 21)

John Gould, the entrepreneur-naturalist was less patrician in his instructions to his collector John Gilbert in 1804.

> ". . . the lovely little Parrakeet that *you* have called *Nanodes Pulchellus* I never saw before. It is a little beauty. If you meet it at Port Ess. [ington] get all you can *quietly* . . ." (p. 67)

Hooker worked through Dunn and others. Darwin harried Thomas Mitchell for geological details. Richard Owen, potentate of comparative anatomy, demanded and received almost every fossil that was found and had no compunction in requesting platypus by caskful and echidnas by the hundred.

The Australian Museum, being the third scientific institution in Australia preceded only by the Botanic Gardens formed in 1816 and the shortlived Parramatta Observatory, 1822-48, and was for some time the centre of natural history in Australia and all of the 'prime movers' except Franklin, were directly involved in its administration. Despite its proud name, it was afflicted with the colonial cringe as evidenced by Bennett's letter in 1836 to Owen.

> "A new arrangement has lately been made with respect to the Museum and Bot. Garden; a Committee of Superintendence being formed over them the principal members of which are Messrs [Alexander] Mac'Leay, [Philip Parker] King, Dr. Thompson and I am appointed by the Governor Secretary to both Committees . . . I am almost certain that the [Royal] College

> [of Surgeons] will have every opportunity of having anatomical preparations . . . bodies will be kept and if sufficient [ly] valuable will be forwarded . . ." (p. 78)

There can be no clear and general demarcation between the first and second phase, but I have long felt that the Krefft affair of 1874 marked such a turning point and that his dismissal from directorship of The Australian Museum was due more to his inflexible determination that it should be a centre of serious research than to his personal shortcomings. He had the effrontery to contradict the great Owen on the nature of *Thylacoleo,* the fossil marsupial lion (and to be proved right by subsequent researchers). When Owen complained to Henry Parker, Krefft replied to the Premier;

> ". . . I take the liberty to remark that a thorough History of our Anals can only be *written in this Country* and in this Colony. There is no Museum in the World which has the Australian Collections we have and not one Professor can command such a series . . . as I brought together . . . I had letters from the greatest of living Anatomists siding with the views I take regarding our Australian Animals and I regret to say that Professor Owen goes on teaching what is not correct."

McCoy was no less of a partisan for the Melbourne museum but as an adjunct to the university rather than as an independent institution.

One could possibly date the beginning of the third of Basalla's phases from the first science graduates in the eighties and, almost contemparaneously, with the first meeting of the Australasian Association for the Advancement of Science (now ANZAAS) in 1887, product of the faith and hopes of Bennett and Liversidge. Interestingly, this brings us back to Banks' interest in the reproduction of the platypus for, when the visiting Cambridge biologist Caldwell solved this question in 1884 and transmitted the solution via Liversidge to the Montreal meeting of the British Association for the advancement of Science in a succinct cable, "monotremes oviparous ovum meroblastic", Liversidge was moved to write to the Sydney *Herald* recommending the formation of an Australasian Association. (And here I would mention a minor error in Dr. Moyall's text: *meroblastic* means segmentation of part of the egg, as in a bird—not 'soft-shelled'.)

It should be mentioned again that Dr. Moyall is not concerned—at least in *this* book—with the historian's game of categorisation. She takes a series of topics including botany, zoology, geology, evolution, scientific societies and universities and, by appropriate choice of extracts from contemporary writing, has permitted certain pioneers of Australian science to communicate directly with the reader.

This book should be on the shelf of every person with an interest in Australian natural history and in every High School library. Bearing in mind the short life in print of most contemporary books. It would be wise to buy your copy now.—*Ronald Strahan, Research Fellow, The Australian Museum.*

THE VOYAGE TO MAREGE: MACASSAN TREPANGERS IN NORTHERN AUSTRALIA, by C.C. Macknight, *Melbourne University Press, 1976; 175 pages; illustrated; $20.00.*

In February 1803 Matthew Flinders, while surveying the north coast of Australia, was much surprised to encounter a large fleet of Macassan *prahus* installed around the islands and bays of Arnhem Land. He learned that such fleets visited northern Australia annually from the Southern Celebes to collect and process *trepang*, a holothurian or 'sea cucumber'; this was eventually traded to the Chinese, who much prized it as a culinary delicacy. These annual visits continued until the early years of the present century, but it has only recently become clear from the fieldwork of such anthropologists as W.L. Warner, A.P. Elkin, R.M. and C.H. Berndt, D.J. Mulvaney, and I.M. Crawford, that contact with Indonesia had a profound effect on Aboriginal technology, linguistics, ritual, mythology, and social life over considerable areas of northern and northwestern Australia.

Detailed investigation of this intriguing situation was not undertaken until the author of this book made it the subject of nearly 10 years of research for his doctoral thesis. *The Voyage to Marege* (the Macassan name for northern Australia) is a distillation of the results of this research but, unlike most adaptations of theses for publication, it is written in a lucid and coherent manner that entices the reader with all the allure of a good detective story. This is probably due to the fact that Macknight is first and foremost a historian and only uses the techniques of other disciplines such as archaeology and social anthropology as support systems to his main theme.

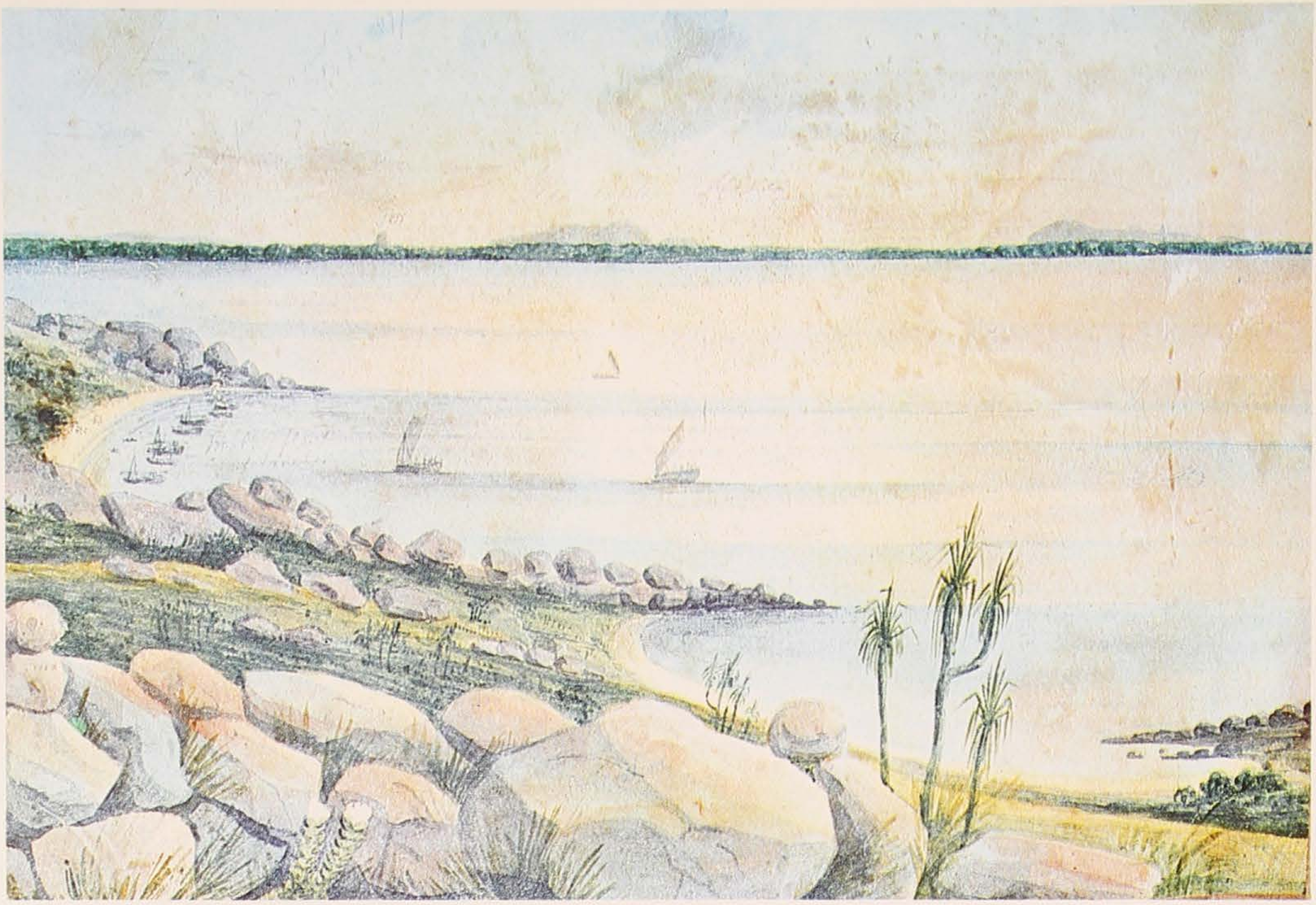
In his reconstruction of events, processes, and human relations, Macknight employed ethnographic reconstruction from published and unpublished documents, study of accounts of early contacts after British settlement in Australia, scientific excavation of Macassan sites on the north coast, and interviews with old Aborigines and Macassans who remembered the actuality of the last voyages. From all of this it becomes clear that the contact was far from superficial. Apart from their introduction to such catalytic items as iron, dugout canoes, alcohol and tobacco, Aborigines were exposed to prolonged periods of acculturation; not only did large numbers of them assist each year in trepanging operations and loaned their women to the all-male *prahu* crews (whether willingly or perforce), but both Aboriginal men and women quite frequently accompanied the Macassans on their return voyages to stay for a season on Sulawesi.

The question of how long this contact had existed before 1800 is still a matter for controversy. Macknight, although he obtained carbon dates of the order of 500-800 BP from several Macassan sites in Arnhem Land, dismisses them as aberrant and opts for a duration of no more than 150 years, mainly because the trade in trepang from Southeast Asia to China did not commence until late in the seventeenth century. However, trepang was not the only product sought by the Macassans, though it was the main one; they also took away pearlshell, pearls, and turtleshell. Nor were they the only Indonesian visitors to northern Australia, since it is on record that boats came also from Sumba and Timor. The cumulative evidence of archaeology, ethnography, linguistics, and genetics would seem to point strongly to a contact of considerably longer duration than merely a century or two.

Whether or not one agrees with all of Macknight's conclusions does not affect the status of his work, since he presents all the relevant evidence in this carefully researched and well illustrated book. It must certainly be classified as essential reading for anyone interested in Australian history, prehistory, and ethnography.

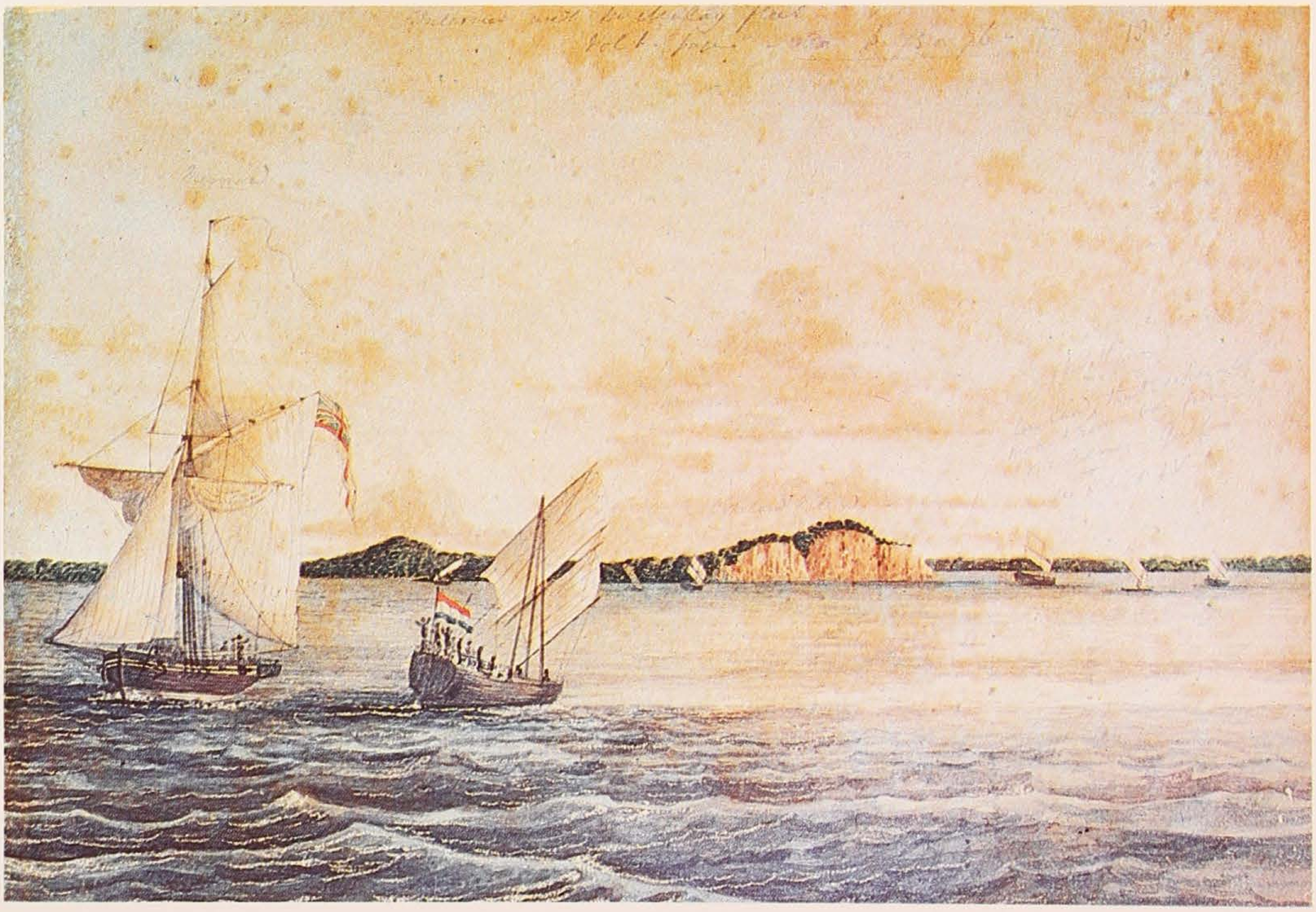
When this reviewer visited Southern Sulawesi in 1972 during a museum collecting trip, everywhere he was asked "Do you know Campbell Macknight?" And when the reply was in the affirmative, the invariable comment "He is a very good man". It is through cross-cultural personal relationships of such quality that the minutiae of ethno-history are gradually elicited and brought together into a meaningful whole. Precisely because Macknight's approach is basically a humanistic one, he is able to carry the reader eagerly along with him through all the fascinating intricacies of his research—*David Moore, Curator of Anthropology, The Australian Museum.*

Bark painting of two praus and trepang boilers under a tamarind tree, by Madaman. It depicts a site at Baramuda in Melville Bay. The black figures are Aborigines, the other Macassans. The background designs belong to the Riradjingu.



Above: Macassan praus watering at Sims
Island 1818. Water-colour sketch by P.P. King

Below: 'View of Copeland Island in
Mountnorris Bay, Interview with Malay fleet'
Water-colour by H.M.C. *Mermaid's* captain P. P. King.



the australian museum sydney

6-8 College Street

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Special exhibitions and activities include

Travelling exhibition - 'Man - A Peculiar Primate'; commencement of Museum Train; the History of the Museum; Conservation of Fauna; Aborigines Now; Music at the Museum; Arid Zones Gallery opens; Ethnic dancing in Hyde Park; Discoverers' Pageant; Special TAMS activities; Australian Institute of Photography Exhibition; Film evenings; Scientific symposia; Children's collections on exhibition.

for dates contact your local Tourist Information Centre

No parking problems when you go by train or bus to the Museum. Just a short walk through Hyde Park. Save on fares, use 'Family Fare' or rail 'Minifare'.

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