AUSTRALIAN NATURAL HISTORY

JUNE 1974 VOLUME 18 NUMBER 2 70c

Lord Howe Island is one of the most interesting and beautiful islands in the world. Its beauty is legendary. Recent visitors from the cruise ship, M.S. *Lindblad Explorer*, a well-travelled naturalist group seeking out-of-the-way places, considered it perhaps the most beautiful island they had ever seen. The high, tree-covered hills to the north; the narrow, low central portion (with which man has dealt most kindly); the turquoise lagoon bordered by breakers and a long, curving arch of beach; and the huge majesty of Mount Lidgbird and Mount Gower thrusting their peaks up from the Pacific to dominate the scene with white bosun birds etched against their dark basalt cliffs—a remarkable land- and seascape.

The island is biologically interesting because it has rich and varied flora and fauna with an unusually high proportion of species found nowhere else. Its lovely lagoon has a flourishing coral reef—probably the southernmost in the world, and there are many species of fish, coral, and other animals which have evolved in the area because of its relative isolation from the great coral reefs in the tropics to the north.

Yet this unspoilt island with its rich natural values is not thousands of miles from anywhere—it is four hours by seaplane from Sydney, Australia's largest city.

This special issue gathers together some of the interesting natural history of Lord Howe Island. By the time it appears, Lord Howe will have an airstrip, which is being built as I write. There is no doubt that it will be visually damaging, crossing the island from side to side and disrupting the graceful curve of the beach. One can only hope that it will be of its anticipated value to visitors and residents and that it will not lead to other kinds of environmental deterioration in this place of historical and natural richness.

F. H. TALBOT

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JUNE 1974 VOLUME 18 NUMBER 2 PUBLISHED QUARTERLY BY THE AUSTRALIAN MUSEUM, 6-8 COLLEGE STREET, SYDNEY

E. Slater

COVER: This view of Mts. Gower and Lidgbird from the Northern Hills shows the cloud cover which frequently obscures these two peaks. The foreground shows the low-lying central portion of the island. (Photo: Courtesy of the New South Wales Department of Tourism.)

ABOVE: Painting of a White Gallinule by George Raper — by kind permission of the British Museum (Natural History).

Annual Subscription — Australia: $2.50, single copy 70c — 85c posted; Overseas: $3, single copy 95c posted. Cheque or money order payable to The Australian Museum should be sent to The Secretary, The Australian Museum, P.O. Box 285, Sydney South 2000.

INTERNATIONAL STANDARD SERIAL NUMBER 0004-9840

FROM FIRST FLEET TO EL TORITO

BY GILBERT P. WHITLEY

LORD Howe Island was evidently unknown to human beings until, like the Great Barrier Reef, it was very nearly discovered by Frenchmen before the English in the eighteenth century. Jean François Surville, in the *Saint Jean Baptiste,* passed to the westward of New Caledonia and Lord Howe Island (neither of them at that time discovered) to a point only 180 miles east of Broken Bay, in December 1769, on his way to New Zealand. His route was traversed eighteen years later by La Perouse in the *Boussole,* who deduced the presence of land (now known as Lord Howe Island) from the abundance of birds. In his log-book, on 17 January 1788, La Perouse recorded that at 31°28'S. and 159°15'E., the ship was surrounded by innumerable sea-birds which made him suspect that he was passing near some island or rock and might discover some new land before arriving at Botany Bay, then 180 leagues away (*Voyage de La Perouse,* vol. 3, 1797, p. 263)[1]

Whilst Lord Howe Island, on a clear day, is visible from about fifty miles, it is often clouded or hazy and difficult to see from a small ship. Thus its official discovery was left to the British a month later.

Governor Phillip commissioned Lieut. Philip Gidley King[2] to sail from Sydney to Norfolk Island and form a settlement there. King left in the *Supply,* commanded by Lieut. Henry Lidgbird Ball, who discovered Lord Howe Island and Ball's Pyramid on 17 February 1788. Great numbers of black and blue petrels and many gannets surrounded the ship on the 19th February. They did not land until the return journey, when Ball noted abundance of turtle, of which they took aboard eighteen, but there was no good anchorage and "a reef of coral rock." David Blackburn, who was with Ball observed that Lord Howe Island ". . . abounds with Turtle Much superior to any I have ever seen, on the Shore we Caught several sorts of Birds, Particularly a Land Fowl of a Dusky Brown About the size of a small Pullet, a Bill 4 Inches Long & feet like a chicken. Remarkably fat & good, Plenty of Pidgeons, a white fowl—Something like the Guinea hen, with a very strong thick & sharp pointed bill of a Red Colour—stout legs & claws—I believe they are carniverous they hold their Food between the thumb or Hind Claw & the Bottom of the foot & lift it to the mouth without stooping so much as a Parrot. Some of them have a few Blue feathers on the wing. Here is also a Web footed Fowl In General of a Deep Blue. Its Bill 2 inches long—straight but suddenly bent downwards at the end. Very sharp and strong. ... We took them Burrowing in Holes like Rabbits—The Bay abounds with a Variety of Excellent Fish." The birds stipulated (of which more anon) were, respectively, the woodhen (land fowl), the extinct pigeon, white gallinule and petrel. These birds had never known man and were so tame they could be knocked over; some were so conditioned to their island haunt that they had lost the power of flight.

Other vessels of the First Fleet visited the island in 1788. Some of the sailors kept notes and made water-colour drawings. In May 1788 Arthur Bowes mentioned pilot fishes and sharks about 49 miles offshore in his journal, now in the Mitchell Library, Sydney. He said, "when I was in the woods amongst the birds I cd. not help picturing to myself the Golden Age as described by Ovid." Bowes drew the white gallinule (soon extinct). He barbecued birds on what is now Old Settlement Beach, amongst them pigeons (now extinct) "the largest I ever

The photo opposite was taken in 1923. It shows the author on the Main Back Block Road of Lord Howe Island amongst towering greybark trees.

1. Original:— "Le 17, par 31^{d}28' de latitude Sud, et 159^{d} 15' de longitude orientale, nous fumes environnés d'une innombrable quantité de goélettes, qui nous faisaient soupçonner que nous passions auprès de quelque île ou rocher; et il y eut plusieurs paris pour la découverte d'une nouvelle terre avant notre arrivée a Botany Bay, dont nous n'étions cependant qu'a cent quatre-vingts lieues . . "

2. King's son, Philip Parker King, was a committeeman and trustee from 1836 to 1856 of the Australian Museum, whose links with Lord Howe Island are unique, extending back to early times in the island's history. This museum contains almost all the zoological specimens collected at Lord Howe Island over the last 105 years.

GILBERT WHITLEY has visited Lord Howe Island seven times—the first with the entomologist Anthony Musgrave, in 1923, the last with the *El Torito* expedition in 1973.

The coast of Lord Howe Island varies from tree-lined shores to steep rocky cliffs. Man has enjoyed the diverse beauty of the island since its discovery in 1788.

saw." Lieut. Watts simultaneously described various birds and added "Numbers of ants were seen, which appeared the only insect at this place, except the common earthworm." Then Thomas Gilbert in the *Charlotte* in May 1788 noted birds he caught, such as the white gallinule, others "not unlike peacocks" (unidentifiable) and "Partridges likewise in great plenty . . . Several of those I knocked down, and their legs being broken, I placed them near me as I sat under a tree. The pain they suffered caused them to make a doleful cry, which brought five or six dozen of the same kind to them, and by that means I was able to take nearly the whole of them."

One of the artists was George Raper, whose paintings I have studied at the British Museum (Natural History), the Mitchell Library, and the Alexander Turnbull Library, Wellington, New Zealand. These showed views of Lord Howe Island with the brig *Supply* there, and a priceless series of paintings of the white gallinule, the extinct pigeon (of which no specimen exists) and the wood-hen (which still lives in extremely reduced numbers).

Governor Hunter also painted the woodhen, the white gallinule and the vanished pigeon, his drawings being in the National Library, Canberra. His 1791 painting of a "Man of Lord Howe's Group" reproduced in his *Journal,* shows a native of another Lord Howe Island, ours having been uninhabited.

Curiously, none of the great French scientific expeditions of the early nineteenth century came near Lord Howe Island.

Russian vessels came hereabouts in the 1820s, principally Thaddeus von Bellingshausen in September 1820 when, as he says, ". . . we caught a large glutton fish or shark in our wake; the shark was accompanied by several little fish, the so-called pilot fish or satellites, 8 inches or less in length, resembling a perch, with stripes of a bluish colour. There were also a few sucking fish. Sharks are very quickly hooked, and this one which had been following us was no exception . . . There were two sucking fish attached to the shark, just under the fins. The whole fish was 9 feet 2 inches in length, and whilst being skinned the whole body made convulsive movements and the heart moved, even after having been taken out. Inside the body we found a bladder or sac on either side, and in each of these twenty-four fine live embryo sharks, about 14 inches in length, from the head to the tip of the tail. They were already able to swim and we threw some of them into the sea. Some swam about near the surface and others went into the depths wriggling like groundlings. In the shark's stomach we found a very soft sort of shell about 6 inches in diameter and 2½ inches in thickness called the paper nautilus. From this one can clearly see the size of the jaws and throat of the shark . . ."

Bellingshausen's "glutton fish" (and perhaps the sucker fish too) was sketched by the artist aboard the *Vostok,* Paul Mikhailov, so the drawing may yet turn up in the Soviet Union for identification.

Many ships must have made (largely unrecorded) visits to Lord Howe Island in the early nineteenth century. In 1831 "a great number of bronzewing pigeons" were shot by treasure-seekers from the barque *Caroline,* and in 1834 an escaped convict "collected fish and birds" as food for his associates. There were many whalers, sealers and sandalwooders in the South Seas at this time and Lord Howe Island was in "the Middle Grounds" of the whalers. Edward Cattlin's log of his whaling voyages in the brig *Genii* is in the Mitchell Library. Characteristic entries, when off Lord Howe Island and Ball's Pyramid, were:

"Monday 29 Dec. 1834. A.m. Moderate Breezes and at 5.30 saw whales. Stood towards them. Proved to be Finback. Broke out the Main hold for Whale line Beef Pork and Peas . . ." Next day, he "Saw many Finbacks and Porpoises at 6." Sperm whales were seen on 1 January 1835, but no whales were taken or there would have been flukes sketched in the margins of Cattlin's log on those days.

There was a small settlement on the island in 1834, and in 1836 land rails were described as very large and plentiful and formed the principal food of the people there whose population was increasing.[3] In 1836 or 1837, Alexander Macleay had several live woodhens in captivity in Sydney, brought to him from the island. From 1844 to 1847 Dr. John Foulis lived on Lord Howe Island (his property is now "The Pines"). He wore a Quaker-brown coat and a bird of similarly coloured plumage was known as the Doctor Bird as a result. Foulis wrote a report mentioning various animals and collected fossil bones which he correctly recognised as turtles.

The United States Exploring Expedition under Captain Charles Wilkes, U.S.N. was at Ball's Pyramid on 26 November 1839. The complete zoological results are not available to me but do not seem to record any animals of importance from the Lord Howe Island regions.

The "Private Journal of John MacGillivray . . ." concerning his voyages in H.M.S. *Herald* between 1852 and 1855 is an unpublished

3. Nautical Magazine, 8, 1839: 447.

This grey whaler shark was sketched by the author during his visit to Lord Howe last year with *El Torito*.

manuscript in two volumes at the Admiralty Library, London. Of this the Mitchell Library possesses a microfilm copy. On September 3rd 1853, MacGillivray landed on Lord Howe Island, which he found "... alive with colonies of a singular cricket-looking wingless insect between four and five inches in length which the people on the island have designated the "land lobster" ... it does not leap ... It feeds on rotten wood." MacGillivray also saw "centipedes of considerable size, large cockroaches, ... and a very fine large *Bulimus* (the land shell, now *Placostylus*) ... and a thin, flattened *Helix*." He found the black and white magpies very good eating and collected an owl which had fed on a moth and some beetles. Physaliae (bluebottles) and Janthinae (violet snails) had been driven ashore on beaches and on land. MacGillivray found various sorts of shells and two kinds of lizards: "a Gecko which appears to be of the genus *Pentadactylus*. Another lizard ... (*Mocoa*?)." There were no snakes, frogs or toads on the island. From day to day, various birds, shells and insects are mentioned and on the rocks (of the lagoon) shells, radiata and crustacea were collected. He searched for woodhens (apparently unsuccessfully), their "numbers having been thinned by the wild cats, the descendants of those landed by the master of a Sydney whaler five or six years ago." He obtained a rarity, the skull of a seal which had been washed up on the beach there. While MacGillivray climbed the Admiralty Islets on 15 September 1853, a fishing party had been trying, with indifferent success. He joined them after dusk and recorded: "I found that not more than 3 or 4 fish—all of small size—had been taken. Although on a previous occasion (1851?) a boat's crew with six lines had caught in two hours in this vicinity 357 lbs. weight of good eating fish (Salmon, 72 lbs. Rock Cod 71. Blue fish 214.)

From 1851 to 1854 H.M.S. *Herald* paid several surveying visits and John MacGillivray collected animals which went to England along with his meticulous field notes. Denis Macdonald (one of the first Honorary Correspondents of the Australian Museum) was surgeon aboard and wrote zoological papers.

The Journal of the Bostonian naturalist, William Stimpson, mentioned animals from between Sydney and Lord Howe Island in 1853 and 1854, but much of his work was destroyed by the great fire of Chicago in 1871.

John Brazier (who later became conchologist at the Australian Museum) collected shells at Lord Howe Island in 1855 and was there with W. S. Wall aboard the *Curacoa* in 1865. There was a case of homicide on the island in 1869 so an investigation was held. The ship *Thetis* carried a party from Sydney, amongst whom was the famous naturalist and collector, George Masters, and several botanists such as William Carron, who had been on Kennedy's expedition to Cape York, and R.D. Fitzgerald of orchids fame. The latter obtained woodhens for Dr. George Bennett in Sydney who sent some to London, enabling Sclater to give the species a scientific name. The *Evening News* of 31 May 1869 says of Lord Howe Island; "As it has long been known as a lawless place, the resort of whalers and runaways, the public will doubtless approve of the course taken by the Government in extending the protection of the law to those who reside there." At this time Krefft listed 15 species of birds, 12 families of beetles and 2 other insects from the island. Fitzgerald and Carron revisited the island in 1871, when other botanists collected for Baron von Mueller, and Brazier gathered land shells in 1872-1873.

In the 1870s island residents, and the collector, E. H. Saunders obtained specimens for the Australian Museum. He is said to have sent shells from the summit of Mount Lidgbird, but Iredale records that Roy Bell, many years later, was the first to cut a track to its top. Captain J. Armstrong, Resident Magistrate, also collected for us. He and a few companions were the first to land on Ball's Pyramid, in 1882. Alexander Morton, an American, was employed by the Australian Museum to collect at Lord Howe Island in that year. A scientific survey by the N.S.W. Department of Mines provided the turtle fossils which Owen named *Meiolania*. So great was the interest generated in Lord Howe Island's distinctive fauna that the Australian Museum sent an expedition there in August-September 1887, consisting of R. Etheridge, J.A. Thorp and T. Whitelegge. The result was a special *Memoir* published by the Museum in 1889 which laid a firm foundation for future work. There were so many naturalists at Lord Howe Island after that (apart from residents, at least 40 in the last 83 years), that mention can only be made of a select few in the field of zoology alone.

G. A. Waterhouse collected butterflies in 1897. Edgar Waite went aboard *Thetis* in 1898 to try to trawl for deep sea fishes, but the weather prevented this. Waite revisited the

island in 1902 with his young assistant, Allan McCulloch, and they made a great collection, mainly of fishes, for the Australian Museum. In 1903, L. Waterhouse collected birds, still in the possession of the Waterhouse family. Charles Hedley, the famous conchologist, stayed at "The Pines" in 1908 and obtained a large *Argonauta*, 10½ inches across, as well as hundreds of smaller shells. Basset Hull and A. J. North collected birds' eggs rather than many birds. Then in 1913 Reg. Oliver and Roy Bell, who had been on the Kermadec Islands together, teamed up to collect birds, shells and plants. McCulloch, assisted by Ellis Troughton, was there again in 1921-1922, making fine collections and field notes. Both fell in love with the island and revisited it almost annually afterwards. McCulloch made the first cinema films of the fishes and birds there. It was Troughton who suggested the introduction of owls to combat the rats in the 1920s. Rats

A.R. McCulloch, 1921

Wooden sleds called "shans" were the main form of transport on the island during early settlement and exploration.

badly affected bird and plant life and may have exterminated the weird stick insect known on the island as a Tree Lobster (*Dryococoelus australis*), but the latter may still persist on Ball's Pyramid. In 1923, the Morrisby brothers ascended the Pyramid for about 700 feet, reporting gannets, lizards and an insect of the silverfish kind (*Lepisma*).[4]

The day of the collector was waning, and scientists were becoming more interested in the pattern of distribution of animals in island groups, their life-histories and ecology, and in their conservation. Bird photography had replaced collecting skins and eggs. However, in 1937, an adventurous party visited the wild Elizabeth and Middleton Reefs to make the first zoological survey there. Keith Hindwood studied the birds of Lord Howe Island and produced a paper about them which is a masterpiece. Tom Iredale and Ms. Joyce Allan studied shells and zoogeography, and other people, in many parts of the world, wrote papers on the island's fauna. The entomologist, Paramonov, called Lord Howe Island the "Riddle of the Pacific", because of the problems raised by its animal life.

From the 1950s beautiful colour plates and slides of the island became common. Mr. James Brown, Keith Gillett and others produced remarkable results photographically.

Ms. Julie Booth made valuable collections of shore fishes and Japanese tuna fishermen were demonstrating what large fishes existed offshore. In 1965 Ball's Pyramid was climbed to the top for the first time by John Davis and others in a Sydney Rock Climbing party.

J.W. Evans found peloridiid bugs on the top of Mount Gower which were closely related to South American ancient forms.

In the 1960s a number of the younger men from the Australian Museum have studied Lord Howe's animals. H. Cogger studied the reptiles, Walter Deas and others dived with scuba gear and photographed marine life. J.V. Peters catalogued the butterflies, P. Colman collected shells, etc.; H. Recher produced a thorough report on ecology; C.N. Smithers studied birds and insects, the latter also dealt with by Geoff Holloway. Other bird observers were Gary Sefton, Alan Rogers and H.J. Disney, the latter energetically climbing Mount Gower a number of times to inspect the dwindling population of the woodhens, now one of the rarest birds in the world (*see article, page 70*).

Finally, in 1973, a joint expedition was mounted by the National Geographic Society in Washington, and the Australian Museum; in association with Walter Starck and his ship *El Torito* a team of scientists from the U.S.A. and Australia made a concentrated study of the fish-fauna, the last catalogue of which had been published in 1904. Over 6,000 fishes belonging to more than 100 families were collected, and a check-list of them has been prepared for publication.

Undoubtedly, for many years to come, Lord Howe Island will have many fascinating secrets of nature to reveal in its remarkably rich zoological treasury.

FURTHER READING

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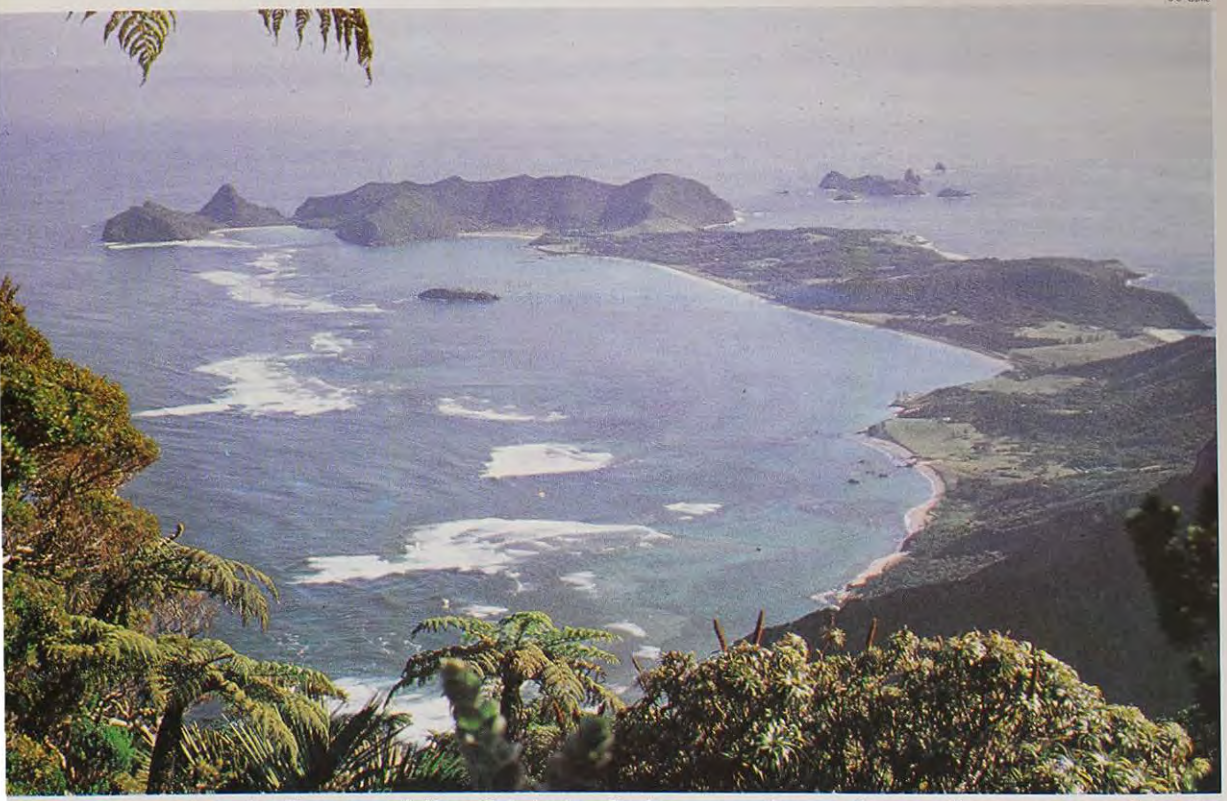
DEFUNCT VOLCANOES

Lord Howe Island and adjacent Ball's Pyramid are the eroded remnants of ancient volcanoes set in the Tasman Sea on the western edge of an extensive undersea ridge, the Lord Howe Rise. The Rise is 18-29km thick, and is probably a drowned rib of continental crust left behind when the Tasman and New Caledonian Basins opened up in Cretaceous times. The crust in eastern Australia is 30-45km thick. Between the Rise and Australia the floor of the Tasman Sea is formed of oceanic basalts which welled out from a crestal ridge active around 80-65 million years ago and which are now buried under thick blankets of marine sediments.

The Lord Howe Island Volcano was not part of the episode of sea-floor spreading but formed during a much later and more localised volcanism. It was part of the volcanic activity that affected many parts of eastern Australia after the continent split away from Antarctica about 55 million years ago, though some of this activity took place as recently as a few thousand years ago.

J.C. Game



The structure of the Lord Howe Rise was investigated by the Deep-Sea Drilling Project in late 1971 when the ocean-going research vessel

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AND EXTINCT HORNED TURTLES

BY LIN SUTHERLAND AND ALEX RITCHIE

Glomar Challenger drilled boreholes in the ridge. The holes passed through several hundred metres of calcareous marine oozes dating back to the latest Cretaceous Period (some 70 million years ago) before penetrating underlying volcanic rocks (continental rhyolites) probably about 100 million years old.

Lord Howe is only one of several volcanic peaks in the Tasman Sea. The others, known as the Tasmantid and Lord Howe Rise guyots, form chains of submerged sea-mounts with flat tops truncated by former wave action. The guyot tops appear to get progressively deeper towards the northern end of the chains, deepening from about 95m to 435m. The older volcanoes at the northern end of the chain have apparently subsided more than the younger ones at the southern end. Some workers have suggested that such volcanic chains were formed successively as the Australian plate (migrating northward away from Antarctica) passed over a hot spot in the earth's mantle. The Lord Howe Volcano does not, however, fit easily into this scheme because it has undergone repeated volcanism over one site and the last burst of activity post-dates anything known in New South Wales, a few hundred miles to the west. It may be that the hot spot which caused the guyot chains was restricted and did not extend under the Lord Howe Rise, or that some other volcanic mechanism was responsible for their growth.

The island can be divided into a number of physiographic units. The higher, more resistant igneous rocks form volcanic hills (North Ridge and Intermediate Hill—older volcanic series) and volcanic mountains (Mts. Gower and Lidgbird—younger volcanic series). The sedimentary units consist of low-lying coastal dune, alluvial, and scree deposits; the coral reef; and the lagoon.

The older volcanic series consists of horizontal lavas and even older inclined volcanic rocks, both altered, and both intruded by later dyke swarms.

The inclined series of basalt lavas is exposed on the east coast of the island between Mutton Bird Point and Red Point and they dip up to thirty degrees to the southwest. They differ from the other volcanics in containing a much greater proportion of coarse agglomerates amongst the lavas, indicating considerable explosive volcanism.

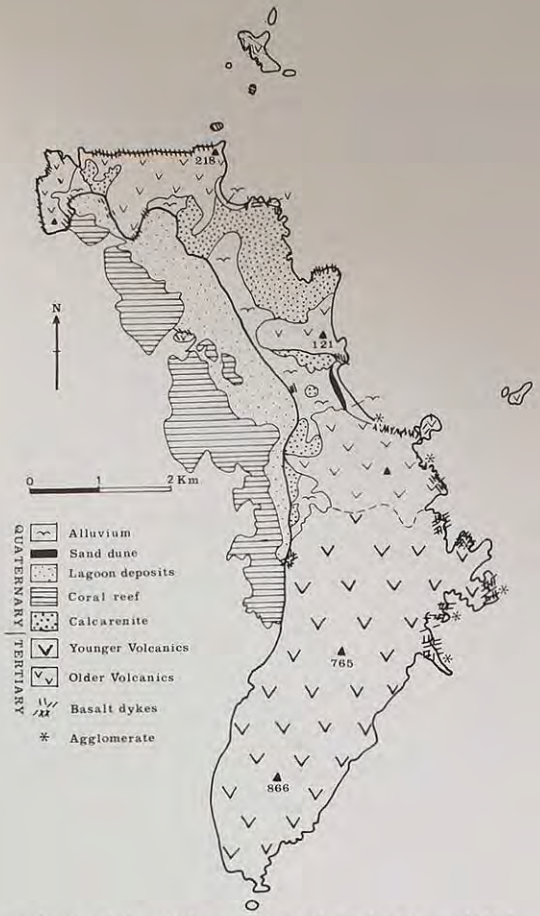
The altered horizontal lavas outcrop in the north of the island to a height of some 210m and similar rocks make up the Admiralty Islets and the spectacular 550m high spine of Ball's Pyramid about 20km away to the south. Radiometric dating of these rocks is difficult because of the alteration but it is thought that they were probably erupted in the late Miocene and not more than ten million years ago. Apart from the degree of alteration, there is little difference in the type of alkali basalts in the older and younger series on Lord Howe Island.

The younger volcanic series is represented by the impressive succession of horizontal layered lavas in the south of the island, perfectly exposed in the cliffs of Mt. Gower and Mt. Lidgbird. Individual lava flows may reach 20m in thickness and the total thickness is around 860m. Below these lavas and around the northern part of the island the older volcanic series is cut by swarms of dykes which are probably associated with (and may represent feeder channels for) the younger lava succession. The dykes are vertical or steeply dipping, up to five metres wide and in some places (near Old Gulch, on North Beach, and on Rabbit Island) the dyke swarms become very dense.

The rocks of the series are typically silica deficient basalts (alkali olivine basalts and hawaiites) composed mainly of the minerals olivine, plagioclase, pyroxene, and iron-titanium oxides. Interspersed at several levels in the lava succession are varieties particularly rich in the larger, early formed crystals (up to 60%) of olivine (oceanites) and pyroxene (oceanite-

View of Lord Howe Island from Mount Gower, looking north over the volcanic hills, which are veneered with dune and beach deposits and fringed on the west by the coral reef and lagoon.

ALEX RITCHIE is Curator of Fossils at the Australian Museum. His principal research interest is the early evolution of fishes, particularly those of Devonian age (see article in AUSTRALIAN NATURAL HISTORY, March 1974, page 28).



Geological map of Lord Howe Island, compiled from maps published by Standard (1961) and Game (1969)

ankaramite) which settled out and accumulated for some time in the underlying volcanic chambers before being carried up and erupted with the lava. The basalts towards the top of the lava succession show a tendency to become richer in soda and poorer in silica.

A trachybasalt (richer in silica, alumina and soda), however, cuts the upper lavas of Mt. Gower. This suggests that late-stage fractions of the lava evolved chemically towards trachytic rocks and these may have been present in the higher, but now eroded, lavas of the original volcano. The rocks in the dyke swarms are similar to the flow basalts of the younger series, except that olivine tends to be much scarcer.

The various volcanic rocks forming much of Lord Howe indicate clearly that the volcano passed through several periods of activity over a considerable period of time. The youngest volcanics forming the southern end of the island have been dated, by radiometric means, at eight million years ago. This would indicate a late Miocene age. In contrast, the oldest volcanics on the island are estimated to have been erupted at least thirty million years ago. In the intervening twenty million years these older rocks had been largely removed by erosion before the younger activity in late Miocene times again built up the volcano to considerable proportions. It has been estimated that this younger activity created a large, elongate shield volcano measuring about 50km from north to south and 16km east to west. Since activity ceased the size of this volcano has been greatly reduced by erosion, and the remnants of it now form Lord Howe Island and Ball's Pyramid. It may have risen to around 4400m above the sea floor, standing perhaps twice as high above sea level as the present island. Some 1200m of lavas have been stripped off and the present island probably only occupies about one fortieth of its original area (representing a volume loss of over 90%).

All visible lava flows on Lord Howe are typical of lavas erupted into the air but the location in the Tasman Sea suggests that the submerged pedestal may be largely built of lavas erupted under or into water. The pedestal profile (*page 47*) is typical of sea mounts built by submarine eruptions and the steep slope (beginning at about 50-100m depth) may mark the transition between the two types of lava flows. Such a plane, acting as an erosional weakness, would also facilitate the development of platforms at that level. This may be partly responsible for the wide submerged shelves that surround the island and which were probably cut by wave-action when the sea level fell to about this position during the last Glacial of the Pleistocene. Sea levels relatively lower than the present level are also inferred for the times in which the volcano was active in the early Tertiary and in the late Miocene. This would fit in with the scarcity of marine sediments of these ages along the eastern coast of Australia.

The sedimentary deposits on Lord Howe Island are all comparatively recent, dating from the Pleistocene or younger.

The most widespread deposit is calcarenite, a cross-bedded, sandstone-like sediment in which the individual grains are composed of calcium carbonate instead of silica, with a calcareous cement holding them together. The calcarenite is formed mainly by fragmental coralline algae (*Lithothamnion*) with smaller proportions of coral, foraminiferal and molluscan debris. The highest point reached by the calcarenite is on the windward side of Transit Hill at about 80m above sea level.

Several periods of deposition have been identified within the calcarenite deposits which are

Anthony Musgrave 1923

A fine exposure of cross-bedded calcarenite, the remains of ancient dune deposits of Pleistocene age.

separated from one another by several feet of soil, containing fossil shells of land snails (*Placostylus bivaricosus*) and occasional bird bones; a fossil bat has also been recovered.

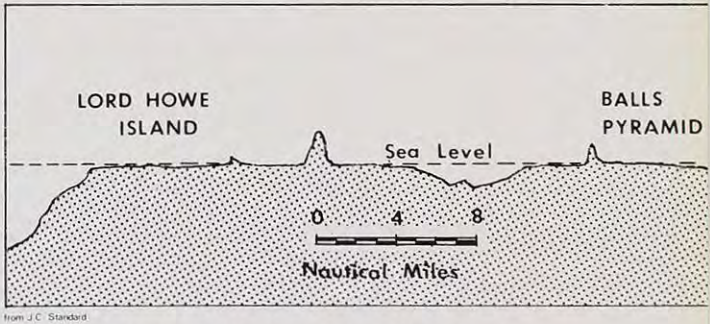
The calcarenite is easily weathered and becomes extremely porous, This effect of subaerial weathering is only found above high-water mark—below this level the rock is solid and relatively impervious. Ground water passing through the calcarenite has formed vertical solution pipes and caves but the water stops when it reaches the basalt surface immediately underlying the calcarenite. It has been suggested that the calcarenite deposits piled up around the higher volcanic masses during the Pleistocene when the sea level was much lower, perhaps 100m below present level. The calcerous material was probably derived from the widespread wave cut platform up to 40km across.

The only sand-dune on Lord Howe lies behind Blinkenthorpe Beach and consists of material derived from the calcarenite and the beach sand but of somewhat finer grain size. The dune is 10m high, 25m wide and about 100m long.

Lord Howe Island represents the southernmost true coral reef on record at the present time. Although coral growth occurs around the island it is only on the west side that a proper reef has formed. The most important cementing agent is not coral but coralline algae. The lagoon enclosed by the reef is very shallow with an average depth of only one metre at extreme low tide. It is floored with calcareous sand of approximately the same composition as the calcarenite. The reef acts as a breakwater against storm waves which would otherwise easily and rapidly cut the island in two by removal of the weathered, porous calcarenite.

A considerable amount of new information on the sedimentary profile has been obtained from investigations carried out by the Hydraulic and Soils Division of the N.S.W. Department of Public Works, in connection with the construction of an airstrip on the island. Between 1970 and 1973 this research team, led by Mr. Tadanier, drilled over 100 holes at depths between thirty and forty feet giving a good cross-section of the narrowest part of the island.

North-south profile across the Lord Howe Volcano. Lord Howe Island and Ball's Pyramid rise from the submerged pedestal (vertical scale exaggerated), which is about 70km across and reaches a depth of 2400m in this section.



from J.C. Standard

The calcarenite and especially the intercalated soil horizons have yielded land snail shells and birds bones but by far the most important and intriguing animal preserved in the sedimentary rocks of Lord Howe is the giant, horned turtle, *Meiolania platyceps,* extinct for many thousands of years, whose bones have turned up in con-

John R. Paxton

Ball's Pyramid viewed from the southeast shows lava flows of the older horizontal volcanic series. In the distance, the peaks of Mts. Gower and Lidgbird form part of the younger volcanic series of the Lord Howe Volcano.

siderable numbers. Most of the specimens have come from sites where the calcarenite is weathering away quite rapidly (near Ned's Beach and Hunter Beach) and other bones have come to light in the gardens of island residents.

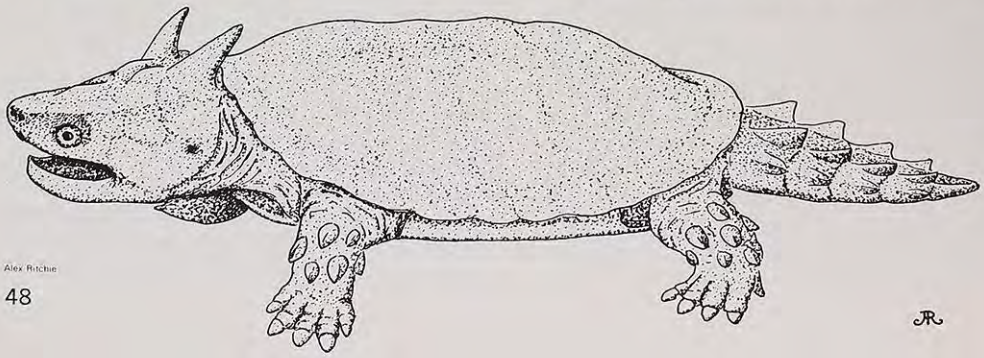
The first specimens were recovered in the 1880s and sent to England where they were described by Sir Richard Owen. Owen also described a much larger species, *M. oweni* from the alluvial Pleistocene deposits on the Darling Downs, Queensland. A third species, *M. mackayi*, has since been discovered in phosphatic guano deposits on Walpole Island, about 170km southeast of New Caledonia Other bones attributed to *Meiolania* have come from a Miocene gold-bearing, deep lead deposit near Gulgong and from Pleistocene deposits near Coolah (both in N.S.W.)

The relationships of these species to one another and to other types of extinct horned turtles and possible explanations for their scattered distribution were discussed by R. A. Mittermeier (AUSTRALIAN NATURAL HISTORY 1972, 265-9).

Adult specimens of *Meiolania platyceps* must have reached about 1.5 metres in length with a large, low bony shell which was quite thin except along the margins. The skull is large, subtriangular and solidly constructed, bearing prominent horn-like structures at the back of the head. The head could not have been retracted into the shell. The tail was similarly protected by a long, inflexible bony sheath armed with pointed spikes.

Unfortunately no complete skeleton of *Meiolania* has yet been recovered. A complete carapace (upper shell) was discovered in 1959 in

This composite reconstruction of *Meiolania platyceps* shows what this extinct horned turtle must have looked like. It would have been about 1.5 metres long.



Alex Ritchie

the cliff at Ned's Beach but in such a fragile state that it collapsed during excavation (AUSTRALIAN MUSEUM MAGAZINE 1960, 191-6). Another skeleton came to light in 1971 during the excavation of a swimming pool at the north end of the island but was extensively damaged during removal. However the latter specimen has recently been completely freed from the rock using an acid technique and fine examples of articulated hind and fore feet have been recovered. These are the first virtually complete feet of the animal to be found and they confirm what had previously been suspected. *Meiolania platyceps* had relatively short stumpy legs and toes not unlike the famous giant land tortoises of the Galapagos Islands. The toes end in broad, flattened claws suitable for digging and the structure of the foot clearly indicates a heavy, land-living animal with few of the specialisations for swimming found in true marine turtles.

The eggs of *Meiolania* have also been discovered in calcarenite deposits on Lord Howe, sometimes in small clutches. The eggs are spherical and about seven centimetres in diameter.

The Carbon-14 isotope method has been used by D. F. Squires (1963) to try and date parts of the sedimentary sequence on Lord Howe and to estimate the date of the extinction of *Meiolania*. One sample, from the southern end of Middle Beach, consisted of shells of the land snail, *Placostylus*. These came from a brown loamy horizon overlying a coral-sand bed with land snail shells and bird bones (including petrels and a small penguin) and were dated at 20,700 (plus or minus 700) years ago.

The second sample tested was a large fragment of the reef coral, *Pocillopora*, collected from marine sands underlying dune sands at the south end of Ned's Beach a few feet to one side of the site where the cluch of *Meiolania* eggs was discovered and about four feet below the level of the complete *Meiolania* carapace found in 1959. This sample was more than 38,500 years old and essentially beyond the range of Carbon-14 testing.

The sketchy evidence suggests therefore that *Meiolania* probably died out considerably before 20,000 years ago. The mystery of how it reached Lord Howe Island and how long it flourished there remains unsolved.

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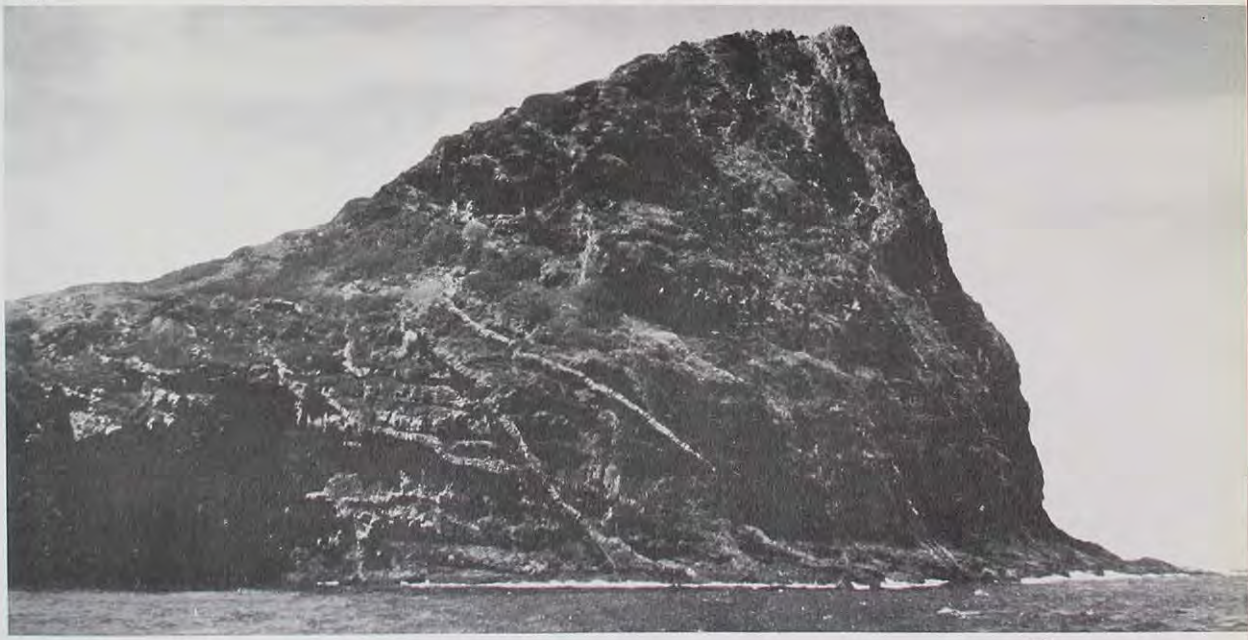

Dyke swarms intersecting lava flows of the older volcanic series of the Lord Howe Volcano.

A TROPICAL OUTPOST IN THE

Like glittering jewels, the volcanic peaks of Lord Howe Island pierce the azure Pacific 630 kilometres off the east coast of Australia. Situated at 31°33'S latitude, this island represents what is probably the world's southernmost coral reef and is of special interest to marine biologists because of its geographic location. Many of the marine organisms found there are tropical forms presumably transported sporadically as larvae via warm oceanic currents from the Great Barrier Reef and New Caledonia. In addition, a significant portion of the fauna is composed of species which normally frequent cooler waters to the south. Thus the surrounding waters provide an unusual mixture of temperate and tropical organisms.

Lord Howe Island consists of a narrow twelve kilometre-long strip of land lying in a general north-south direction. The most conspicuous topographical features are the twin peaks of Mt. Lidgbird (765m) and Mt. Gower (866m), which occupy most of the southern portion of the island. Rising abruptly from the sea, they form a spectacular backdrop to the lagoon which is situated on the leeward or western side of the island. The lagoon is approximately six kilometres long and one and a half kilometres across at its widest point. It is mostly shallow (average depth one to two metres) and consists largely of sandy bottom, but at several places, including Sylph's Hole and Comet's Hole, depths to eight metres are encountered as well as rich areas of living coral.

The lagoon fringing reef is pierced by Erscott's Passage (three to five metres) to the south and by North Pass (four to six metres). The latter constitutes the main entrance and is easily negotiated by small boats. Outside the lagoon the shoreline bottom drops off rather quickly to depths of fifteen to twenty metres and then gradually slopes to deeper water. The 200-metre line is generally located seven to twelve kilometres offshore. There are several small rocky islets around the periphery of the island. The most noteworthy are in the Admiralty Group, which is comprised of seven islets off the northeast tip of Lord Howe. Ball's Pyramid is a monolithic spire about twenty kilometres southwest of the main island which rises to an elevation of some 550 metres. The pyramid, like the small islets, is inhabited by large populations of sea birds.

Lord Howe Island is located near the middle of an oval-shaped submerged rise measuring about nine by eighteen kilometres with general depths of thirty to sixty metres. The bottom is rocky with deposits of calcareous sand in depressions. Fine sediments occur only in the deeper parts of the lagoon. Most of the shoreline is steep with

Gerald R. Allen

The Lord Howe Island anemonefish *(Amphiprion latezonatus)* at 30 metres. This species was known from only one specimen before the expedition, which collected an additional eleven individuals.

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SOUTH PACIFIC BY GERALD R. ALLEN AND JOHN R. PAXTON

rocky cliffs extending to the water's edge and depths of ten to twenty metres or more immediately adjacent to shore except along the lagoon. Sandy beaches occur only along the lagoon shore and in three small areas along the eastern side of the island. The near-shore habitat consists mostly of highly evolved volcanic rock—caves, ledges, fissures and archways are common underwater features. Reef-building corals are common but usually exist as scattered isolated colonies and not as massive reefs. Coral growth is profuse only in very restricted areas around the edges of deeper lagoon holes.

The most striking feature of the marine habitat to one familiar with tropical coral reefs is the lush growth of algae, probably brought about by the relative scarcity of herbivorous fish schools which keep algae on tropical reefs grazed down to a stubble. Also, as would be expected from an island so removed from the tropics, the number of coral species is not large. On the basis of oceanic sea surface temperatures, the waters around Lord Howe Island range from a low of 17°C in winter to 25°C in summer, although these extremes are not reached every year. Shallow lagoon waters are sometimes warmer, however. McCulloch took readings from 21° to 27.5° in December 1902.

Gerald R. Allen

Grey reef sharks *(Carcharhinus galapagensis)*. This is the most common shark in Lord Howe waters and can occur in large numbers.

The fish fauna of Lord Howe Island is particularly interesting. The first inshore fishes were collected by the crew of H.M.S. *Herald* in 1853. Since that time approximately 225 species have been taken; most of these were recorded between 1889 and 1925. The Australian Museum has long been associated with the study of the island's fish fauna. Museum ichthyologists Ogilby, Waite, McCulloch, and Whitley are largely responsible for the previous documentation. Early naturalists at Lord Howe Island procured most of their specimens by such methods as hook and line, beach wash-ups, shallow seining and derris poison dispersed in tidal pools. Many fishes, particularly the deeper-dwelling varieties, have eluded these methods. Today it is possible to collect fishes underwater with aqualungs to depths of at least seventy metres. Modern collections are further enhanced by an assortment of devices which include emulsified rotenone (a plant derivative which suffocates fishes), explosives, quinaldine (a chemical anaesthetic), and a variety of specialised nets and spears. The prospect of utilising these methods in the previously unexplored depths of Lord Howe Island were extremely exciting.

Early in 1973 Frank H. Talbot, Director of the Australian Museum, was awarded a $10,000 grant by the National Geographic Society, Washington, D.C., for the purpose of making a modern survey of the fishes of Lord Howe Island. The ichthyological team which he assembled for this task included Australian Museum biologists Barry Goldman, Douglass Hoese, Barry Russell, and the authors. John Randall, an authority on tropical reed fishes, represented the Bernice P. Bishop Museum of Honolulu. Walter Starck II, a research associate of the Australian and Bishop Museums, provided logistic support for the expedition's diving activities with his superbly equipped research vessel, *El Torito*. This 64-foot shallow draft ship carries a two man wet submarine, two decompression chambers, electrolung rebreathing devices as well as normal scuba gear and an auxiliary work boat. Other features include a laboratory, library and photographic facilities, making this an ideal platform for collecting activities. In addition, we were fortunate to be accompanied by Gilbert Whitley, former Curator of Fishes at the Australian Museum and author of numerous

The lagoon at Lord Howe Island showing anemonefish, wrasses, and brain coral.

H.G. Cogger

H.G. Cogger

Gerald R. Allen

The splendid hawkfish *(Cirrhitus splendens)* at 10 metres. This species is restricted to Lord Howe Island.

scientific publications, many involving Lord Howe fishes.

Most of the expedition members arrived at the island on the first of February. Initially our collecting efforts were confined to the shallow lagoon reefs. We encountered rich coral growth at several localities and an abundance of fishes. The lagoon is a special tourist attraction and glass bottom boats make daily visits, but we were granted special permission to collect on a limited basis. After *El Torito* arrived we were able to turn our attention to the deeper offshore waters. In contrast to the lagoon, there is very little coral in these areas. The submarine landscape is dominated by volcanic boulders, seaweed, and vast sandy stretches. One of the most productive localities for collecting was at North Islet, one of the Admiralty Group. At depths between twenty and thirty-five metres we encountered huge schools of yellow-tail kingfish (*Seriola*), fusilers (*Caesio*), stripeys (*Atypichthys*), fairy basslets (*Pseudanthias*), and brown pullers (*Chromis*). We also collected several individuals of a rare wide-banded anemonefish (*Amphiprion latezonatus*) previously known from a single specimen collected over seventy-five years ago. Kingfish are so prevalent that the sportfishing at times is not really very sporting. In addition to providing recreation, these excellent fish end up on the breakfast tables of the island's guest houses. The saddled rock cod (*Ephinephelus daemeli*) which sometimes exceeds seventy-five pounds is another species frequently taken by hook and line.

A large population of grey whaler sharks were present in waters outside the lagoon and occasionally caused problems during our collecting activities. These sharks afforded Starck an opportunity to continue his experiments with shark repellent wetsuits for diver protection. At Marion Reef, in the Coral Sea, he found that sharks were reluctant to feed on banded sea snakes, even when the reptiles were offered during the height of a feeding frenzy. Working on the assumption that the sharks were somehow repelled by the pattern of alternating black and white bands, Starck next conducted experiments utilising aluminium rods bearing this design. He found that hungry sharks would not take a bait which was tied to the snake-like rod, while they eagerly devoured baits attached to plain-coloured

H.G. Cogger

John R. Paxton

Diving party on the research vessel, *El Torito*, preparing to collect fishes off Ball's Pyramid.

rods. The next step was to determine if the banded pattern could be used by divers to ward off sharks. We found a concentration of forty-five grey whalers about five kilometres off the western side of Lord Howe Island. Several divers wearing conventional black wetsuits entered the water and were immediately approached by the curious shark pack. Several minutes later Starck quietly slipped into the sea wearing a black suit with a bold pattern of white bands. The sharks dramatically disappeared from sight. The same results were obtained repeatedly during a one hour trial period. Obviously this approach to shark protection holds promise.

The month long expedition was a tremendous success. We made more than 100 collecting stations during the survey, most with spears and quinaldine. While we wanted to obtain representative samples for the Museum's reference collections, we were particularly interested in collecting as many species as possible. With so many trained ichthyologists making up the collecting team, our species list built up rapidly. As time progressed, divers were able to selectively spear or anaesthetise individual specimens of species we had not previously collected.

Our activities attracted considerable attention on the small island. On most days teams of divers worked on the outer areas of the lagoon or offshore. At night the days catch would be brought back to the makeshift laboratory in the back of the guest house where half of us stayed. There the specimens would be identified and preserved in formalin prior to being packed in plastic bags and drums. We kept a running list of the species taken and were collecting new records up to the last days of the expedition. The identification and preservation often ran well into the evening and the lab occasionally became crowded with visitors interested in our work. The people of Lord Howe Island were most hospitable and helpful, bringing in beach-washed specimens and allowing us to examine the results of the annual Lord Howe Island Fishing Competition conducted during our stay. A significant number of Lord Howe Island fishes had previously been sent to the Australian Museum by local residents, who have a considerable interest in and knowledge of their marine life.

In addition to the primary collecting activities, a number of other projects were undertaken. Starck continued his shark work described above and took a number of underwater photographs, both still and movie. Randall spent most of his evenings photographing in colour most of the species we collected. The Lord Howe Island slides will be added to his large collection of Indo-Pacific reef fishes which he will eventually publish. Talbot, Goldman, and Russell ran a series of collection stations utilising two-pound charges of gelignite. The quantitative results from these stations will be compared with similar surveys made at One Tree Island on the southern portion of the Great Barrier Reef to indicate differences or similarities in species composition and total fish weight and numbers from the two areas. Hoese continued his studies on gobies living in branching coral which he had begun at One Tree, while Allen made observations on the damselfishes of the island. Paxton obtained specimens of the light-producing bullseyes (*Parapriacanthus*) and was able to complement his studies on Australian luminous fishes.

We collected over 6,000 specimens belonging to nearly 300 species and more than 100 families. Of this total, 186 represent new records for the island, including at least eight species which were previously unknown to science. The fish fauna of Lord Howe Island now stands at more than 400 species, a substantial increase over the 225 which were previously recorded.

Fishes commonly seen in the lagoon are McCulloch's anemonefish (*Amphiprion mccullochi*), Elegant wrasse (*Anampses elegans*), Norfolk cardinalfish (*Apogon norfolcensis*), Painted morwong (*Goniistius ephippium*), Spiny demoiselle (*Paraglyphidodon polyacanthus*), Sailorfish (*Parma polylepis*), Parrotfish wrasse (*Pseudolabrus luculentus*), and Pacific perch (*Trachypoma macracantha*).

The four fish groups with the most species are the wrasse family Labridae (forty-seven species), the damselfish family Pomacentridae (twenty-six species), the goby family Gobiidae (twenty-three species) and the butterfly or coralfish family Chaetodontidae (twenty-two species). These families are also dominant on the Great Barrier Reef. Indeed, more than fifty percent of the fish species found on the island are relatively widespread in the tropical Pacific. Only twenty species, or about five percent are restricted to Lord Howe Island, or to Lord Howe and Norfolk Island. While most of the species

are found in Australia, some ten percent are also common to New Zealand. A few of the fishes have affinities with those of Easter, Rapa, and Pitcairn Islands in the subtropical South Pacific. Additionally some ten percent of the inshore forms are temperate fishes endemic to the region which encompasses southern Australia and includes New Zealand. Thus, the Lord Howe Island fish fauna is made up of a number of different zoogeographic components, the tropical one being most dominant.

It is likely that a number of the tropical species found at Lord Howe represent expatriate populations, carried from Australian or New Caledonian reefs by warm southern currents, but unable to breed in cooler southern waters. Biological studies would be necessary to confirm this hypothesis, but the presence of very few individuals of some species and the absence of certain forms like the snapper, which had previously been taken around the island, suggest that breeding populations are not always present. The vagaries of the southern currents and the annual fluctuation in water temperature extremes may well result in a change of faunal composition from one period to another. Lord Howe Island would make an excellent site to conduct studies on species colonisation.

Marine invertebrates and algae from Lord Howe Island are not as well known as the fishes, as no recent intensive surveys have been undertaken. Roy Tsuda of the University of Guam is currently studying algae collected during our survey. Although his research is still in the preliminary stages, most of the species he has examined are subtropical forms. He may find a number of new records for the island, as most of our collections for him were from ten to twenty metres, below previously collected depths.

John Veron of James Cook University in Townsville has recently completed a study of the island's corals. He found twenty genera represented at Lord Howe, a considerable reduction compared with the Great Barrier Reef but more than the number found at the Solitary Islands off northern New South Wales or on the mainland coast at approximately the same latitude. The dominant genus was the staghorn (*Acropora,*) with at least thirteen species. Veron's results will soon be published in the *Proceedings* of the Second International Symposium on Coral Reefs, held in Queensland last year. Other marine invertebrates commonly seen on the reef are listed in the accompanying table.

With its picturesque lagoon and associated coral growth, Lord Howe Island is a fascinating study area in the vast southern ocean. However, much remains to be learned about its marine life and it is hoped that the environment there does not suffer as man continually strives for progress.

COMMON SHORE INHABITANTS OF LORD HOWE'S ROCKS AND REEFS

High Shore Littorinid-Black Zone	Periwinkles: Noddiwink (*Nodilittorina*) and Blue Australwink (*Littorina unifasciata*), also *Littorina coccinea* Microscopic plants coating the rocks with a blackish band
Mid-Littoral Mollusc-zoanthid Zone	Periwinkles: *Bembicium melanostomum*, Black *Melanerita*, *Nerita plicata* Limpet-like forms: True limpets, two species (*Cellana howensis* and *C. analogia*); False limpets, several species of *Siphonaria* Barrnacles: When present, Pink *Tetraclita* (due to isolation of Lord Howe Island, barnacles are rare) Oyster: Tropical *Crassostrea* (*C. amassa*) Worm-mollusc band: Upper, *Dendropoma* Sp. (coats rock surfaces); Lower, *Vermicularia* sp. Other common Molluscs: Cart rut shell (*Dicathais orbita*), Cowries, Black and Yellow cone (*Conus ebraeus*) In pools: Waratah Anemone (*Actinia tenebrosa*), Urchin in self-excavated holes (*Echinometra mathaei*), starfishes, crabs, shrimps and half-crabs (*Petrolisthes* sp.); colonial zoanthid anemones (*Palythoa*) form sheets on the rocks
Infra-Littoral Coelenterate-Lithothamnion Cualerpa Zone	Prominent algae: Green *Caulerpa* spp., encrusting 'lithothamnions', Turtle Weed (*Chlorodesmis*) and *Sargassum* spp. Coelenterates: True or Hexacorals and False or Octocorals like Organ Pipe coral (*Tubipora musica*), Blue *Xenia* (*X. elongata*), and fleshy alcyonarians (*Lobophyton* and *Sarcophyton*), Giant Anemones (?*Stoichactis* or *Radianthus*), with their attendant fish Echinoderms: Needle-spined Urchin (*Diaema*), Red-tipped Urchin (*Heliocidaris tuberculata*), *Tripneustes gratilla*, Black holothurians (very common—two spp.), Yellow *Stichopus* and others; many species of starfishes—Brittle Stars and Feather Stars Prominent Molluscs: Smaller clams (*Tridacna maxima*), Tuban Shells (*Turbo cepoides*), Tiger Cowries and other tropical molluscs

compiled by Elizabeth Pope

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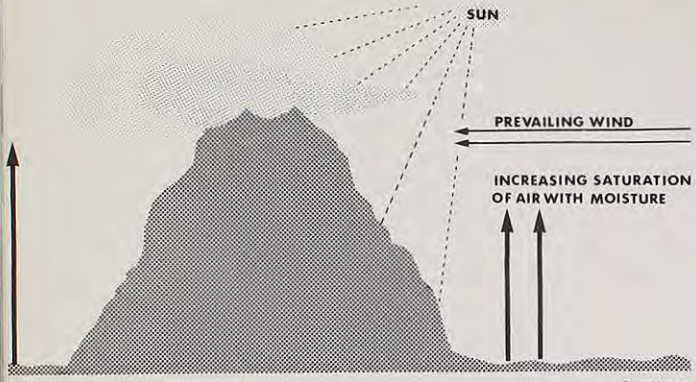
VEGETATION AND ENVIRONMENT

The first overwhelming impression one receives of Lore Howe Island is of its spectacular topographic relief. The summits of Mt. Gower and Mt. Lidgbird rise dramatically in the south and dominate the view from any other position on the island. At the opposite end of the island the prominent east-west ridge of the Northern Hills forms a broad arc enclosing the lagoon to the west. Sheer cliffs rising hundreds of metres are common on the sides of Gower and Lidgbird and form the seaward side of the Northern Hills. Weathering and erosion have superimposed on these volcanic masses a complex system of valleys and ridges.



Susan Harrison

The central low-lying part of the island offers a marked contrast to this ruggedness. While basaltic rocks of Pliocene and Pleistocene age make up the hills and mountains to the north and south here the ground surface is of calcarenite, calcareous sand deposited by winds curing the Pleistocene and later cemented. Extensive clearing for cultivation and homes has taken place here further accentuating the gentle rolling character of this part of the island.

The minimum monthly mean temperature of Lord Howe Island is 16°C (August) and the maximum monthly mean temperature is 23°C (February). As Richards (1966) defines tropical rainforest climate as having a temperature regime that seldom drops below 25°C, Lord Howe Island must be considered to have a subtropical climate, which is in keeping with its relatively high latitude. The maritime nature of the climate, however, keeps the annual fluctuation low (7°C).

The mean annual rainfall for the island (more than 1600mm) conforms with Richards' (1966) definition of tropical rainforest climate. The rainfall is distributed unevenly through the year with an average low of 100mm in February and a high of 200mm in June and July. It is worth noting that low rainfall and high temperature coincide in February creating particularly adverse conditions for the vegetation.

Another characteristic of the climate that is of considerable importance for the vegetation is the consistently low relative humidity of 75-78 percent. It is soon apparent to any visitor that Lord Howe Island is an exceedingly windy place. August is the month of highest winds (average 13 knots) though the low months of January and March may still be considered windy (average 9-10 knots).

The climatic data presented above are from only one locality in the central lowland part of the island. With increasing elevation a number of changes in climate affecting vegetation take place. The most well-known of these is decreasing temperature though other equally important changes in climate accompany increasing elevation. As air cools, its moisture holding capacity declines and with it the saturation deficit and rate of evaporation. Eventually, provided the land mass is high enough, the dew point is reached and increasing precipitation results. This is accompanied by greater frequency of cloud cover and less sunlight (see drawing this page.)

It has been established that the height at which these changes occur varies with the size of the mountain and its distance from the ocean. On mountain masses near the ocean, cloud forms at lower elevation because the air has a high moisture content and requires less cooling. This has been termed the Massenerhebung Effect. The air has a higher moisture content on the windward side and therefore, cloud will form at a lower elevation.

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BY STEPHEN S. CLARK AND JOHN PICKARD

Climate may also influence vegetation indirectly through its effect on the soil. Nutrients will become available more slowly and nutrient cycling will operate at a decreased rate. Because of the decreased effectiveness of evaporation soil waterlogging may also take place and lead to less available phosphorus and nitrogen.

The complex topography of valleys and ridges on Lord Howe Island interacts with wind providing varied exposure conditions with far reaching implications for the vegetation. The effect of increasingly exposed conditions on the rate of transpiration at the leaf surface is illustrated on this page.

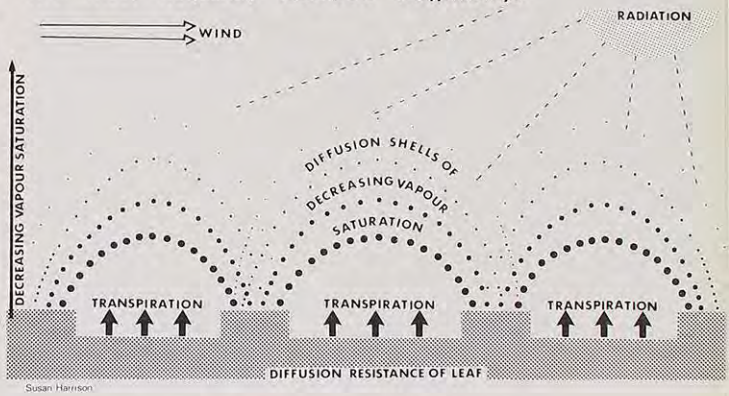
Here it is apparent that with incoming solar radiation and the process of photosynthesis taking place, the stomates on the leaf surface are open and water vapour is diffusing outward. This creates a gradient of vapour saturation from the inside of the leaf outward (diffusion shells of decreasing concentration of water vapour are shown). Windy conditions continually break down these shells, thus steepening the gradient and increasing transpiration. It has been shown that a small leaf remains closer to air temperature. Thus the air inside the leaf holds less moisture saturation, and this helps to keep the gradient across the leaf surface low, decreasing the rate of water loss.

Thus with increasing exposure to wind and solar radiation one would expect plants to have smaller leaves or to employ some means of increasing their internal diffusion resistance. Both have, in fact, been found to be true of some species on Lord Howe Island.

Because of the changes in environment associated with increasing exposure and elevation, the most favourable conditions for the vegetation occur in the lower, more sheltered parts of the island. The valley bottoms, particularly, provide protection from wind as well as favourable moisture and light conditions. Here the vegetation assumes the stature of a forest as much as twenty metres in height. The trees are straight and branching near the top forms a dense canopy. Leaves are large and palms, lianas, and plank buttresses as well as the distinctive stilt roots of screw pine (*Pandanus forsteri*) are common features contributing to the appearance of the forest.

A considerable variety of species comprise the vegetation. Among the more common species are scalybark (*Cleistocalyx fullageri*) and blue plum (*Linociera quadristaminea*). In addition to the screw pine (*Pandanus forsteri*) already mentioned, which may form nearly pure stands along water courses, the thatch palm (*Howea forsterana*) also has a tendency to occur in pure stands, particularly on calcareous parent material.

As one proceeds up the sides of the valley or toward a more exposed aspect, the vegetation lowers in stature. The trunks of the trees branch nearer to the ground and the branches as well as the trunks are crooked and distorted. Palms are seen less frequently as are stilts and buttresses though lianas are still common. A great variety of species are no longer found and one encounters most frequently blackbutt (*Cryptocarya triplinervis*) and greybark (*Drypetes australasica*).



Under the still more exposed conditions of prominent ridges or steep cliffs the vegetation declines in height to a shrub community, again with crooked and distorted branches and stems. Now lianas are absent as well as palms, buttresses, and stilt roots. The small leaves predicted from the above consideration of transpiration are found in abundance. Species common here include bullybush (*Cassinia tenuifolia*) and tea tree

JOHN PICKARD is Plant Ecologist at the National herbarium. He has been engaged in mapping the vegetation of the state of New South Wales as well as that of Lord Howe Island.

Stephen S. Clark

Lowland mixed forest occurs at lower elevations and in the more sheltered parts of the island. One or two or a variety of tree species may be present.

At intermediate exposures the rainforest on the island assumes a more open appearance. The trees, *Drypetes australasica* and *Cryptocarya triplinervis*, are often crooked and distorted.

H.F. Recher

H.F. Recher

With extreme exposure conditions trees disappear entirely and are replaced by scrub vegetation. While a variety of species occur, *Melaleuca howeana* and *Cassinia* tenuifolia are among the common shrubs.

Gnarled mossy forest found at the summit of Mount Gower. Abundant ferns and epiphytes are characteristic of this vegetation.

E. Slatter

(*Melaleuca howeana*) though a variety of shrub and herb species may be found.

It is difficult to separate the effects of elevation and exposure on Lord Howe Island because an increase in elevation is often accompanied by increased exposure. As one climbs upward, increasingly precipitous slopes afford fewer sheltered positions. However, once the summits of Gower and Lidgbird are reached the effects of environmental change accompanying elevation are fully apparent. The vegetation is once again reduced in height and trunks and branches distorted but the great abundance of epiphytes and filmy ferns testifies to the abundance and reliability of moisture. The cap of cloud that often obscures the summits of Gower and Lidgbird offers a further indication that the Massenerhebung Effect is operative.

The species found on the mountain tops, particularly Gower, are also distinctive. Many species of ferns endemic to the island are found here as well as three of the four endemic angiosperm genera—*Negria, Hedyscepe,* and *Lepidorrhachis.*

Observation, then, informs us that the vegetation changes both in terms of species and appearance with increasing exposure and elevation. It would be interesting to know, however, the relative importance of these two factors when compared with other environmental changes which may also be influencing the vegetation. One way of doing this is to prepare an ordination of the vegetation. First, species lists are prepared from a number of localities selected at random on the island. These may be considered as 'samples' of the variety of vegetation to be found on Lord Howe Island. Next these samples are arranged in a multidimensional space (difficult to imagine but mathematically possible). Samples with many species in common appear close together in this space and samples with few species in common appear far apart.

The space defined by the vegetation samples will, of course, not be perfectly symmetrical. The figure on this page shows a plot of two out of the three most important axes or directions of variation of the vegetation space. The individual samples of Lord Howe Island vegetation, seventy-three in all, appear plotted on these two axes. By reference to the position of these sites on the island it becomes apparent that high exposure sites tend toward the left on Axis 2 and low exposure sites toward the right. High elevation sites appear toward the top of the figure along Axis 3 and low elevation sites toward the bottom. The relationships are not perfect ones

because other factors intervene. It is highly unlikely that the vegetation of any area, however simple, can be explained as a response to only two factors. Generally speaking, however, here is striking confirmation that elevation and exposure are exerting an influence of considerable importance on the vegetation of Lord Howe Island.

Geological evidence indicates that Lord Howe Island was once part of a much larger land mass. We also know that Pleistocene lows in sea level would have exposed other island 'stepping stones' between Lord Howe Island and New Zealand to the south and Malaysia to the north. The theory of island biogeography tells us that these two factors of increased size and intervening land areas would have facilitated dispersal of a great variety of plant species. The species making the journey would then, of course, have been subjected to the further test of finding a suitable environment among the alternatives offered by Lord Howe Island. Very probably the variety of possible environments decreased as the size of the land mass was reduced. Species were given the alternatives of extinction or adjustment to a new environment through evolution. Today Lord Howe Island provides the wonderful opportunity of observing this ongoing process of vegetation responding to the environment.

FURTHER READING

RICHARDS, P.W.: The Tropical Rainforest, Cambridge Univ. Press, 1966.

ISLAND INVERTEB

J. McKean

The spectacular Tailed Emperor Butterfly occurs from the Lesser Sunda Islands to the Solomons as well as in northern and eastern Australia. The Lord Howe Island population, through its isolation, has evolved into a form recognisably different from its Australian counterpart.

The study of the fauna of a small island is appealing to almost every field zoologist. There are many reasons for this. Some are scientific, some are aesthetic; but to the zoologist interested in land invertebrate animals, an additional reason is that the area of a small island restricts the fauna so that it is of manageable size. The first task in any zoological study is to identify the species and it is here, right at the outset, that invertebrates confront the zoologist with his first problem. The number of species is so great that many scientists spend their whole working lives identifying and naming species. In Australia alone there are well over 50,000 known species of insects and there is reason to believe that the number in existence is at least twice that. No wonder small islands are attractive—at least it should be possible to obtain a working knowledge of the composition of the fauna in a reasonable time. This is not to say that invertebrate species are few on small islands; they are there in abundance, but the island shores do form a well defined boundary to the area being covered.

Not only are invertebrates numerous in species, there are often vast numbers of individuals. They represent, in total mass, a great deal of living material, and the impact which they make on the environment and their contribution to the whole living system are enormous. The invertebrates, between them, show a tremendous variety of adaptations in structure, physiology and behaviour; they also show a variety of mechanisms for dispersal to suitable habitats, a matter in which every species must be adept if it is to survive.

Islands are good laboratories in which to study dispersal and colonisation because they are pockets of limited habitats separated from the source of colonising individuals by a stretch of inhospitable sea. Islands are good places in which to ask questions about the nature and origins of the fauna and flora.

Although the task of compiling inventories of species is fairly well advanced, there are still many invertebrate groups on Lord Howe Island about which we know little and it is unlikely that a list could be complete for any group except perhaps butterflies.

In looking for areas from which the fauna of the island came it is natural to look at those land areas which are nearest or which are big and have a varied fauna. From this point of view it is not Lord Howe's most conspicuous invertebrates that are the most interesting. The bright, showy butterflies which atrract the tourist's eye and are, therefore, important to the island's image, are all known from other areas. Twenty-four species of butterflies are known from Lord Howe Island; several of them are found also on other Pacific islands and all are found in Australia. Being such mobile animals, it is not surprising that additional species arrive from time to time. These may or may not be able to establish themselves. If suitable plants are available on which its caterpillar stage can feed, a species may become part of the fauna, either permanently or perhaps only for a generation or two if climatic conditions are not continuously suitable. There are several species of butterflies which have only been seen once on the island; these may not arrive very frequently and do not establish themselves. Other species, such as the Caper White (*Anaphaeis java*), have been seen to arrive in thousands. These swarms are sometimes from Australia and sometimes from New Caledonia, the populations from these places being differently coloured and so recognisable. The Caper White cannot breed on Lord Howe Island because its caterpillars feed only on the leaves of caper trees (*Capparis* spp.), which do not occur on the island. Should, by any chance, this plant become established on the island the Caper White butterfly would probably become part of the fauna.

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RATES

BY COURTENAY SMITHERS, DAVID McALPINE, PHIL COLMAN, AND MICHAEL GRAY

The process of plant introduction followed by butterfly establishment took place in the case of the Wanderer butterfly (*Danaus plexippus*), which became a resident species on Lord Howe after the introduction of milk weed (*Asclepias curassavica*), the food plant of its caterpillar. The original home of both plant and butterfly is North America. Butterflies are very mobile creatures and are strong fliers; we know that some of them can cross as much as a thousand miles of sea if conditions are suitable. The butterflies of the island are not really as isolated from other populations as one might think. This is borne out by the fact that distinct species have not evolved on Lord Howe; this is the way with highly mobile animals.

Just as the introduction of one organism may assist or be essential for the establishment of another, so may one well be responsible for the disappearance of another. The Lord Howe Island Phasmid (*Dryococelus australis*) is a large, wingless species of stick insect which was endemic and very common on the island until the introduction of rats. It is now known only from isolated Ball's Pyramid. The phasmid is large and, being flightless, fell an easy prey. It is to be hoped that rats are never allowed to colonise Ball's Pyramid, even temporarily, because the phasmid would then surely become extinct as there would be no other such substantial items of food available to the rats. In strong contrast to the active, wide-ranging butterflies the Lord Howe Phasmid has not been found elsewhere. It has relatives on other islands, such as New Caledonia. Since there can be no great traffic in phasmids to and from Lord Howe Island the population has remained in isolation long enough for the evolution of a separate species to occur.

Invertebrates are generally small; their many species go unnoticed by most people and are known only to the specialists who seek them out. This is a pity because they are such interesting animals. It is amongst these small animals that zoologists often find the best material for answering scientific questions.

The flies (*Diptera*) of Lord Howe Island have recently become the centre of renewed interest among some entomologists whose studies show that Lord Howe Island's fauna has a close relationship to that of the Australian mainland but includes some elements not closely related to mainland insects. Dr Pont of the British Museum has recently studied the Muscidae (the family which includes the House Fly and the Bush Fly), amounting to twenty-three species on Lord Howe Island. Five of these are apparently endemic and a further nine are restricted to Lord Howe and Norfolk Islands. The other species are all present on the Australian mainland. On the other hand, there is a notable absence (or ap-

David Rootes

The Lord Howe Island Phasmid was thought to have become extinct after the introduction of rats to the island in 1918. This historic photograph of a recently dead female phasmid taken on Ball's Pyramid in 1964 was the first evidence of the continued existence of the species.

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Phil Colman

H.F. Recher

Gudeoconcha sophiae, one of the largest snails on the island was once quite common. It is now restricted to only a few localities on the northern end of the island. Growing to about 40mm in diameter, it is quite easy to see—probably a factor in its virtual disappearance through rat predation.

The photo at right shows evidence of rat predation of the introduced European snail, *Helix aspera*. In some places large piles of such broken shells can be found under crevices and in boles of trees where only rats could hide.

parent absence) of a number of large and common Australian groups from Lord Howe.

The family Platystomatidae has been studied by D.K. McAlpine of the Australian Museum. So far only five species are known on the island—*Pogonortalis howei, Duomyia howensis, Naupoda insularis, Rivellia* sp., and *Guamomyia* sp. The *Rivellia* is perhaps identical with a mainland species, but the other four species are endemic to the island. *P. howei* and *D. howensis* are very closely related to mainland species, and there is a further undescribed species of *Pogonortalis* on Norfolk Island. The genus *Naupoda* is represented on the Australian mainland by a single species restricted to the tropical northeast and not very closely related to *N. insularis*. *Naupoda* is widely distributed, occurring in Fiji, Africa, and many intermediate places. *Guamomyia* has been found in numbers by Ms Zenta Liepa on the roots of *Pandanus* on the foothills of Mt Lidgbird. Other species of the genus occur in New Guinea and on Guam, but not on the Australian mainland.

The only representative of the stilt-legged flies (family Micropezidae) is an undescribed endemic species of genus *Metopochetus,* with relatives known from New Guinea and adjacent islands, through eastern Australia to Tasmania and southwestern Australia. The Lord Howe species differs from all others of the genus in the absence of the broad black bands on the wing. This lack of adornment by comparison with mainland relatives is parallelled by the Lord Howe representative of the lauxaniid genus *Poecilohetaerus.* In the six species of this genus found in Australia and New Zealand there is invariably a pair of white dorsal stripes on the head and thorax. These are absent on the Lord Howe species, so far only known from the summit of Mount Gower. Perhaps these are species recognition features and there is no need for them in areas where there is only one species.

A very small fly of the family Asteiidae recently collected near Salmon Beach has proved to be of special interest. It differs considerably from all other known living members of the family and closely resembles the fossil *Succinasteia* from Baltic amber, about 40,000 years old.

About seventy species of land snails have been listed from Lord Howe but it is probable that this number is high, as some species have been described more than once. Nevertheless, Mr Coleman of the Australian Museum collected about forty species in three weeks in February 1971 during a dry period (which was not good for collecting). Distribution of the various species seems to be fairly wide over the island, with a vertical limit more binding than a geographical one. Some species seem to be more specific to certain plants, but most appear to utilise a wider range of habitats.

When considering the relationships of the Lord Howe species we can detect connections with the fauna of New Zealand, New Caledonia, Norfolk Island, and the Kermedecs; less so with the Solomons, New Hebrides, and eastern New Guinea. Very few families are represented in Australia. The proportion of species known only from Lord Howe is very high. This is what would be expected in a group not given to rapid movement. Destruction of habitat by man, goats, pigs, and rats have certainly affected the occurrence, and sometimes distribution, of species of molluscs. When we compare the present fauna with species listed in earlier times we see that some species formerly common, and even abundant, in some or many areas are now almost extinct—for example, the large, spectacular, ground-dwelling molluscs of the genus *Placostylus*. The main species, *P. bivaricosus*, which can attain a length of three inches, apparently is now existing in only four small colonies, whereas from early reports it was dispersed widely from sea-level up to the mountain tops. The Rabbit Island species, *P. cuniculinsulae*, has completely disappeared. Another large species which used to be widespread and common is *Gudeoconcha sophiae* but this can now be found alive at only seven localities, all on the north end of the island. It, too, has disappeared from Rabbit Island. Many dead shells of both *Placostylus*

and *Gudeoconcha* can be found elsewhere, often in piles under rocks and crevices and often with a hole chipped dorsally, suggesting rat predation.

In the Erskine Valley, on the moist slopes, and near the trail to Mt Gower, extreme damage to the whole environment seems to have been caused by pigs and goats. Surface litter has been heavily disturbed, rocks and logs turned or broken, ground cover eaten down or killed, and in places erosion has set in. The mollusc population has been virtually eliminated, the few remaining species being tree dwellers and small, cryptic species in leaf litter and soil

Terrestrial molluscs are sensitive to habitat change, and with the changes on Lord Howe we must expect extinction of several species.

A recent survey of the spiders of Lord Howe carried out by Michael Gray of the Australian Museum, has yielded more than a hundred species, of which at least fifty per cent are known only from the island. Of the remainder about half are known to occur also in Australia, while others occur in such areas as New Caledonia, Norfolk Island, Polynesian islands, and New Zealand. It is interesting to note that in some groups there is a tendency towards development of distinctive populations at different altitudinal levels, a phenomenon seen also in molluscs. Some species are extremely abundant and some show interesting behaviour patterns.

The large Golden Orb Weaver (*Nephila imperialis*) occurs on all parts of the island. Their webs commonly harbour the smaller male spiders and several tiny, silvery scavenger spiders (*Argyrodes antipodiana*). The Leaf-curling Orb Weaver (*Phonognatha graeffi*) is also common in lowland forest, while in grassland areas around the coast and near creeks the Slant-web Orb Weaver (*Leucage granulata*) predominates.

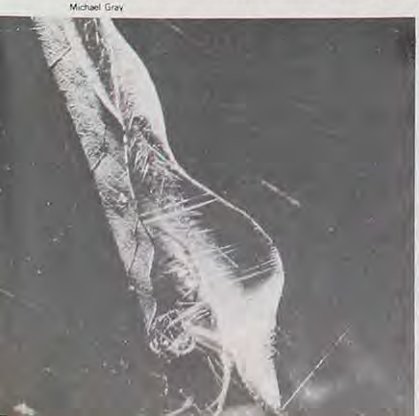
The 'platform' web of *Archaearanea extrilidum* with its curled-leaf retreat and guy-line tangle above, is found on shrubs and trees in lowland and highland forest. This species is of added interest because it is apparently the prey of a much smaller linyphiid spider (about three millimetres long) which was found only in association with *A. extrilidum* corpses in their curled-leaf retreats. The linyphiid has an obvious bright red spot near the end of the abdomen, which is otherwise black. This spider may possess quite a potent venom with which it subdues its larger prey, but the details of this relationship require further study. Another therid species, *A. diversipes,* shows an interesting behavioural variation in relation to its egg sac. Instead of suspending the sac in or near the web, as do other therids, *A. diversipes* carries its single white egg sac in its jaws. Presumably, predator protection (for example, against parasitic wasps) is the basis of this unusual behaviour.

Widely distributed on foliage, notably of palms, are the clubionid hunters, *Clubiona excavata,* which roll the ends of palm leaves into tubular retreats, and *Chiracanthium* spp. Also widespread on palm foliage is the spectacular elongate, Jumping Spider (*Pseudomaevia cognata*) whose retreat consists of two adjacent palm leaves held together by spots of very strong silk. The thomisid, *Diaea rubropunctata,* also commonly uses palm leaves to construct a retreat by bending a leaf at right angles and to the side to form a silk-lined cell.

In ground litter, two distinctively marked species, *Tharpyna speciosa* and *Storena* spp., are very common in lowland forest, while the cribellate litter web builder, *Oramia frequens,* and the Wolf Spider (*Lycosa gloriosa*) extend into highland regions.

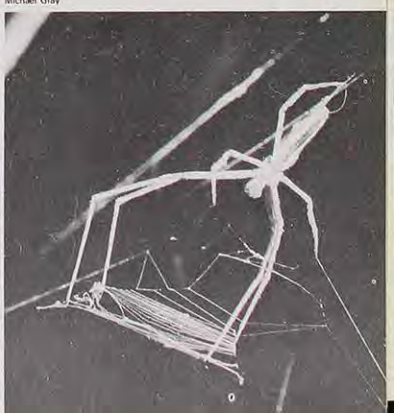
Cycloctenus vittatus is a lowland hunter confined to forest clearings and grassed areas. There are no mygalomorph spiders (relatives of the Funnel-web) on Lord Howe, and despite the abundance of spiders and the fears sometimes expressed by visitors when they become entangled in the strong webs of the Golden Orb Weaver, only one species known to be harmful to man occurs on the island. This is the Redback Spider *(Latrodectus hasselti),* which is common in the settlement area and has probably arrived only with human settlement.

Michael Gray



Michael Gray

Michael Gray



This Leaf-curling Spider (left) is in the catching position at the mouth of its retreat

The web of the Golden Orb-weaver (centre) is very strong and can be as large as a metre across.

The Net-casting Spider (right) captures its food by casting the silk net, held by the front legs, over any suitable prey which ventures nearby.

COLONISATION AND EXTINCTION

THE BIRDS OF LORD HOWE ISLAND

BY H. F. RECHER

An early account of the birdlife of Lord Howe Island is contained in a manuscript written by Surgeon Arthur Bowes. Bowes visited Lord Howe in May 1788, two months after it had been discovered by the *Supply*. As one of the first persons to land on Lord Howe Island, he found the birds abundant and incredibly tame. In Bowe's terms, they were easy to hunt. Today, there is little resemblance to the 'Golden Age as described by Ovid' in which Bowes fancied himself. The birds he found abundant are now rare or extinct and the lowland forests and swamps have been changed to town and pasture.

The transformation from the 'Golden Age' was abrupt. Lord Howe Island became a way station for sailing ships—a place to obtain water and meat. Settlers came and cleared the land and before the nineteenth century was half over, the larger and more edible of the island birds had disappeared. In this way, Lord Howe Island is not very different from other islands colonised by Europeans. The International Union of Nature Conservation has calculated that 217 kinds of birds have become extinct in the last 400 years—200 of these were island races or species.

Extinction is a perfectly natural process, but the expansion of Western Civilisation has greatly increased the rate of extinction. The clearing of land for agriculture, hunting, the introduction of predators and diseases, and most recently the pollution of the environment with chlorinated hydrocarbons (for example DDT) have all helped accelerate the rate. The processes have been the same wherever Europeans have settled, but their effect has been greatest on islands. In order to understand why this is so, we need to look at the peculiar features of islands and the behaviour of island birds.

The Bird of Providence, locally known as the Big Hill Mutton Bird, nests on the tops of Mount Gower and Mount Lidgbird in winter.

We can begin with the obvious—most islands are small and all are surrounded by water. In effect, this means that islands are hard to get to. The smaller the island and the farther it is from land, the more difficult it is for an animal to reach the island. Colonisation of islands is, of course, easier for birds than for reptiles, mammals or amphibians, but even birds have difficulty in reaching very remote islands. Just getting to an island does not mean that colonisation will be successful. The island must be a suitable habitat and enough individuals of the opposite sex must be present to ensure successful reproduction. It is not surprising, therefore, that biologists have found that the number of successful colonisations of islands is fewer than the number of animals which actually reach an island. Some birds are much better colonisers than others. Silvereyes (Zosteropidae) which are common garden birds throughout Australia are particularly good colonisers. This is due to their ability to fly long distances and to the fact that Silvereyes normally travel in flocks. If they reach an island, there are plenty of male and female Silvereyes to establish a population. Silvereyes are so good at colonising that many islands have been colonised more than once and have two or more species. Lord Howe Island originally had two species, but the Robust Silvereye is extinct.

Since most animals find it difficult to reach islands, successful colonisers are effectively isolated from populations on other islands or on continents. In the course of time we would expect island populations to change as they adapt to the particular conditions of the island on which they live. If they are sufficiently isolated, they will evolve into a distinct race or species. Thus, as in the case of the Silvereyes, a second or third colonisation of the island by the parent species may result in two or more species living together even though both were derived from the same stock. As a consequence of these evolutionary processes, islands have a high proportion of endemic species or races, that is, forms which are not found elsewhere. When Lord Howe Island was discovered, it had fifteen species of land birds, fourteen of which were forms endemic to Lord Howe Island (five species and nine races or subspecies).

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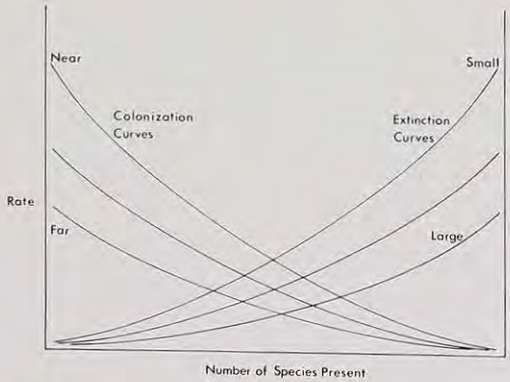
E. Slater

INDIGENOUS LAND BIRDS OF LORD HOWE ISLAND

Species	*Status/Year of Extinction*	*Cause of Extinction*
WOODHEN (*Tricholimnas sylvestris*)	between 18 and 24 individuals survive	rats, pigs and predation by man are likely causes of the decline in numbers
WHITE GALLINULE (*Porphyrio porphyrio albus*)	not certain, but prior to 1844	killed for food
LORD HOWE PIGEON (*Columba vitiensis godmanae*)	last seen between 1853 and 1870	killed for food
GREEN-WINGED PIGEON (*Chalcophaps indica*)	common	
LORD HOWE PARRAKEET (*Cyanoramphus novaezelandiae subflavescens*)	about 1870	killed as an agricultural pest
LORD HOWE BOOBOOK OWL (*Ninox novaeseelandiae albaria*)	not certain, but probably after 1919	not known, but possibly interbred with introduced *N. novaeseelandiae boobook*
LORD HOWE SACRED KINGFISHER (*Halcyon sancta adamsi*)	abundant	
VINOUS-TINTED THRUSH (*Turdus xanthopus vinitinctus*)	between 1919 and 1938	exterminated by rats
LORD HOWE WARBLER (*Gerygone insularis*)	between 1919 and 1938	exterminated by rats
LORD HOWE FANTAIL (*Rhipidura cervina*)	between 1919 and 1938	exterminated by rats
LORD HOWE GOLDEN WHISTLER (*Pachycephala pectoralis contempta*)	abundant	
LORD HOWE SILVEREYE (*Zosterops tephropleura*)	abundant	
ROBUST SILVEREYE (*Zosterops strenua*)	between 1919 and 1938	exterminated by rats
LORD HOWE STARLING (*Aplonis fuscus hullianus*)	between 1919 and 1938	exterminated by rats
LORD HOWE CURRAWONG (*Strepera graculina crissalis*)	between 30 and 50 individuals survive	cause of decline not known

Compiled from Hindwood (1940), Fullager et. al. (1972)

In addition to having a high proportion of endemic species, islands tend to have fewer species than are found on an equivalent area of mainland. The fifteen species found originally on Lord Howe are far fewer than the seventy or more species we'd find breeding on thirteen square kilometres of the North Coast of New South Wales. The small number on islands can be accounted for by the size of the island and its degree of isolation. Quite simply, the smaller the island the greater the chance of extinction, and the more isolated the island the slower the rate of colonisation. Extinction is a function of population size—the smaller the population the greater the chance of extinction. Because island populations tend to be circumscribed and smaller than continental populations the rate of extinction is naturally greater on islands than on continents. Species can only be replaced on islands by colonisation and the more remote the island, the slower the rate of colonisation.



In the chart on this page, I have plotted simple curves for the rates of extinction and colonisation against the size of islands and their degree of isolation. Where the curves intersect an equilibrium is reached between extinction and colonisation rates. The equilibrium value is the number of species which will be found on an island of that size and degree of isolation. We can easily see from the figure how a small and remote island could have fewer species than a small island close to the mainland.

It is clear why such a large proportion of recent extinctions have occurred on islands. The small size of island populations greatly increases the risk of extinction and where an endemic population is concerned there is no chance of recolonisation. The history of the birds of Lord Howe Island vividly illustrates this and shows the different ways in which European man has hastened the extinction of island birds.

Of the fifteen land birds indigenous to Lord Howe Island, nine are extinct and the Woodhen and Currawong are rare enough that their survival is in doubt. The birds which were first affected by the advent of man were those which were good to eat or afforded sport. As happens on many islands where man and other mammalian predators are absent, the birds did not associate men with danger. Another species, the Lord Howe Parrakeet, was destroyed for the damage it caused to grain and fruit. The extinction of this group of birds was largely complete

J. McKean

Masked Gannet with chick on Roach Island.

by the 1860s. In some ways, the next bout of extinction was even more dramatic.

There are no native mammals on Lord Howe Island and though cats, pigs, goats, and mice were introduced during the nineteenth century, they did not have a serious effect on the land birds. However, in 1918, the supply ship, the SS *Makambo* grounded on Ned's Beach and the common ship rat (*Rattus rattus*) arrived on Lord Howe Island. Within five years, five of the remaining indigenous species of birds were extinct as a direct result of the rats. The ship rat is partially arboreal and preys extensively on eggs and nestlings and probably on nesting birds as well. As with the larger birds hunted into extinction, the song birds of Lord Howe Island were incapable of associating these new arrivals with danger. It is likely that the rats also hastened the decline of the Woodhen which had remained tolerably common in the more remote parts of the island.

Extinction has not been the only change in the avifauna of Lord Howe Island. Many species have been introduced and others have colonised the island from New Zealand and Australia. It is difficult to know the exact origins of the birds

J. McKean

Fleshy-footed Shearwater sitting beside its nest burrow

which were indigenous to Lord Howe Island, but it certainly received species from Australia, New Zealand and New Caledonia. Some ornithologists have considered New Caledonia to be most important, but this is only because many of the indigenous land birds are of wide spread groups which can not be assigned to any region in particular. The Lord Howe Island Woodhen, Lord Howe Pigeon, Vinous-tinted Thrush, and Lord Howe Starling are of New Caledonian origin. The Golden Whistler and Currawong are from Australia, and the Parrakeet is from New Zealand. Of the recent arrivals, two, the Black-bird and the Song Thrush, are probably from New Zealand and two, the Nankeen Kestrel and the White-faced Heron, from Australia. The Starling may have come from either place. Of many attempts at introducing birds, only the Barn Owl, Tasmanian Masked Owl, and Magpie Lark have been successful. The owls were introduced to combat the rat plague—without success and at the price of establishing two more predators on the island.

There are many interesting things about the birds which successfully colonised Lord Howe Island in recent years, but the one thing which stands out is that all depended in one way or the other on man. The Black-bird, Song Thrush, and Starling are European birds introduced to the region, if not Lord Howe, by Europeans. The Kestrel, White-faced Heron, Magpie Lark, and Starling were able to colonise the island only because men had created a suitable habitat by clearing the forest. The owls were of course introduced, but more than that, they probably depend upon the rats as a food source and the rats are another introduction of man.

What this illustrates is that island ecosystems are incredibly sensitive to change. Change occurs naturally, but the advent of Western Man sets in train a series of events over which we have little, if any, control. In many ways, Lord Howe Island has been more fortunate than other islands colonised by Europeans. It retains large areas of natural vegetation and many of its most interesting animals survive. The future of the island and of the island's remaining birdlife depends largely on how we act over the next few years. Uncontrolled development of tourism and the introduction of new plants and animals can only lead to changes in which the island's native wildlife will suffer the most. This need not happen. Our knowledge of island ecology and of the wildlife of Lord Howe Island enables us to plan a future for the island which is compatible with the environment and which will ensure the survival of endemic species.

Seabirds are the real wealth of Lord Howe Island. Twelve species of seabirds nest on the island or on nearby islets and Ball's Pyramid; another eighteen species visit the area. Many of the nesting colonies are easily visited and in the past the islanders collected Sooty Tern eggs and muttonbird chicks for food. Such activities had less effect on the seabirds than the clearing of land and the introduction of predators.

Major colonies occur on Lord Howe Island between Ned's Beach and the Clear Place (Fleshy-footed Shearwater), Mutton-bird Point (Masked Gannet), Malabar (Red-tailed Tropicbird), and Mt. Gower and Mt. Lidgbird (Providence Petrel). Roach Island (Sooty Tern, Masked Gannet, Wedge-tailed Shearwater and White-bellied Storm Petrel), Rabbit Island (Wedge-tailed Shearwater), and Ball's Pyramid (Sooty Tern, Noddy) are the most important offshore nesting areas for seabirds. All are free of introduced predators and are important for the conservation of seabirds.

The numbers of birds nesting in these colonies is considerable. It is estimated that 100,000 Sooty Terns nest on Roach Island alone and despite inroads by agriculture, the Fleshy-footed Shearwater colony on Lord Howe contains 50,000 birds. A similar number of Providence Petrels nest on the summits of Mt. Gower and Mt. Lidgbird.

The seabirds of Lord Howe Island represent a valuable resource. The island is one of the few places where nesting colonies are so easily visited and bird behaviour studied. It is hoped that the future will see a tourist industry based on tours of the nesting colonies, and the establishment of a research station devoted to the study of seabirds.

Painting of the extinct Lord Howe Pigeon *(Columba vitiensis godmanae)* by George Raper—by kind permission of the British Museum (Natural History).

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PIGEON of LORD-HOWE-ISLAND

WOODHEN

There are many examples of birds on islands becoming extinct due either to the deliberate introduction of domestic animals, like pigs and goats to run wild as food for passing mariners or ship-wrecked sailors, or to the accidental introduction of rats, and then cats to try to control the rats, or to man himself killing for food or destroying the birds as pests eating his crops. Lord Howe Island has suffered in all these ways. The biggest disaster was when the rats escaped onto the island in 1918 from the ship-wrecked S.S. *Makambo,* and within two years many of the small passerine birds had disappeared. The Lord Howe Island Woodhen has managed to survive, but in decreasing numbers and retreating further into the southern mountain area, until now it is only found on the summit of Mount Gower, with a recent report of one seen and two empty nests found on Mt. Lidgbird. This woodhen is a flightless rail about thirty-eight centimetres long, or the size of a bantam chicken. It is about the same size as and has similar habits to the New Zealand Weka (*Gallirallus australis*). The Weka, although similar in colour, differs from the Lord Howe Island Woodhen in having harsher feathers and a stronger wedge-shaped bill. The bill of the woodhen is longer and slimmer. The nearest relative to the woodhen was probably the similar flightless rail, *Tricholimnas lafresnayanus,* on New Caledonia, but this is now thought to be extinct; the last reported sighting was in 1936.

Lord Howe Island was first sighted and named by Lieutenant Lidgbird Ball on his way to Norfolk Island on 15th February, 1788 in the *Supply.* On his return journey to Sydney, he landed a party on 13th March and David Blackburn, Master of the *Supply,* in a letter wrote ". . . on the shore we caught several sorts of birds, particularly a Land fowl of a Dusty brown about the size of a small pullet, a bill four inches long and feet like a chicken. Remarkably fat and good . . ." In May 1788, three transports and the *Supply* again visited the island. Surgeon Arthur Bowes of the transport *Lady Penrhyn* on 16th May landed and recorded in his journal "a curious brown bird about the size of a Land reel (rail) in England walking totally fearless and unconcerned in all part around us, so that we had nothing more to do than stand still a minute or two and knock as many as we pleased with a short stick—if you throw'd at them and missed them, or even hit them without killing them, they never made the least attempt to fly away and indeed would run only a few yards from you and be as quiet and unconcerned as if nothing had happened".

Pigs were put on the island in the early 1800s by the Captain of a whaling ship. The first settlement was made on the island in 1834.

By 1853, Assistant Surgeon Macdonald of the research ship H.M.S. *Herald* recorded that the woodhens inhabited the mountainous parts, but he unfortunately did not obtain a specimen. Up to the time of the arrival of the rats in 1918, the birds were readily found in Erskine Valley, on Mt. Lidgbird, and Mt. Gower and Little Slope. In 1936, K.A. Hindwood saw one in Erskine Valley and more on the way up to the summit of Mount Gower. In November 1969, the author and C.N. Smithers of the Australian Museum visited the island and spent two nights on the summit of Mt. Gower. We saw sixteen birds and considered their numbers were now very low with only odd birds found wandering below the summit.

In February 1971, a survey of the island fauna and flora was initiated by the Lord Howe Island Board of Control under the leadership of H.F. Recher, Curator of the Department of Environmental Studies at the Australian Museum and a survey of the population and habits of the woodhen was started.

Visits were made in February, April, August, October, 1971, and January and September 1972, with an average of ten nights spent camped on the summit. These visits were only made possible with the help of islanders who carried some of our equipment and food to the summit. Although the summit is not very high (852 metres), the climb is straight up and very steep above the saddle between Mt. Lidgbird and Mt.

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Gower. The climber has to negotiate a rock step known as the 'Get up place', and pull himself up by the roots and branches of the trees and shrubs. The summit is a moss forest and always damp, and not only is it difficult to light fires, but there is very little dead wood available so that primus kerosene stoves had to be used for cooking. The summit area including the steep slopes is about twenty-six hectares made up of ridges and valleys with small streams running from the higher southern side to the Northern cliff edge. It was considered a load of not much more than eighteen kilograms was a fair weight for anyone to climb up to the top with, although many of the islanders, who were used to carrying palm seed could probably carry more.

In February 1971, fifteen birds were caught and individually colour-banded with a combination of three coloured plastic rings on one leg and an aluminum band of the Australian Bird Banding Scheme of the CSIRO on the other leg.

On subsequent visits the sightings of the marked birds were recorded with aluminum tags on the trees and a five-centimetre wide orange plastic tape band also round the trees for easy relocation of the site. Further unbanded birds were caught when possible and also previously marked ones to check on their weight, moult, etc. In September 1972, all the unmarked birds were caught and banded, so that from then on any unmarked bird seen was a new bird.

The results of these observations show that there is only room for nine territories on the summit and that never more than nineteen adult birds were observed. The few young hatched every year did not survive unless a vacancy occurred when one of a pair of birds in a territory disappeared. Then a young bird might take the place of the lost bird.

At the last visit in September 1972, the count was seventeen birds and later in November a chick was reported seen with a marked pair near the camp site.

Woodhens are omnivorous feeders eating anything that appears edible and even picking up objects to see if they are edible, and if not discarding them again. They feed mainly on soil fauna, scratching the leaf litter away with their bills, not with their feet as a fowl or Lyrebird does. They pull aside palm fronds with their bills to get whatever is underneath. They peck at rotten logs and moss and also dig holes with their bills. They were seen to eat the chicks of the Brown-headed Petrel (*Pterodroma melanops*,) and also the petrel eggs were found pierced and obviously eaten by the woodhens. Many rails are known to be great egg-stealers, and in former times the islanders did not care for them round their houses as they found and ate the hens' eggs. The pair that visited our camp soon became very tame and besides eating the remains of the porridge in the billy, or anything else thrown out, they were very fond of butter and would take it from your fingers.

When we left camp we had to close the tents or the woodhens would enter them and eat anything they could find, particularly the butter out of the butter tin. Objects too big to eat, like biscuits, were broken by hammering them with their bills. However they found fresh army biscuits too hard to break. One bird was seen hammering an army biscuit, but failed to break it. It then nibbled the side of the biscuit, raised its bill to hammer the biscuit again, but stopped half-way down, apparently remembering that the biscuit was too hard.

The pairs on Mt. Gower appear to be completely territorial, remaining in the same territory the whole time and driving out any intruding birds.

Very little is known about their breeding habits and very few nests with eggs have been found. These have usually been found accidently. The nest with eggs may be down a mutton-bird burrow or well hidden amongst leaf litter. There is one record of a clutch of four eggs, two records of two eggs, and one record of one egg, but perhaps that clutch had not been completed. Like some other rails such as the Tasmanian Native Hen, Dusky Moorhen and New Zealand Weka, after the young are hatched, less concealed nursery nests are made in more obvious places, and these are the nests that are usually found. Nursery nests are used for brooding the young at night or in bad weather.

It does not seem that there are often more than three or four young successfully hatched each breeding season on the top of Mt. Gower

The photograph in the background shows the fern forest habitat at the top of Mount Gower. This is the home of the few surviving birds of this species.

H. J. de S. Disney

E. Slater

H.J. de S. Disney

OF SKETCHES SKINS AND SKELETONS

F. Knight

This map shows the sites where bird bones were collected on Lord Howe Island.

Two centuries ago when mariners of the first Fleet discovered, explored and described Lord Howe Island, they marvelled at the tameness and abundance of bird life on the island. There is no evidence to suggest that the island had been previously disturbed by man and there were no land mammals. The combined effects of habitat destruction, over-harvesting and predation, removed some species of birds and permitted other species to replace them.

Some of the extinct birds are represented by skins, skeletons, and nests in museum collections and we have a fair idea of what they looked like, how they lived, and when they died out. Of others there are only descriptions and paintings which were made at the time of the island's discovery. There were also species that were not recorded. Fortunately numerous bones have survived in caves and in coral sandstone and dunes on the main island. The process of bone preservation has been assisted by burial in petrel burrows.

When we combine the historical and prehistoric evidence, the following picture emerges of the avifauna on the main island at the time of discovery, 1788.

The Little Penguin *(Eudyptula minor)* was probably a rare visitor as it is now. Remains of a similar small penguin have been found in coral sand dune cliffs with a radiocarbon date of about 20,000 years ago. It may have bred on the island during the ice ages.

The Providence Petrel *(Pterodroma solandri)* bred in the forests of the northern hills as well as on the southern mountains in large numbers. It still nests in large numbers on the mountains, and may return to the hills following the recent removal of feral pigs and goats. This bird was exterminated by over-harvesting on Norfolk Island after it helped to save the first settlers and the crew of the wrecked *Sirius* from starvation.

A small petrel, similar to the Black-winged Petrel *(Pterodroma nigripennis)* bred on shoreline slopes and headlines around the island. In recent years the Black-winged Petrel has colonised Lord Howe Island, the Chatham Islands and probably Norfolk Island. Indications of the occurrence of a similar bird in prehistoric times consist of bones found on Lord Howe Island and of a painting made on Norfolk Island by a member of the *Sirius* party.

A few Kermadec Petrels *(Pterodroma neglecta)* may have nested on exposed cliff ledges as they still do at the south end of the main island and on Ball's Pyramid.

The Fleshy-footed Shearwater *(Puffinus carneipes)* nested in huge colonies in the lowland palm forests. Many of its colonies have been destroyed by clearing for settlement. It still breeds in the residual lowland palm forests.

The Wedge-tailed Shearwater *(Puffinus pacificus)* nested in open grassy areas around

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and these do not usually survive until the next breeding season, unless a vacancy occurs in one of the established pairs. Apparently, after becoming independent the young have to live a skulking existence inside the other occupied territories.

It is clear that the population on the summit of Mt. Gower rarely exceeds twenty individuals of which two at least are young birds and unlikely to survive.

During the survey, botanists climbing Mt. Lidgbird and island residents failed to find any woodhens on or near the summit, and none had been seen in recent years. However an islander climbing Mt. Lidgbird in December 1972, saw an unbanded bird and found two empty nests, so there are apparently one or two still near the summit of this mountain.

The population is only just maintaining itself. Why the birds are not expanding and found down below the summit is not known. It is suggested that tourists should not be allowed on the summit without a guide. To preserve the species from any disaster, climatic or otherwise, an area should be fenced in below the mountains, and birds brought down from the summit and established there. This area would need to be strongly fenced to keep out cats, dogs, and if possible rats, and a ranger would need to be appointed to look after the birds. A suitable area would be on Transit Hill. Besides looking after the birds, the ranger should also study their habits with a view to trying to find out why the birds are no longer found in the lower mountain areas. It is felt that efforts should be made to protect this unique rail.

Painting of a Woodhen *(Tricholimnas sylvestris)* by George Raper—by kind permission of the British Museum (Natural History)

This male Woodhen was a frequent visitor to the author's camp on Mount Gower. He is shown here breaking up a biscuit.

BY G. F. VAN TETS AND P. J. FULLAGAR

the shores of the island as it does at present.

The Little Shearwater *(Puffinus assimilis)* nested in large colonies in the lowland sand dunes where its bones are numerous. It no longer nests on the main island. In 1971, a small colony was found nesting on nearby Roach Island.

The White-bellied Storm-Petrel *(Fregetta grallaris)* nested in rock crevices on the slopes of the hills and mountains. It probably no longer nests on the main island.

The White-faced Storm-Petrel *(Pelagodroma marina)* nested in large colonies in the lowland sand dunes where its bones are numerous, but there is no historical record of its occurrence on the island, not even as a vagrant.

The Red-tailed Tropicbird *(Phaethon rubricauda)* probably nested in large numbers under bushes and rock ledges on cliff sides around the island as it does to this day.

The Masked Booby *(Sula dactylatra)* nested in open grassy areas on the main island and was taken for food by the discoverers, in the lowlands. It still nests on outlying islands and on inaccessible ledges and headlands of the main island.

The White Gallinule *(Notornis alba)* roamed the forests, thickets, and open areas of the lowlands and the northern hills. It was flightless and had relatively short wings, feet and toes. There are several paintings of the gallinule on Lord Howe Island and two skins, one in Vienna, Austria, and the other in Liverpool, England. It is not certain that these skins are from Lord Howe Island. There is some evidence to suggest that the Liverpool bird was obtained by Sir Joseph Banks from New Zealand or possibly from Norfolk Island, before the discovery of Lord Howe Island. Photographs of both skins, x-ray photographs of the bones left in the Vienna skin, bones removed from the Liverpool skin, and the bones found on Lord Howe Island indicate that the gallinule is a small version of the Takahe *(Notornis mantelli)*. The Takahe was thought to be extinct, until in 1948 a small remnant population was discovered on the South Island of New Zealand.

A large pigeon was reported from Lord Howe Island at the time of discovery. Very little was known about it other than that it was large, very tame, and good eating, until Dr. F.D. Godman showed G.M. Mathews a painting of it by G. Raper. Mathews named the pigeon from the painting — *Raperia godmanae*, in honour of the artist and Mrs. Godman. He later identified it as probably *Columba vitiensis*. Except for copies of this painting the only other known illustration of this pigeon is a watercolour by John Hunter. In 1971 and 1972 bones were found on Lord Howe Island which resembled those of *Columba vitiensis* taken at Brown's River near Port Moresby, New Guinea.

F. Knight

Left ulnae of a pigeon, *Columba vitiensis*—left from New Guinea and right from Lord Howe Island.

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EXPLOITATION vs CONSERVATION

Until recently Lord Howe Island has prospered as a tourist resort, but transport difficulties, rising costs and the changing cultural values of Australians have put the island at a competitive disadvantage with mainland resorts. The problems center on the antiquated flying boats which served the island until mid-1974 and which were heavily subsidised by the government. To solve the problem it is proposed to construct an airstrip and replace the flying boats with a regular jet service. Lord Howe Island could then be incorporated in the mainland air transport system.

The airstrip which the government originally proposed to build was to be between 1300 and 1500m long and located in the low-lying area known as Moseley Park. The strip would have extended anywhere from 100m to 300m into the lagoon depending upon its final orientation. Needless to say, the proposal met with considerable concern among conservationists in Australia. It was feared that the airstrip would damage the lagoon and affect the coral reef. Additionally, it would mar the beauty of the island and lead to the expansion of tourist facilities.

At the same time that an airstrip was being considered for the island, visiting biologists reported that the vegetation of parts of the island were being severely damaged by feral goats. This threat to island ecosystems together with the uncertainty of the island's capacity to accomodate increasing tourism without environmental damage, made it clear that a detailed survey of the island's environment was needed. In 1970 the Board which administers Lord Howe Island requested that the Department of Environmental Studies of The Australian Museum conduct a survey of the island. It was not intended that the survey focus narrowly on the environmental effects of the airstrip itself. Rather, the survey was to have, firstly, the purpose of determining the present abundance and distribution of island wildlife, as a baseline against which to assess the effects of future development of tourism. Secondly, these data were to be used in recommending a programme for conservation for the island and in recommending ways in which an enlarged tourist industry could be developed which was compatible with natural values.

Lord Howe Island is a beautiful and precious place. The combination of a small population, isolation, and mountainous terrain has thus far prevented extensive development. As a result, Lord Howe Island retains a large proportion of its indigenous wildlife and is of considerable scientific interest. The unique qualities of Lord Howe Island and its wildlife have been abundantly expressed in the other articles of this issue, and no attempt will be made to deal with them in detail here. Our concern is, rather, to discuss the present state of the island and ways in which it can be maintained for the enjoyment of future generations.

Information on the natural history of Lord Howe Island prior to 1889 is sketchy, anecdotal, and difficult to interpret. However, since that time a succession of travellers, biologists and geologists have visited the island and there are reasonable data on which to base a modern environmental survey. In our survey, emphasis was placed on the most important and easily studied groups of plants and animals. Thus, the island's vegetation was carefully studied and mapped as were the locations of nesting colonies of seabirds, the woodhen, and colonies of the endemic land snails. Even though many other groups were studied in the survey, it was not necessary, or indeed possible, to have extensive data on all the wildlife of the island. Recommendations for conservation and management and for subsequent monitoring of environmental change can be based on a thorough knowledge of a few groups of 'indicator' organisms. Plants and animals which we know play an important role in natural ecosystems can be used as guides to the status of the entire system.

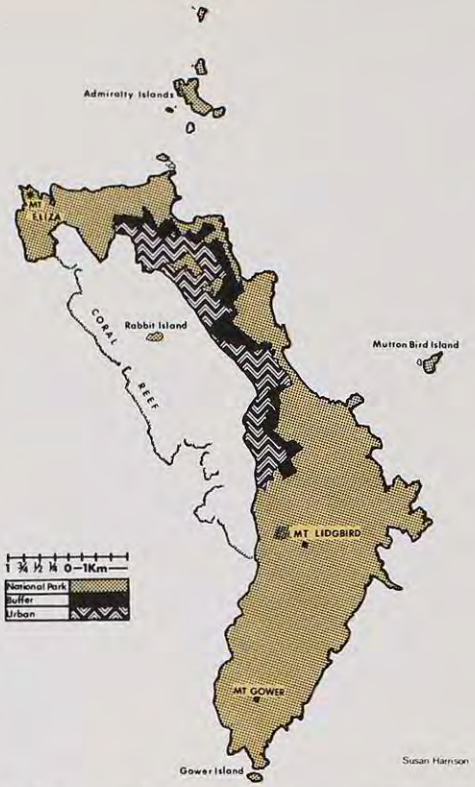
Many of the results of the environmental survey are contained in the articles on plants, birds, invertebrates, and so forth which appear in this issue of AUSTRALIAN NATURAL HISTORY. Here we need only say that the environmental survey concluded that Lord Howe Island retained a worthwhile representation of its native plant species and plant communities. No species of plant native to the island is endangered though some are restricted in their distribution and may be represented by small populations. A few weed species are invading the island and goats and pigs are causing some damage. In all cases, control, if not eradication, is feasible.

BY H.F RECHER AND S.S. CLARK

The animals indigenous to Lord Howe Island have been more seriously affected than the island vegetation. A number of species are extinct and others are endangered. Birds, reptiles, and land snails have been most affected. Destruction of the island fauna has resulted from a combination of human activities including habitat alienation, hunting for food, and the introduction of pests and predators. Nevertheless, Lord Howe Island retains a very satisfying proportion of native plant and animal life and is worthy of conservation.

The spread of weeds and the effects of cats, owls, pigs, goats and rats are major environmental problems on Lord Howe, just as they are on many islands in the Pacific. Though 120 plant species have been recorded as naturalised, only a few of these have managed to invade the natural vegetation. Tiger Lily occurs throughout the southern hills and Cherry Guava shows signs of spreading into the forest from disturbed sites such as abandoned pasture. Unfortunately, Cherry Guava is spread by fruit-eating birds such as the Lord Howe Silvereye. Norfolk Island Pine was planted along the lagoon front, but is now established locally in the native forest. Unless removed it can be expected to emerge from the canopy of the forest and to ultimately change the effect of the wind on the forest structure. Fortunately the control of most introduced species which could affect native plant communities is still possible and a principal recommendation coming from the environmental survey was the destruction of these exotics. It was also suggested that the importation of a number of other species be prohibited and that native plants be used for windbreaks and other landscaping. In recent years there has been an unfortunate tendency to use plants from New Zealand, Australia and Norfolk Island for these purposes.

Introduced animals present the most serious environmental problem on Lord Howe Island. It is the one which is most difficult to correct. Goats and pigs were introduced some time in the nineteenth century. From time to time their numbers have been augmented by free-ranging domestic animals. In recent years goats have only been locally abundant and in 1970 an eradication programme was started. Between 1970 and 1973, 220 goats were shot and all except two or three eliminated from the north end of the island. An unknown but significant number remain on the slopes of Mt. Gower where the terrain has impeded shooting. The main damage caused by goats was to the sparse vegetation of the cliffs. Pigs are now found only in the southern parts of the island where they have extensively damaged the ground vegetation and disturbed the soil. Damage is most evident on the slopes of Mt. Lidgbird and Mt. Gower and in the Erskine Valley. In these places, surface litter is plowed, rocks and logs turned or broken, and ground cover eaten and trampled and some erosionn is evident. Snails and other invertebrates which one would expect to find abundantly in these moist places are absent or rare. Pigs can also be controlled by hunting.



Cats, rats and owls are the other important pests. All are predators on the native lizards and birds, but rats have caused the greatest damage. Rats are responsible for the extinction of five species of birds on Lord Howe and for the reduction in numbers of lizards. Presently, rats are controlled near the settlement by the use of poison baits, but it is impractical to extend this to the more remote parts of the island. Rats and cats are important pests on many islands and

control may ultimately require the use of diseases, just as rabbits were controlled in Australia with the use of Myxomatosis virus.

Man's survival in the island ecosystem like that of any other new arrival depends upon his finding or creating a suitable niche. In doing so he alters the habitat of other island species and acts as an efficient competitor and predator. In addition (as we have seen), he brings with him other species of animals and plants, themselves potential competitors or predators and adapted to the disturbed condition resulting from man's activities.

For these reasons, one must be concerned about the ways in which we develop and use Lord Howe Island. By itself, the airstrip may not have a major environmental impact, but if it is accompanied by a great expansion of the islands population and an increase in tourism the effect could be disastrous for the island ecosystem.

Presently plans exist for a 1000m airstrip located in Mosely Park. This strip will not extend into the lagoon and will only be able to handle small aircraft. However, conservationists consider it possible that the strip may be extended at a later date and the Australian Conservation Foundation has called for a public inquiry into the effects of all transport to Lord Howe Island. Clearly, the issue remains the way in which the island is developed and used. The airstrip will only affect land which has already been alienated for agriculture and it is not really likely to be extended into the lagoon. If it is extended, it must be remembered that the lagoon has only a few deep holes and is otherwise quite shallow. The substrate of the lagoon is coral sand and supports relatively few kinds of animals and plants.

The airstrip and the scars of construction material quarries will be ugly, of that we can be sure; and the longer the strip is the more it will intrude on the beauty of the island. It will not, however, impair the island's wildlife. Development and tourists will, unless proper planning is undertaken.

Lord Howe Island is not large and recent colonisations by birds and the spread of some introduced plants shows that its environment is easily changed. It is important, therefore, to retain as much of the existing natural landscape as is possible. However, the land reserved must be available for human use and it must contribute obviously to the island's economy. If it does not, or if people are prevented from using the land, it is inevitable that groups will press for its development.

We have therefore recommended that a large part of the island including all the small offshore islands, and Ball's Pyramid should be rigorously protected. The map on page 75 shows those parts of Lord Howe Island which we believe should be reserved to ensure the survival of the island's indigenous plants and animals. We have recommended that the reserve should be given the same status of Parliamentary protection that is afforded National Parks in Australia and that certain adjoining lands be retained as a buffer between the developed parts of the island and the reserve. Within this buffer zone development would be minimal. To support these recommendations, we have suggested that in the future, the tourist industry on the island should emphasise the natural features of the island and its flora and fauna. To this end a management plan has been outlined (Recher, 1972) which will expand the walking tracks through the island's forest, permit limited camping and encourage people to visit the bird nesting colonies on offshore islands. We do not believe in the rigid application of the philosophy that nature should be seen and heard, but not touched. Strict preservation may have the short term benefit of protecting wildlife and may be essential in some instances, but it fails in the long term to instill an appreciation of nature and the need for conservation in the general public. On Lord Howe Island we have the opportunity to let people live in and enjoy an island ecosystem. Ideally, this experience could teach them something about the relevance of ecology to their everyday lives. The appointment of a ranger staff and the creation of a natural history museum will help ensure that the island is used and enjoyed with a minimum of interference to animal and plant populations. We hope the ranger will be a person who is not only a competant biologist able to understand the island ecosystem, but a person who enjoys and is tolerant of people.

It is not enough to reserve part of Lord Howe Island as a natural area and leave the remainder of the island to develop in a haphazard fashion. The whole of the island must be developed to take advantage of and blend with the island's natural features and great beauty. It is clear that the environmental survey should have incorporated the talents of one or more persons from the fields of town and country planning and sociology. We recommended that persons with these particular talents be consulted before completion of the airstrip and expansion of tourist facilities. It will be necessary for them to draw up a development plan in consultation with the biologists who participated in the environmental survey. Only in this way will it be possible for

J. McKean

RED-TAILED TROPIC BIRD

LORD HOWE ISLAND WOODHEN

FERAL GOATS ON RABBIT ISLAND

H.F. Recher

Isobel Bennet

EIGHT-RAYED SEA STAR *(Patiriella calcar)*

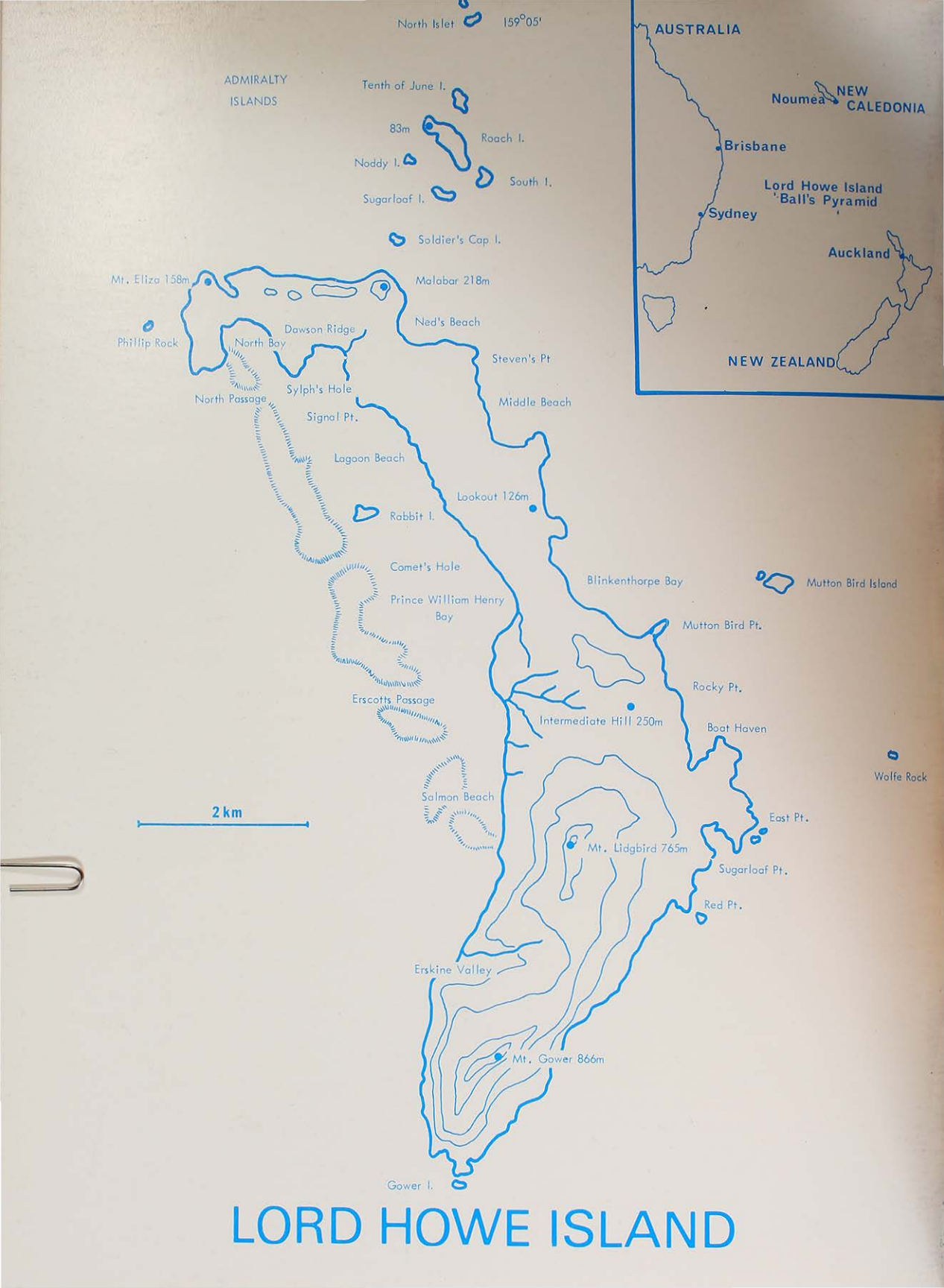
E. Slater

development to proceed while minimising its detrimental effects on the island's wildlife. We have been pleased that many of our recommendations have been considered favourably by the Board which administers Lord Howe Island and that a planning team from the State Planning Authority is now discussing with us the future of Lord Howe.

It is interesting that biologists made a number of recommendations on the development of Lord Howe Island which went far beyond the scope of a simple biological survey, and the need to conserve the island's wildlife. Considerable concern was expressed by all participants in the survey over the expansion of the island's automobile population and the extension of the road system. To some extent these expressions of concern and interest arose because, collectively, we have been witness to the total subjugation of natural values to the automobile on three continents—North America, Europe, and Australia. There must be a few places in the world where the needs of people and not cars determine the pattern of development. But also as biologists we considered the human community and its needs as part of the island ecosystem. It is no more difficult to plan for the survival of man on an island than to plan the survival of other species, but it is equally essential.

FURTHER READING

RECHER, H.F.: A Report to The Lord Howe Island Board on an Environmental Survey of Lord Howe Island, 1972.



LORD HOWE ISLAND