The AUSTRALIAN MUSEUM MAGAZINE

EDITED BY C. ANDERSON, M.A., D.Sc.

Vol. IV, No. 1. JAN.-MARCH, 1930. Price—ONE SHILLING.

PUBLISHED QUARTERLY.

The AUSTRALIAN MUSEUM

COLLEGE STREET, SYDNEY

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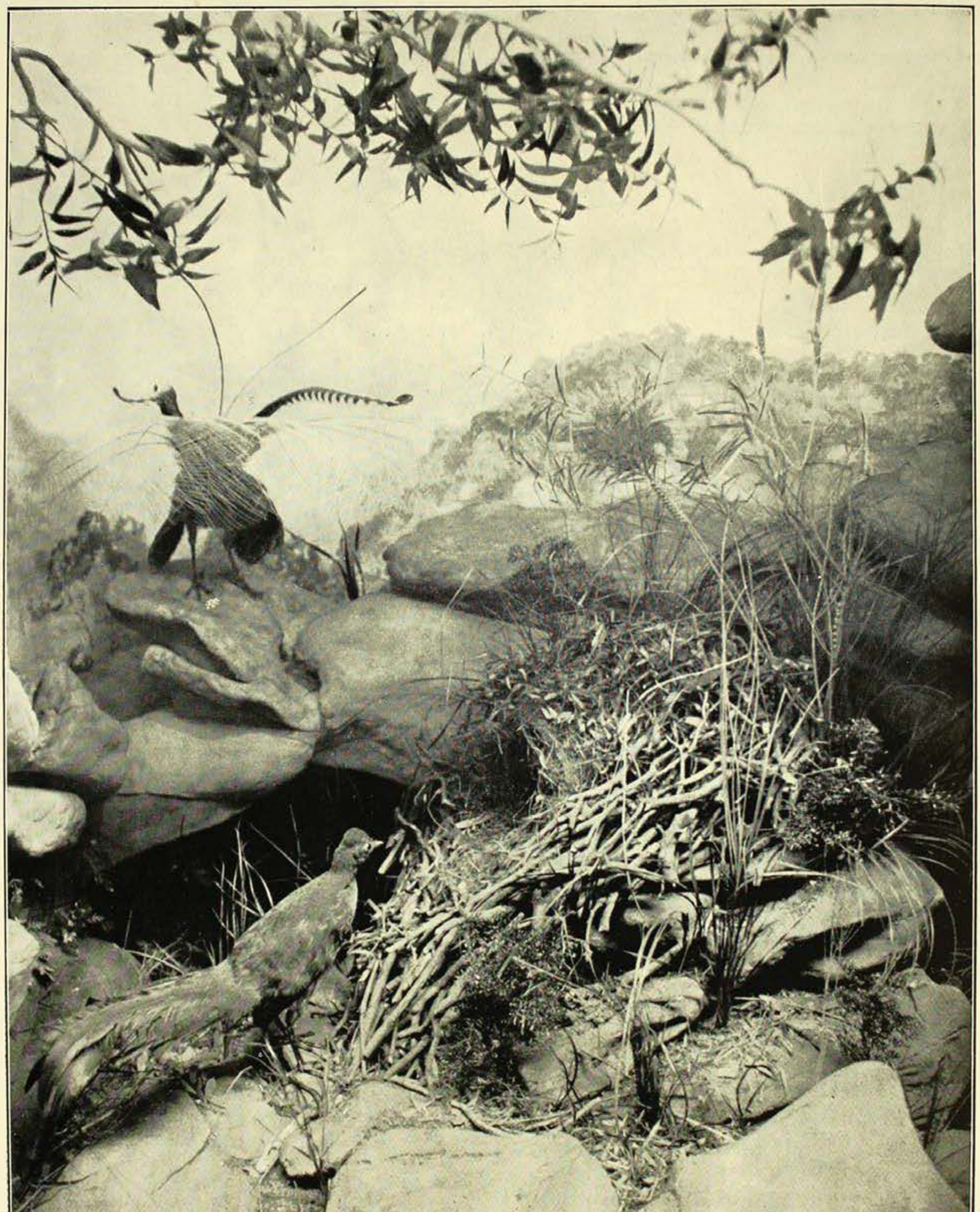
VOL. IV, No. 1. CONTENTS. Jan.-March, 1930.

Published Quarterly by the Trustees of the Australian Museum, College Street, Sydney, in the months of January, April, July, and October. Subscription 4/4, including postage.

Communications regarding subscriptions, advertising rates, and business matters generally in connection with THE AUSTRALIAN MUSEUM MAGAZINE should be addressed to the Secretary.



The Lyre Bird at Home. A habitat group recently installed in the Australian Museum.
[Photo.—*G. C. Clutton.*

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Published by the Australian Museum - - - - *College Street, Sydney.*

Editor: C. Anderson, M.A., D.Sc. Annual Subscription, Post Free, 4/4

VOL. IV, No. 1. JANUARY-MARCH, 1930.

The Lyre Bird at Home

A NEW GALLERY GROUP FOR THE MUSEUM.

BY J. R. KINGHORN, C.M.Z.S.

THERE are numbers of people who have seen Lyre Birds in their natural state, and there are many who may have heard but not seen them, but the great majority know them only by name, photographs, or other illustrations, and it is mainly on account of this that a new and beautiful habitat group, showing the female at the nest and the male in full display, has been added to the attractions of the Museum.

There are two species of Lyre Birds: the Superb, which inhabits the coastal districts of New South Wales and south-eastern Victoria, and the Albert, from north-eastern New South Wales and south-eastern Queensland, while a variety of the Superb known as Prince Edward's Lyre Bird was observed by Mr. A. H. Chisholm to inhabit the granite belt near Stanthorpe, Queensland.

The Lyre Bird has been very aptly described as the prince of mocking birds, for its repertoire of calls seems to be almost unlimited, among them being the screech of the cockatoo, the songs of the butcher bird, whistler and magpie, the squealing of young foxes, the grinding and cutting of a sawmill. Maybe you have heard him in the jungle in the early morning, perhaps also you have watched him dancing on his dancing mound, and seen him showing off to his admiring mate, who often in the bracken only a few yards away appears to take no notice. There she is engaged in scratching for insects and apparently unconcerned, but no doubt she always has one eye proudly watching him. Though the male appears to be completely wrapped up in his dancing, his mimicry, and display of plumage, his senses are ever on the alert, as are those of all creatures born in the wild, and any slight movement of the observer, the tiniest sound, which is perhaps almost inaudible to the human ear, is instantly transmitted to the delicate senses of the bird and away he goes. You may follow him for miles along his well-worn tracks, you may get a glimpse of him as he flits from mound to mound,

Male Lyre Bird in display. This specimen, one of the figures in the group, was mounted by the Museum taxidermists in the field. Contrary to the popular idea this is the posture adopted when displaying.
[Photo.—*G. C. Clutton.*

with a cackle here or a call there, but you have disturbed him and might as well go back to camp and come again tomorrow.

So much has been written and written so well by others about this wonder bird that there is nothing I can add. Mr. A. H. Chisholm, in "Birds and Green Places," tells the whole story as no one else can; Mr. Tom Tregellas has written his memorable observations in "The Emu"; Messrs. R. T. Littlejohns and S. A. Lawrence told of their experiences in "Birds of Our Bush"; while quite lately Mr. K. A. Hindwood wrote of him and figured him in this MAGAZINE, and there are many other accounts both in books and in the daily press. You can learn a lot by reading, but you will never know the bird until you have succeeded in seeing and hearing him in the bush.

To observe him you must study his movements, learn of his runways, the position of his dancing and scratching mounds, and you must learn to crawl on the ground like a beetle and wriggle along like a snake; but above all you must have plenty of time and patience.

THE DANCING MOUND.

The dancing mounds are elevated hillocks of loose earth sandy loam, leaves, twigs and other debris common to the undergrowth, and measure from three to ten feet across and up to about two feet in height. These are made by the bird among the bracken or low scrub and heath along the foot of a gorge or the side of a hill in the forest areas, and are connected by runways. Dancing mounds are often referred to as scratching mounds or scratching grounds, and, while the former may have evolved from the latter, the scratching ground is not always used for display. Many of the scratching grounds are merely dining rooms, where the debris of fallen leaves attracts insects. When scratching and searching for food the lyre bird reaches well forward with one foot and grasps a claw full of debris, which is more or less rolled backward, thus uncovering the much-sought-after worms, grubs and other succulent food. If the bird scratches in a circle, facing outward the while, a mound may be formed, and so we can understand the formation of dancing areas, and, if the bird takes a particular fancy to any one mound, he might make it a permanent dancing mound.

NESTING.

The nest, which is constructed during the winter months, is a dome-shaped structure composed of twigs and sticks, in the middle of which is a snug chamber made of grass roots and fibres, and it is in this that the egg is laid and the young hatched. The egg is a dark purplish brown covered with darker spots and blotches. Only one egg is laid for a sitting, and even that is not very carefully guarded by the parent bird. Sometimes it is deserted by the female for days at a time, though maybe she sits on it at night. Often the egg has been found to be quite cold, though this does not appear to affect incubation, provided the period of desertion is not too long. Incubation has been set down at periods varying from six to eight weeks, but in the majority of cases it is nearer six.

THE GROUP IN THE MUSEUM.

The gallery group contains a male in display, a female, nest and egg in natural surroundings representing a portion of French's Forest, and already comments, both complimentary and otherwise, have been made regarding it. Of adverse criticisms only three are worth considering, and I could not do better than to mention them and answer them here. It has been said that the male would not be found displaying on a rock; that he would not be found displaying so near the nest (in this instance three feet away); that the attitude of the bird is not correct.

The male, when displaying his plumes and dancing during the courting season, dances mainly on his special mounds, but in moving from one mound to another, he hops on to rocks and logs, and often while on these will flick his tail right over his head, as Tom Tregellas and others have recorded it, and there is evidence that the bird has been observed displaying on flat rocks at National Park. The critics may be quite right in stating that he would not be found dancing so near the nest, but in a Museum group which is only six feet in depth there is nothing else to do but to show the birds to the public as best we can; we have taken advantage of "taxidermist's licence" and shown both birds in one group. The attitude of the bird in display is true to nature, it is wonderfully carried out, and those who know the bird would not have it otherwise. The nest was obtained after the nesting season, and the scene was painted on the spot by Miss E. A. King, who later prepared the background of the group. The birds were secured at Yarramalong Mountain by Messrs. W. Barnes and J. H. Wright, who, after a week's observation, mounted them in the field. The whole group was designed and constructed by Mr. H. S. Grant, Taxidermist, and his two assistants, and it is, in the opinion of the many ornithologists who have viewed it, a masterpiece. Also it is a marvel to all that so much could be shown to such good advantage in so small and cramped a place as a museum gallery.

Low Tide at Quail Island, twenty miles west of Port Darwin. In this region the tide falls from twenty-six to twenty-eight feet.

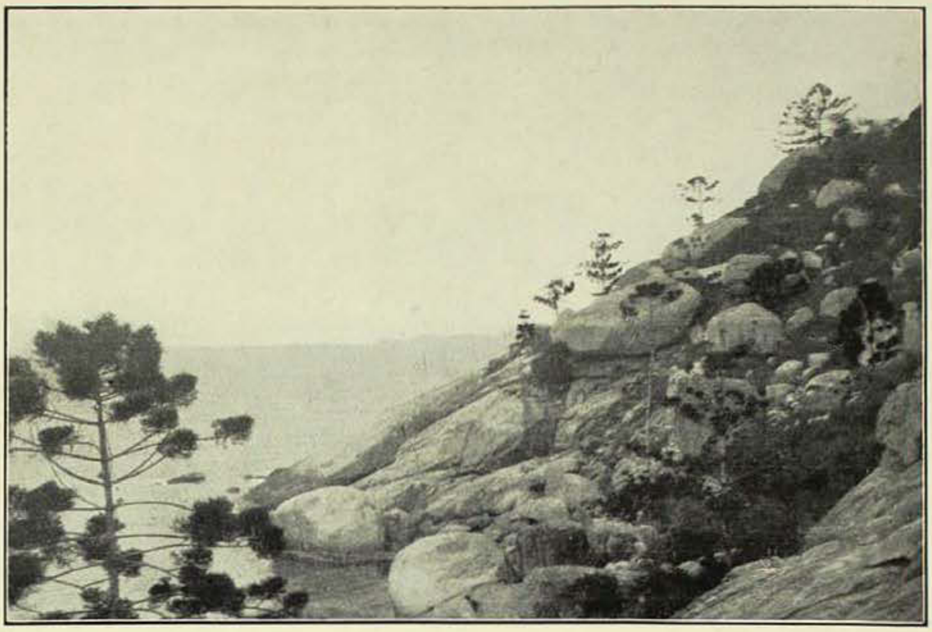
[Photo.—*A. A. Livingstone.*

This article, complete in itself, and the first of a series of three, describes the experiences of the author during a collecting trip through the tropic zone of Australia in the company of Dr. H. Lyman Clark, of the Museum of Comparative Zoology, Harvard, Cambridge, Mass., U.S.A.

AROUND Australia to collect and study marine animals and over ten thousand miles of travelling to be done in five months. Nothing delights the heart of a naturalist more than to pore over maps and charts seeking out places most likely to yield results and to visualize the vast possibilities of such a venture.

A departure was made in June of 1929, a time when the tropical zone of our continent would yield its best weather in the form of a mild warm atmosphere and gentle trade winds. We headed north, and with the passing of the days so the cold winter blasts of the south succumbed to a more pleasant atmosphere. The Great Barrier Reef, so well known and which has no like anywhere else in the world, was approached soon after leaving the city of Brisbane. This gigantic natural breakwater of coral runs parallel with the Queensland coast for over one thousand miles, and harbours a fauna as rich in colour and numbers as the handsome multi-coloured corals themselves. Here the reef bends and swings inshore sometimes as much as eighty miles, while there it runs out seaward until no trace can be found of it under one hundred miles from the shore. Passages occur, however, for steamers to make use of, but woe betide the ship and all it carries should an error in navigation be made. Despite the fact that the Barrier holds its charms, its unseen and protruding fangs, sharp as razors, are ever ready to rip the plates of any ship steered unknowingly into its clutches. By day these fangs of coral are revealed by a milky wash on the surface waters, while at night their positions are shown by a series of winking lights strung out like some vast illuminated boulevard ashore. And so the ship goes on its course.

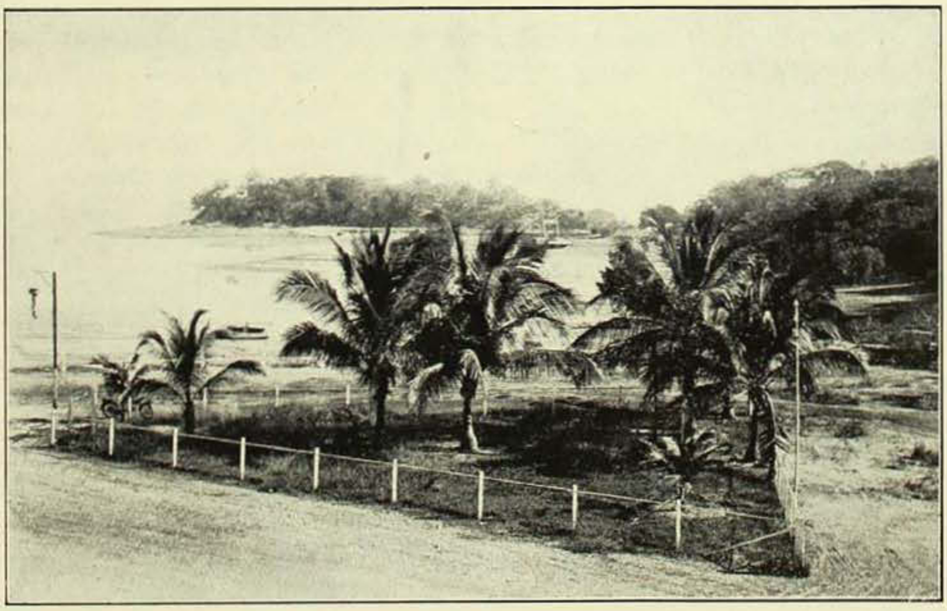
With Townsville in sight comes to memory that renowned and historical navigator, Captain James Cook, who, years ago, sailed and braved the myriad dangers of the Barrier Reef and incidentally named the island we were rapidly approaching. Magnetic Island, off Townsville, is hilly, rugged and picturesque, with deep ravines, sheltered beaches and tall gaunt-looking pines. Here, indeed, was an introduction for the uninitiated to a true tropical atmosphere. Vast mango trees, swaying palms, coconuts, coral, and the vast expanse of cobalt blue water so characteristic of the warmer seas.



Magnetic Island, named by Capt. James Cook during his eventful survey of the Great Barrier Reef, is composed of hills and valleys sparsely covered by pines.
[Photo.—*A. A. Livingstone.*

Onward, still north, steamed the vessel until at last Cape York, the most northerly point of the Australian continent, was rounded and the port at Thursday Island reached.

The township on Thursday Island, like most of its kind, straggles along the shore like a long snake; a town where white rubs shoulders with black and where the half-castes are forever in the foreground. Galvanized iron and wooden structures, in some cases well built with a thought to the intense heat of the "wet" season, line the two main streets, while here and there are the huts of the aboriginal and Chinese population. Around the large jetty lie the pearling luggers in scores awaiting stores or discharging their valuable cargo. With Thursday Island left behind, we steamed westward across the opening to the vast Gulf of Carpentaria, which is bounded on the west by the great promontory of Arnhem Land. Situated on the far side of this huge land area is the township of Darwin, where the first long stay was to be made.



The waterfront of Darwin, capital of North Australia. The foreshores are picturesquely clothed in dense vegetation, which becomes a riot of colour in the "wet" season.
[Photo.—*A. A. Livingstone.*

At Darwin, where the main operations of the expedition were to commence, the author was met by Dr. H. L. Clark, to whom he owes much, both professionally and from a personal point of view. Plans for a systematic investigation of the nor'-west coast were soon prepared, and with the kindly help of the residents of Darwin were soon put into practical operation.

Darwin, the capital of North Australia, is situated on a hill and overlooks the waters of the port. The foreshores are picturesquely clothed in a dense undergrowth of tropical greenery, broken here and there by a jagged outcrop of grey and white rock. The township itself is divided more or less into sections, each nationality having its own particular area. Here the white quarter is situated, there the Asiatic tenements, while down the road lies the native compound. All persons are free, however, to roam at will, with the exception of the natives kept and cared for in the Government Compound.

Dr. H. L. Clark and two local enthusiasts sift the sand of rockpools at Night Cliff, Darwin, to secure hidden dwellers.
[Photo.—*A. A. Livingstone.*

In a laboratory situated on the water front, and kindly lent to us for the purpose by Mr. Horsburgh, of the North Australia Commission, we planned for the work ahead. The shores of the port are for the most part rocky, and harbour between tide marks such types of life as crabs, shell-fish, and sea-stars. Under almost every stone lives a crab of a greyish-green colour with a somewhat circular body and flattened clumsy-looking claws. When disturbed these seemingly ungainly creatures hurry with a ridiculously clumsy gait to the shelter of another rock, followed by a retinue of minute sand-hoppers and sea-fleas.

The areas richest in marine life are the open sea-shores where coral and kindred animals dwell. Within the sheltered rockpools myriad types of animals live hidden away in secluded crevices or deep down in the protective fronds of multi-coloured coral. Even in the dark passages and channels of drab-coloured sponges lurk tiny brittle-stars, living in almost perfect security away from the ever inquisitive eyes of enemies.

Most handsome of all, however, and by far the most graceful, are the corals. Although they are never abundant around these rocky shores, one occasionally encounters a sheltered pool left by the tide, which contains a great number of varieties of these curious reef-building animals. Some are branching and a vivid crimson or olive green and yellow in colour, while others, of the conventional staghorn types, are coloured in various shades of blue. Cup corals of small size live in profusion under and in the shade of overhanging ledges of rock, and are held in an upright position by a short stout calcareous stem attached to a rocky base. Such types vary in colour from a deep chrome green to a brilliant emerald, and collectively form a spectacle of great magnificence. In these pools, however, beauty and innocence link hands with beauty and cunning. Among the corals and attached to a rocky bed by means of a thin stem occurs a weed-like structure with delicate and branched silvery fronds. Waving gracefully to and fro at the will of the eddying tide the colony presents a picture of delicacy beyond imagination. But trouble awaits the unwary hand that brushes across these beautiful fronds, for they are cunningly armed with minute stinging darts, which, when loosened, pierce the skin and set up a severe and painful irritation. This branched plant-like structure is really a colony of animals, each living apart from its fellows yet connected by a common flesh. Each little animals owns a separate cell and can throw out its sting-laden tentacles or withdraw them at will. The hydroid colony, as it is called, is made up of hundreds of these little animals, all capable of releasing darts at any type of prey that happens to wander within reach, but on close examination of the fronds one may see other tiny animals entirely independent, and called Skeleton Shrimps (Caprellidæ), creeping at will on almost every part of the colony. Most strange of all, though, is the fact that these tiny crustaceans are left entirely unmolested and obviousiy secure from the deadly stinging darts. These, then, cannot be food animals for the hydroid polyps, neither can they be enemies if treated with such indifference. What, then, are these associates that are allowed to walk on the edge of a precipice, so to speak, yet never fall? In Nature it is an established fact that certain types of animals live together for their mutual benefit, some giving food in return for protection, some using their gaudy colours to attract prey to a companion, who in turn affords shelter, while others offer food in return for transportation from place to place. Such association is called commensalism, and it is to this one must look to explain the reason for the presence of Skeleton Shrimps on the deadly stinging hydroid.

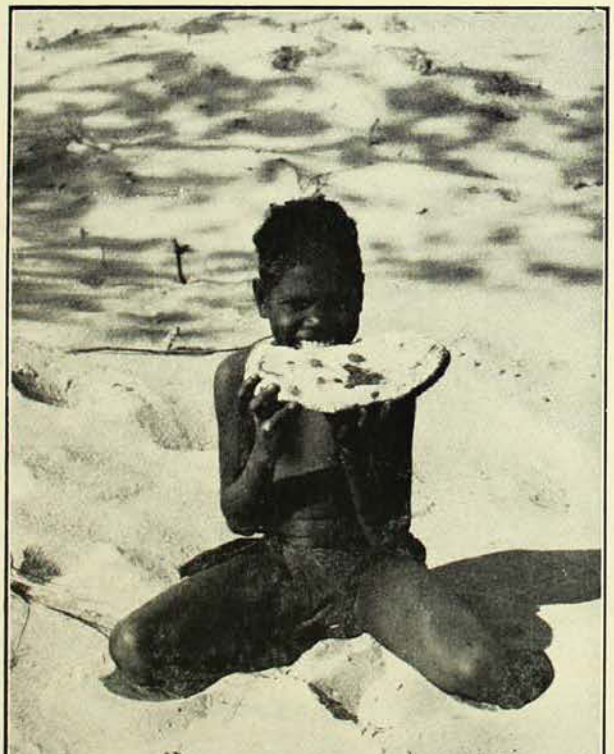
A lake of water-lilies at Ten Mile, Port Darwin. Leeches took heavy toll when barefooted waders ventured into their domain, but Dr. Clark persisted in looking for fresh-water snails.
[Photo.—*A. A. Livingstone.*

On one well remembered day it was necessary to penetrate a densely wooded mangrove shore in order to reach a desired point on the coast. Warnings of crocodiles came vividly to mind and keen attention was paid to the dense undergrowth immediately ahead. As we pushed onward in the heat of such a close atmosphere

A view from Point Charles Lighthouse, about fifteen miles west from Darwin. The waterfront is characteristic of the coast for scores of miles around.
[Photo.—*A. A. Livingstone.*

a rush in the undergrowth to the left caused the party to hesitate and exchange significant glances as to the cause of the sound. The clatter of a bower bird in the same direction dispelled anxiety, and upon investigation we discovered a handsome bower no doubt just vacated by the bird we had heard. A neat tunnel composed of sticks skilfully interwoven formed the centre, and all around, particularly at each end of the tunnel, was a collection of bleached coral fragments brought by the bird to ornament its playground.

Although said to be fairly common, this was the only bower bird playground encountered. Instead of the usual litter of glass and china, the owner of this bower preferred bleached coral for decorative purposes.
[Photo.—*A. A. Livingstone.*



Albert's brother is an advocate of well-baked damper. Besides, he can demonstrate and live up to his convictions in no uncertain manner.
[Photo.—*A. A. Livingstone.*

As the days went on so our area of investigation extended. On some occasions we were accompanied by aboriginal guides, notable among which were the faithful Albert and his child brother. Albert, black and shiny, was an initiated member of his tribe, having just reached maturity in the eyes of his elders, but his white masters, forgetful of the new social rank, carelessly called him Nim. Nim is a native name common to all uninitiated members of certain tribes, and to be still called by it hurt poor Albert's pride. However, he bore up under the unintentional insults to his position and looked proudly to his newly acquired tribal marking and scars for solace. In addition, he was called by a white man's name, and that in itself was some consolation for his master's forgetfulness. Nothing delights the heart of an aborigine more than to be given a white man's name. Almost anything a white man does is imitated by the black fellow. Like his master he must have his tea, sugar, jam, bread, and flour, and even must have a good silver-mounted pipe because " boss gottem one all same this fella."

In remote parts it is not uncommon for a white traveller to be asked " You givem name alonga this fella ? " To oblige, any name is given, the first that comes to mind, and the blacks, quite ignorant of the meaning of the word, accept it for the individual upon whom it was bestowed. In this way some very amusing names are heard when listening to conversation, and even mongrel camp dogs are included in this peculiar form of name coining.

Albert's small brother was about six years of age. His worldly possessions consisted of a very soiled red loin cloth for day wear and an almost threadbare blanket to cover and protect him from the chilly nights. Being a typical child of the wilds his wants were few, hence his lack of extensive worldly goods. His appetite was always good and nothing seemed to satisfy him more than a large damper well baked amid the glowing coals of a small fire.

When landing one day from our vessel for a few days collecting, we were at a loss to discover the reason why Albert and his brother insisted on taking ashore three pieces of old galvanized iron. Thinking that they required them to sleep on and so escape the cold ground at night we allowed them to drag this lumber to our camping spot. With the approach of night Albert got to work. Digging a deep trench in the form of three sides of a square he sank the iron in the sand, leaving sufficient above the surface to act as a wind-break for himself and brother when the early morning winds came up. The problem of the cold sandy ground was soon overcome by Albert. Lighting a large fire inside his tin wind-break, he allowed it to burn until it was bedtime, and then, scraping the hot ashes and embers some distance away, scooped out a good-sized hole in the sand where the fire had been. Into this he and his brother crept, to pass a most comfortable night without the slightest discomforts from cold.

Notes and News

Professor F. Speiser, of the University of Basel, Switzerland, who is on his way to New Britain, recently visited the Museum to discuss his plans for collecting scientific data. Professor Speiser is specially interested in anthropological work, and is accompanied by Mr. H. Hediger, Zoologist.

* * * *

Dr. H. Lyman Clark, of the Museum of Comparative Zoology, Harvard, Mass., U.S.A., along with Mr. A. A. Livingstone, of the Museum Staff, has been collecting marine specimens along the north-west coast of Australia. Whilst in Sydney he made the Australian Museum his headquarters, subsequently leaving for China. He hopes to return to Australia in the near future, finding our fauna absorbingly interesting.

* * * *

Mr. F. S. Mance, Under-Secretary, Department of Mines, and a Trustee of this Museum, has been appointed delegate of the State Government to the Third Empire Mining and Metallurgical Congress in South Africa. He was the recipient of congratulations at the Board meeting held on December 13.

* * * *

Mr. W. W. Thorpe, Ethnologist, has been appointed Honorary Secretary of the Anthropological Society of New South Wales for the year 1930.

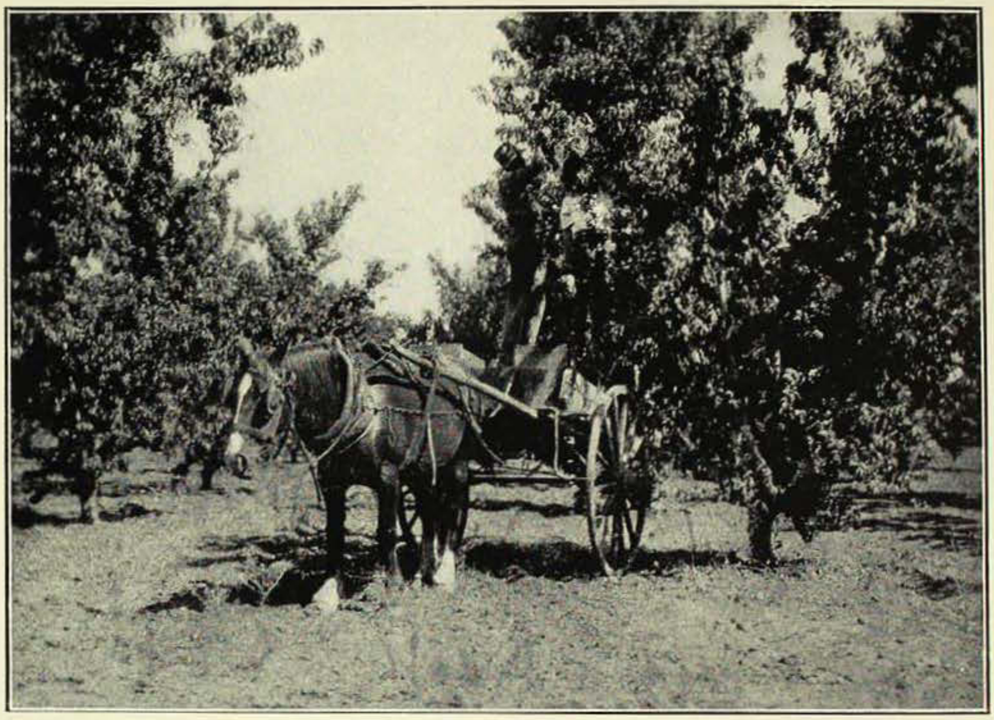
* * * *

The scientific interest of the Great Barrier Reef is perennial and inexhaustible. Mr. W. Boardman, of the Museum Staff, who has already paid two visits to the Barrier, is now spending his annual vacation there. He is accompanied by Mr. Melbourne Ward, F.Z.S., Honorary Correspondent and Zoologist, and we expect that as usual they will bring back many specimens and much valuable information.

The Fight Against Insect Pests

SOME ASPECTS OF APPLIED ENTOMOLOGY IN AGRICULTURE.

By Keith C. McKeown.



The orchard is the "front line" in the war against insect pests. Work in a typical peach orchard.
[Photo.—*K. C. McKeown.*

WHEN primitive man abandoned the nomadic life of the hunter for the sedentary one of the agriculturist he found that those plants which he valued and cultivated were attacked by many insects, which, although those plants were normally their natural food, were, from his point of view, noxious and to be classed as pests. By the same line of reasoning certain plants became weeds, to be rigorously eradicated from his crops. A weed has been defined as a plant out of place; an insect pest may therefore be well defined as an insect out of place—in the human scheme of things.

Man, Nature's insurgent son, considering himself to be Lord of Creation, has always had the unhappy knack of upsetting the balance of Nature, and, as Dr. R. J. Tillyard has well said, has "unwittingly created for himself many problems, which he is now almost at his wits' end to solve."

Many insects, ordinarily rare in our bush, and seldom to be seen except in museum collections, become numerous when their food-plants are cultivated in large quantities under unnatural conditions. An instance of this was well shown some years ago on the Murrumbidgee Irrigation Areas, where the Sugar Gum (*Eucalyptus cladocalyx*) was planted in large numbers as an ornamental tree along the avenues. The Ribbed Case Moth (*Thyridopteryx herrichii*) increased in a phenomenal manner, stripping the trees of foliage, and in many instances seriously damaging, or even killing them; the ravaged trees were hung with thousands of their curious white ribbed cases, usually so rare an object in the bush, and presented a remarkable sight.

Insects devour the cereal crops, the source of man's bread; scale insects suck the sap, while leaf-eating insects destroy the foliage of his fruit trees; borers infest the forest trees and damage the furniture in his house, while termites may destroy even the house itself. Other insects injure man's stored and preserved foodstuffs and his clothing. Against this horde of enemies the brain and energies of the human race are pitted, and employed against them are the methods of modern warfare, deadly gases and flame-projectors, while aeroplanes scatter toxic dusts from the skies. Poisonous sprays are used in this work of destruction, bacterial diseases and even the natural enemies of the insect pests are bred in immense numbers and enrolled in the defensive forces.

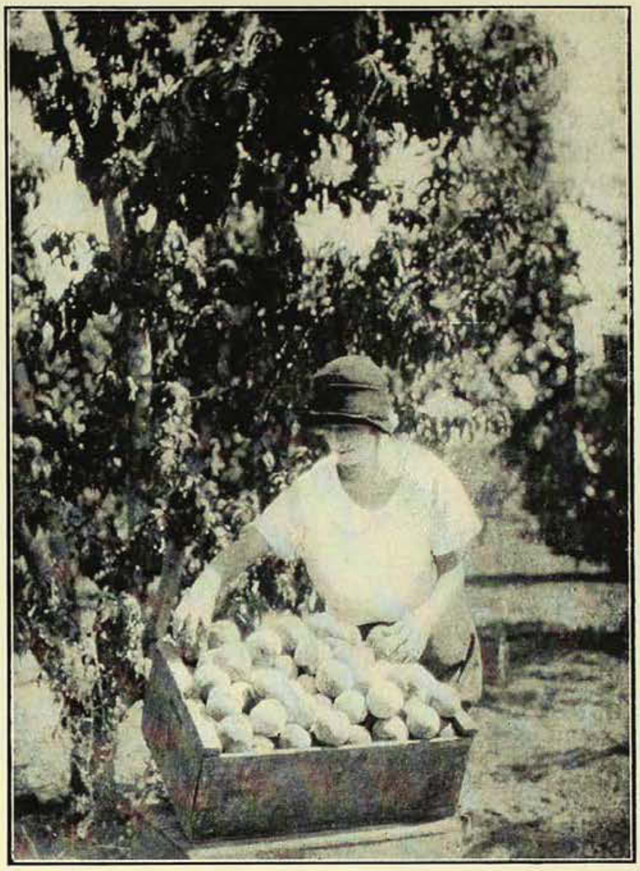
LOSSES CAUSED BY INSECT PESTS.

The losses caused by insect pests throughout the world must reach colossal figures. In the case of Australia alone, a recent estimate (AUSTRALIAN MUSEUM MAGAZINE, III, 5, 1928, p. 147) gives the following figures—a conservative estimate: Loss to the sheep and wool industry from the ravages of blow-fly, £4,000,000 annually, while 60,000,000 acres in Queensland and New South Wales are rendered worthless by prickly-pear. The aggregate annual loss to Australia by insects and noxious weeds is set down at £20,000,000. Another estimate gives an area of 150,000 acres under St. John's Wort in Victoria, and this weed is also spreading rapidly in New South Wales and South Australia. Blackberry, ragwort, convolvulus among other plants also take their quota. The Council of Scientific and Industrial Research is experimenting in the control of these pests by means of their natural enemies.

In the year 1875 the area under vineyards in France amounted to 6,382,000 acres, and in 1885, through the ravages of Phylloxera (*Phylloxera vastatrix*) alone, it had become reduced to 2,868,000 acres. That is to say, within a period of ten years 4,000,000 acres, in round figures, of once prosperous and healthy vineyards had been devastated by these insects. This example, one among many, well shows the immense injury which can be caused to crops by injurious insects.

THE RAPIDITY OF INSECT INCREASE.

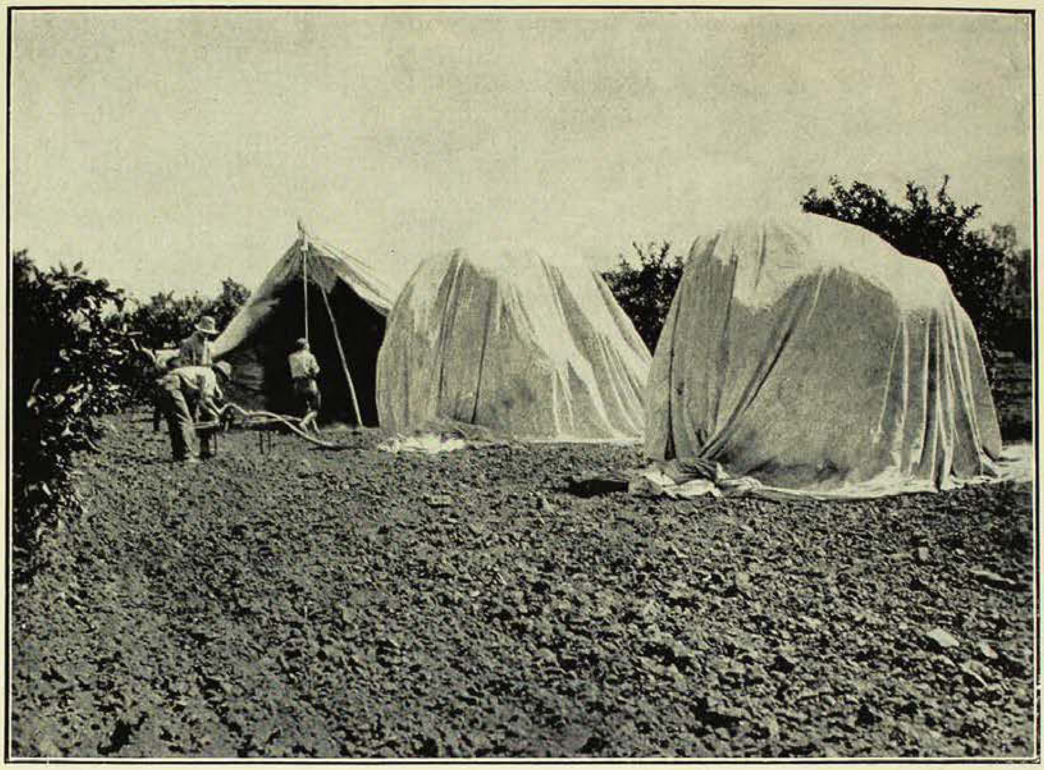
In this place it may be well to give an instance of the rapidity with which some species of insects are capable of increasing. Réaumur, the famous French naturalist,



Good fruit—the reward of constant warfare against insect enemies.
[Photo.—*K. C. McKeown.*

estimated that one female aphis may be the progenitor of no less than 5,904,900,000 individuals during the few weeks of her existence. Even more impressive are the figures given by Professor Huxley: "Assuming that 1,000 aphides weigh collectively about one grain avoirdupois (an under- rather than an over-estimate of their weight), and that only a very stout man can weigh as much as two million grains, or rather more than twenty stone," Professor Huxley computes "that the tenth brood alone of the descendants of a single aphis, if their multiplication remained altogether unchecked by the usual natural causes, which play such an important part in their destruction, would weigh more than five hundred millions of stout men." Fortunately for man an army of parasites and predaceous insects is constantly fighting against this host of enemies and maintaining the balance of Nature, or the earth would soon become uninhabitable.

EARLY IDEAS OF ECONOMIC ENTOMOLOGY.

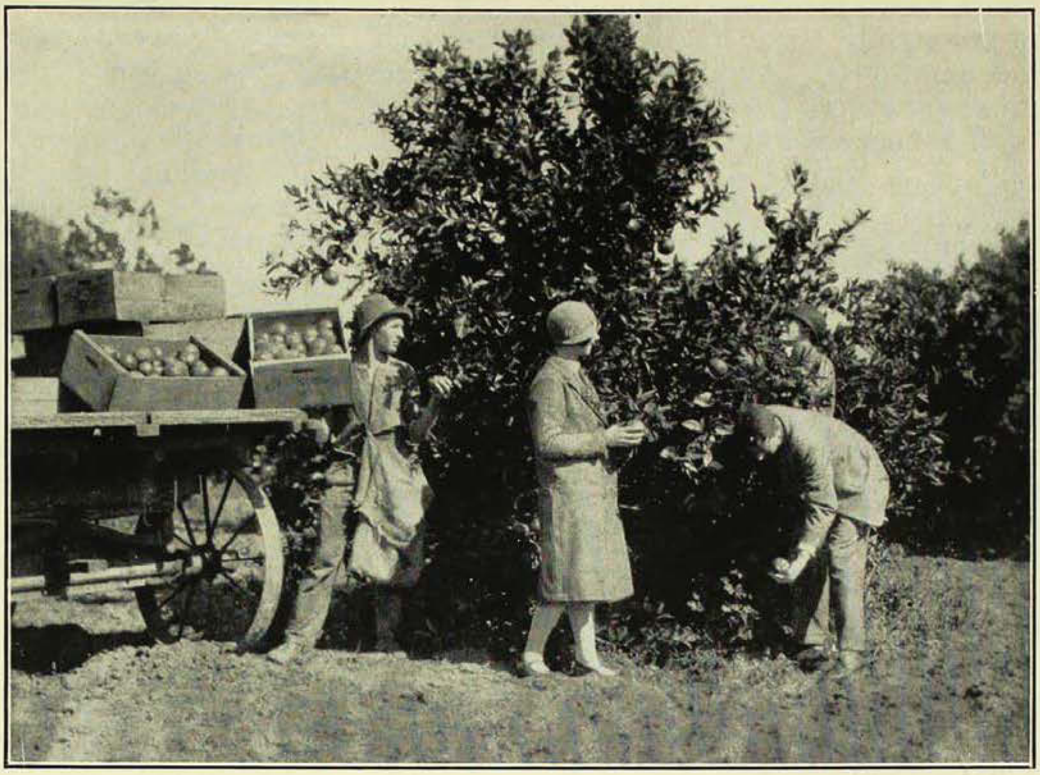


Fumigation of Citrus trees. On the left is the blower used to force the deadly dust under the tent.
[Photo.—*K. C. McKeown.*

Economic entomology, in the modern sense, is of quite recent origin, and although many references to insect pests are to be found in early literature and history, little effort was made by man to control these visitations, which were looked upon as being of divine origin. These early accounts of insect plagues, and of such efforts in "economic entomology" as are recorded, provide a mine of considerable interest and fascination, to be prospected by the searcher in natural history, folklore and tradition.

The earliest accounts of insect plagues are to be found in the Bible; the swarms of locusts and flies, described in *Exodus*, are familiar to all; while the Prophet Joel inveighs against many pests of crops and describes the desolation left behind them. Homer, in the "Odyssey," recounts that borers damaged the bow of Odysseus. Pliny, in his "Natural History," provides a fund of curious tales and references to insects. Cato, in a treatise on agriculture, written about 200 years before the Christian era, is said to refer to wormy apples, evidently the work of that well-known enemy of the orchardist, the Codlin Moth (*Cydia pomonella*); while Pliny, writing nearly 2,000 years ago, states: "The fruits themselves, independently of the tree, are very much worm-eaten in some years, the apple, pear, medlar, and pomegranate, for instance." One can imagine the disgust of a venerable Roman epicure on discovering a worm in his apple at one of those banquets for which the ancient Romans were famed!

During the Middle Ages the priests frequently exorcised the locusts, which, however, it is said, "did not seem one penny the worse, and cheerfully continued in their wickedness." The monk Alvarez gives a curious picture of one of these exorcisms of the locusts; he writes: "Thus chanting psalms we went into the country where the corn was, which having reached, I made them (the Portuguese and natives) catch a good many of the locusts, to whom I delivered an adjuration which I carried with me in writing, by me composed the preceding night, summoning, admonishing, and excommunicating them. Then I charged them, in three hours' time to depart to sea, or else to the land of the Moors, leaving the land of the Christians; on their refusal of which, I adjured all the birds of the air, animals, and tempests, to dissipate, destroy, and devour them, and for this admonition I had a certain quantity of these locusts seized, and pronouncing these words in their presence, that they might not be ignorant of them, I let them go so that they might tell the rest." Strangely similar to this method of "control" is the Arab custom of writing on the wings of four locusts verses from the Koran suited to the purpose, and liberating these insects in the midst of the advancing host, "whereupon the whole swarm are said to at once alter their course and depart." Compare with this the present-day methods of gathering the eggs, poisoning the young "hoppers," or destroying the adults by means of flame-projectors as used in Palestine; less picturesque, perhaps, even if more practical! As late as the year 1783 a plague of the larvæ of the Tiger Moth in England threatened to eat up all green things, and prayers were offered up in the churches for their destruction.



City visitors enjoying oranges free from the scale insects which blemish and depreciate the fruit.

[Photo.—*K. C. McKeown.*

MODERN METHODS IN APPLIED ENTOMOLOGY.

Spray pumps were first employed in insect control about 1880, although prior to that date washes had been employed but were applied by means of brushes or small syringes. Paris green was first used on a commercial scale against the Colorado Potato Beetle in the potato fields in the United States of America about 1870, so it was will be seen that the aid of the chemist has been but recently availed of.

The properties of some of the sprays in use were discovered quite by accident; Lodeman says that Bordeaux mixture—so valuable a specific against fungus diseases—was first used by vignerons in southern France to sprinkle over grapes growing along roadsides, to keep travellers and children from stealing them; it was then found that these vines bore cleaner fruit, and this led to further experiment in the control of fungus diseases.

The sprays in use at the present day for the control of insect pests are based on the feeding-habits of the insects concerned: stomach poisons, chief of which is arsenate of lead, for caterpillars and all insects equipped with biting mouth-parts, while for those which pierce the bark and suck the sap, contact sprays, such as nicotine, and various distillate oils, are employed; these act by closing the breathing pores, or stigmata, and smothering the creature, or killing it by means of poisons absorbed into the respiratory system.

Quarantine is also an important factor in insect control, and is employed with considerable success in keeping pests of other lands out of a country where the transport of plants and fruits is sea-borne. Where quarantine of an inland area is attempted little success may be anticipated, for in these days of rapid transport, motor cars and aeroplanes tend to render all precautions against introduction of pests negligible. In the case of high-priced fruits many ingenious and elaborate means of smuggling them into a quarantine area are employed; Avocado pears have been intercepted on the Mexico-United States border concealed in loaves of bread.

Poisons in the form of dusts are now frequently used in the case of field crops and in the control of forest insects, aeroplanes affording an effective means for their distribution over large areas. Carbon monoxide and other deadly gases have been used with considerable success, but fumigation with hydrocyanic acid gas has proved one of the most successful means of combating scale insects. When the "wet" method, where the gas is liberated from the cyanide by means of sulphuric acid and water, was superseded by the "dry" method, where finely powdered calcium cyanide evolves the gas on exposure to the air, fumigation methods took a decided step forward. The calcium cyanide system of fumigation was successfully introduced into Australia in 1922 by Professor H. H. Quayle, of the University of California.

Almost the first, and perhaps the most successful, application of biological control of injurious insects was the introduction of the Australian ladybird beetle (*Novius cardinalis*) into California in 1888 to combat the Cottony Cushion Scale, which had been accidentally introduced from Australia some years before and had increased with such rapidity that it threatened to devastate the Californian citrus orchards. The introduction of this enemy of the Cottony Cushion Scale (*Icerya purchasi*) was attended with such success that a year later the pest was under control. This success gave impetus to further research in the direction of control of injurious insects by means of their natural enemies, and the world was soon being searched for parasites of noxious insects—a search attended by varying results, but in the main they have proved distinctly encouraging. Biological control of pests is being closely followed up in Australia by the Federal Bureau of Economic Entomology, which is searching for parasites, not only for the destruction of noxious insects, but also for weed control.

The average farmer on hearing that a parasite has been secured to combat a pest tends to jump to the conclusion that his spray pump or other equipment may be scrapped, and the destruction of his insect enemy left entirely to its parasite, but experience to date shows that, although a parasite may prove a valuable check, it cannot alone be considered an effective control of a pest, but must be supplemented by other means.

In economic entomology one of the first essentials in investigating an injurious insect is its accurate identification, for the life-histories and habits of insects vary considerably even in the same group, and an intimate knowledge of the life and ecology of an insect is essential before it can be effectively attacked. In this work the Museum bears its part in the war against pests.

The Habits of Cuckoos

By K. A. Hindwood, R.A.O.U.

CUCKOOS have interested naturalists from early times; Aristotle, the celebrated Greek philosopher, who knew of their parasitic habits, mentions, though does not subscribe to the then popular belief, that they turn to hawks during the winter months. Later, Francis Willughby, an English ornithologist of the seventeenth century, related a curious story concerning the supposed hibernation of a cuckoo. When preparing a fire the servants of a gentleman, to their great surprise, heard the voice of a cuckoo sing three times from under the stove. They hastily drew the willow logs from the furnace ". . . wherefore taking an ax they opened the hole and thrusting in their hands first they plucked out nothing but feathers; afterwards they got hold of a living animal, and this was the cuckoo that had waked so opportunely for its own safety . . . wholly naked and devoid of feathers." Willughby drily concludes: "This cuckoo the boys kept for two years afterwards alive in the stove, but whether it repaid them with a second song the author of the tale has not thought fit to inform us."

The preceding observations, which are quite incredible nowadays, had their origins in the autumnal migration and consequent absence of the old world cuckoo, *Cuculus canorus*. They are but instances of the many fabulous and romantic statements associated at one time or another with the habits of these birds.

During the past fifty years careful and accurate field work by English and continental ornithologists has added much to our knowledge of the somewhat furtive and secretive ways of female cuckoos, and, of course, dispelled the many hypotheses that seem to have been the outcome of the merest speculation. Whilst such observations and the resultant conclusions mostly concern the European cuckoo, they can be applied with slight modifications to parasitic cuckoos inhabiting other regions of the world. The most interesting fact in the history of the cuckoo is its habit of placing its eggs in the nest of other birds and leaving the incubation and feeding of the young to the foster-parents.

It is now generally accepted that female cuckoos watch their intended dupes building and visit the selected nests from time to time. Normally they do not deposit an egg until the nest already contains one or more eggs; after placing their own egg in the nest they remove one belonging to the rightful owner.

Despite the fact that the English cuckoo has actually been photographed laying in a nest, there is ample evidence that in most cases the egg is laid on the ground, transferred to the bill or throat, and in this way taken to the nest.

The actions of the female cuckoo are largely governed by circumstances in no way directly controlled by her. Should the time approach for the deposition of an egg, and no suitable nest be available, she would probably seek a chance nest in which to lay. Thus cuckoo eggs have been found in recently used and old nests; often they are deposited in incompleted structures, in such instances they are mostly overlaid and covered with nesting material. Sometimes eggs are foisted upon finches, but as seed-eating birds are entirely unsuitable as foster-parents, the young cuckoo dies of malnutrition soon after hatching.

The scarcity of suitable nests would also explain the occurrence of two, and on rare occasions three, cuckoo eggs, laid by different birds, or even species, being found in the one nest.

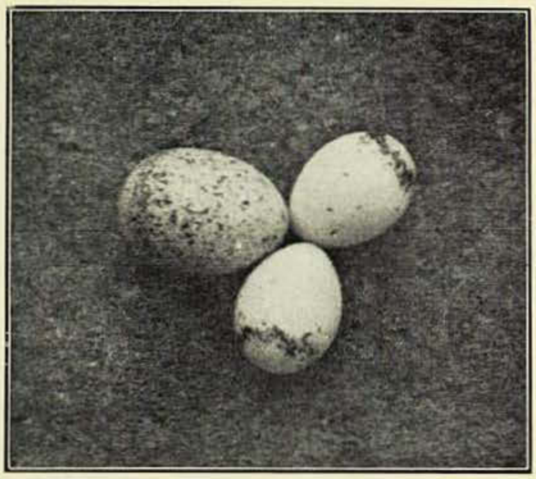
There appears to be a tendency on the part of cuckoos to choose as foster-parents the species by which they were themselves reared, though it does not seem that any species of cuckoo can become so specialized that it will invariably parasitize but one kind of bird. The most potent factor opposing such a happening is that, generally, the distribution of many, if not all, cuckoos is more extensive than that of any of the species they dupe. Moreover, as cuckoos range throughout various types of country and are not necessarily confined to a particular habitat, they must act according to their situation. In this way Nature has wisely distributed the arduous task of tending immature cuckoos among a great number of species, and thus eliminates the remote,

A fully fledged Fantail Cuckoo (Cacomantis flabelliformis) almost ready to leave the nest of its foster-parent, the White-Browed Scrub Wren.

[Photo.—*K. A. Hindwood.*

though latent possibility, of the extinction of any one species through the actions of cuckoos.

In relation to the size of the bird the eggs of cuckoos are indeed small; however, they are normally larger than those of the birds chosen to incubate them. This is a very necessary adaptation; it means that the relatively small egg of the cuckoo hatches before, or about the same time, as the other eggs in the nest, and the young cuckoo, being bigger and stronger, is more easily able to eject its fellow nestlings. In certain instances there is a remarkable similarity in the colouring and markings of the eggs of some cuckoos and those of their victims. Though such is not general, it can scarcely be considered fortuitous, but is probably the result of very old associations.



Egg of the Fan-Tailed Cuckoo (Cacomantis flabelliformis) with the eggs of the Brown Thornbill (Acanthiza pusilla). Approximately natural size.
[Photo.—*K. A. Hindwood.*

The number of eggs laid by a cuckoo during the breeding season is extremely difficult to ascertain. No doubt it varies to some extent according to existing conditions and the species. The English cuckoo is recorded to have laid, under abnormal conditions, twenty-one eggs in forty-six days (Chance, *The Cuckoo's Secret*, 1922, p. 106). Numbers would seem to be considerably less than twenty; even then only a small proportion of eggs deposited would reach maturity, for, apart from eggs being placed in unsuitable nests, nests containing cuckoos' eggs are often deserted by sensitive birds. Again, the young cuckoo, before and after it has left the nest, seems incapable of understanding the warning cries of its anxious foster-parents, and becomes the prey of raptorial birds or other enemies.

The actual ejection of the other nestlings by the young cuckoo has frequently been witnessed. In *The Emu*, Vol. V, 1905, p. 22, Mr. C. L. Barrett gives a vivid description of the murderous act. "Struggling desperately until it succeeded in getting the feebly resisting wren in the hollow of its back, and balancing it there with extended embryo wings, the young cuckoo, with head bowed between its strong legs, which, with claws firmly fixed in the sides, were straddled across the nest, worked its way gradually towards the entrance, and on this being reached suddenly raised the head and with a sharp upward lift of the body pushed the unfortunate nestling over the edge. His work accomplished, the young usurper gave a final shrug of the body, as if to make certain his burden was gone, and subsided exhausted to the bottom of the nest." It may be added that the cuckoo, in casting out either eggs or young does so with its back to the entrance of the nest, or in the case of an open nest, to the inside wall of the structure, ". . . with its head bowed between its strong legs." The unusual position of the head undoubtedly assists the bird to maintain an essential attitude, at the same time helping it to more readily accomplish ejectment.

Many ingenious hypotheses have been advanced in explanation of the actions of the blind, naked, and apparently helpless cuckoo. It seems obvious that it is an inherited impulse, not prompted by consciousness, but stimulated by the presence of other objects in the nest. The cuckoo will just as readily cast out eggs, so that it can scarcely be the movements of the fellow occupants that cause the awakening of, though it may be subsidiary to, the instinct. After the second day the young cuckoo will not attempt to eject anything from the nest. How it finds, when quite blind, the small, hooded, and almost dark opening of various domed nests is another problem; reaction to light is a probable explanation.

Parasitism of nesting birds is not confined to members of the family Cuculidæ, nor do they all have the habit. The several species of cuckoos in America rarely deposit their eggs in the nests of other birds, but construct crude nests of twigs, lay numerous eggs and tend their own offspring.

The genus *Centropus* (Coucals), which really ranks as a sub-family of the true

An early illustration of the Pheasant Coucal (Centropus phasianinus) painted about 1792, soon after the foundation of the Colony, New South Wales. The drawing of the feather shows the peculiar formation of the neck and breast feathers. This illustration is from a collection of paintings in The Mitchell Library, artist unknown, and is reproduced by courtesy of the Trustees of that institution.

cuckoos, comprises some forty species, all of which build nests and incubate their eggs. This genus of birds has a wide distribution extending throughout Africa to the delta of the Nile, Indo-China, Malaysia, and Australia. The Australian species, the Pheasant Coucal (*Centropus phasianinus*), occurs in the northern and eastern parts of the continent, showing preference for swamplands and heath country.

The parasitic habit has been acquired independently by several groups of birds, chiefly the Honey Guides, Indicatoridæ, a typically South African family (several species of cuckoos also occur in South Africa), and the Cowbirds (*Molothrus*) of North and South America. The young of the latter do not habitually eject the other occupants from the nest, but by virtue of greater physical strength maintain the top position in the nest and so obtain all the food, the weaker nestlings being starved to death.

In external characters cuckoos differ somewhat from most birds. Their feet are zygodactyl, or disposed in pairs, the first and fourth toes being turned backwards. In this respect they resemble the parrots. The nostrils of many of the smaller species are circular and prominently ridged, and the feather tracts in most instances are not well defined, whilst the feathers are often soft and silky to the touch. Few birds have the entire body covered with feathers; most have certain defined areas not apparent outwardly, though varying with the species, where feathers are not present.

Notes and News

Mrs. G. J. Waterhouse has, through Dr. G. A. Waterhouse, Trustee, presented to the Museum a valuable collection of shells, including fine series of Cowries and of pearly Nautili, the latter containing samples of all the described species. In recognition of this fine donation, Mrs. Waterhouse has been elected an Honorary Correspondent.

* * * *

Mr. C. T. McNamara, formerly of the Agricultural Department, Papua, is now in Sydney and is proceeding to Africa. For the last few years Mr. McNamara has been an assiduous collector for the Museum, which has through his exertions acquired a very large collection of insects and a valuable series of mammals and reptiles.

From Mr. Frank D. Muller the Museum recently received a valuable gift of Solomon Island ethnological material.

* * * *

On January 1, 1930, Mr. James W. Woodhead, after nearly thirty-three years' service as Printer, entered on long leave prior to retirement from the Museum Staff. Mr. Woodhead always performed his duties conscientiously and efficiently and was most helpful to his colleagues.

On December 5, the Staff met and presented to Mr. Woodhead a gold-mounted fountain pen and a set of gold sleeve links and studs. He will henceforth reside in New Zealand, where we hope he will enjoy many happy years of well-earned leisure.

Inhabitants of the Deep

By T. C. Roughley and G. P. Whitley.

A PREVIOUS article has explained how we came to be aboard the Danish Research Steamer *Dana* on the occasion of her visit to Australia, when we were privileged to obtain first-hand insight into the investigation of life in our ocean depths. In the present contribution an account is given of the natural history of our trip.

About 200 miles east of Sydney the nets were lowered one afternoon into water $2\frac{3}{4}$ miles deep. Down, down they sank until a series of nets had settled to work at intervals of 1,000 metres of wire. The nets trailed behind and below the ship and the *Dana* slowed down to about two knots in order to prevent them from bursting.

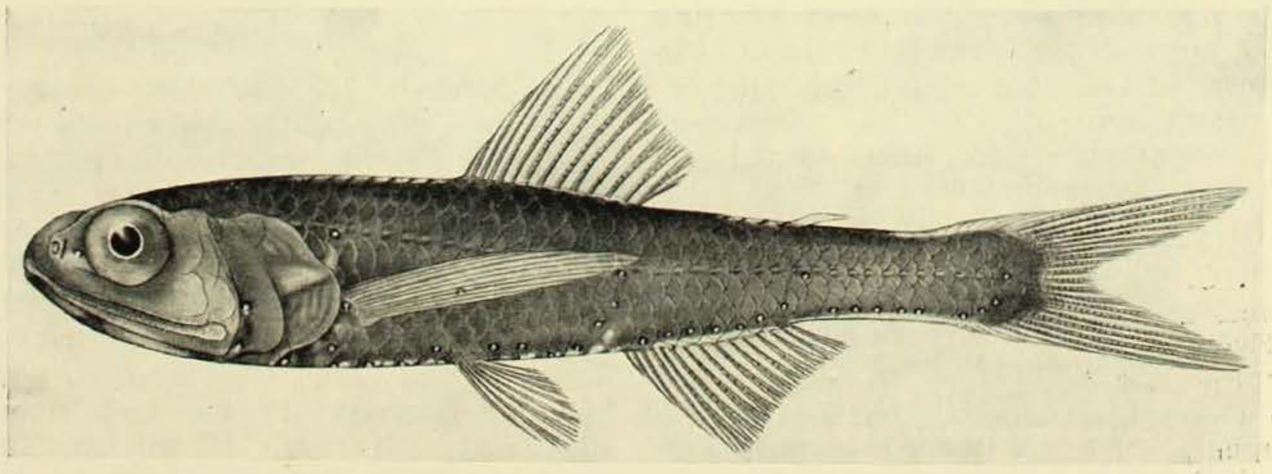
One by one, at long intervals, the nets were brought in after sunset and dark, and the contents of each net washed into separate tubs and immediately labelled.

QUEER FISHES.

Here at last we saw the wonderful creatures of the deep with which our practical experience had hitherto been very limited. From a layer between the surface and 1,000 metres came a small catch of little fishes and invertebrates. A tiny toado was puffed into a perfect ball and floated with seeming indignation amongst a mass of arrow-worms, jelly-fishes and crustaceans. As nets which had been towing in deeper water were raised, it was noticed that the fishes were black or very dark brown, some with sides silvery as tinfoil, others with rows of luminous organs along their flanks or bellies. With these dark-coloured fishes were live prawns, of the gorgeous reddish colour of gold-fishes, and other invertebrates in large numbers. After death, the fishes floated in the tubs but the prawns sank. Though the prawns remained alive for some time after being caught, the fishes were dead or dying as soon as they were hauled in. Owing to the release from the great pressure of the depths to which they had been accustomed, the eyes and intestines of some of the fishes protruded or burst, and in one the head was almost severed by the rupture of the region near the gills.

LIGHT IN THE SEA.

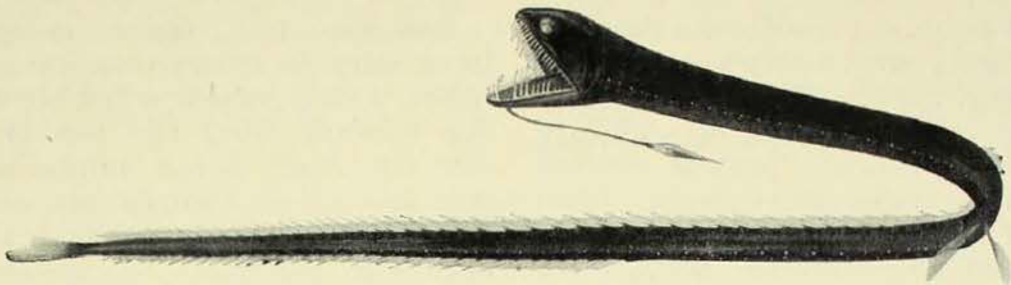
We must now consider for a moment the question of light in the deep sea. How far does the light penetrate the water? Everybody is familiar with the fact that ordinary light is composed of rays of various wave-lengths, comprising red, orange, yellow, green, indigo, blue,



A Lantern Fish (Lampanyctus townsendi) from Lord Howe Island (Rec., vol. xiv, pl. xiv). The spots on the body and head are luminous and serve as recognition marks when shining in the dark.
[*A. R. McCulloch*, del.

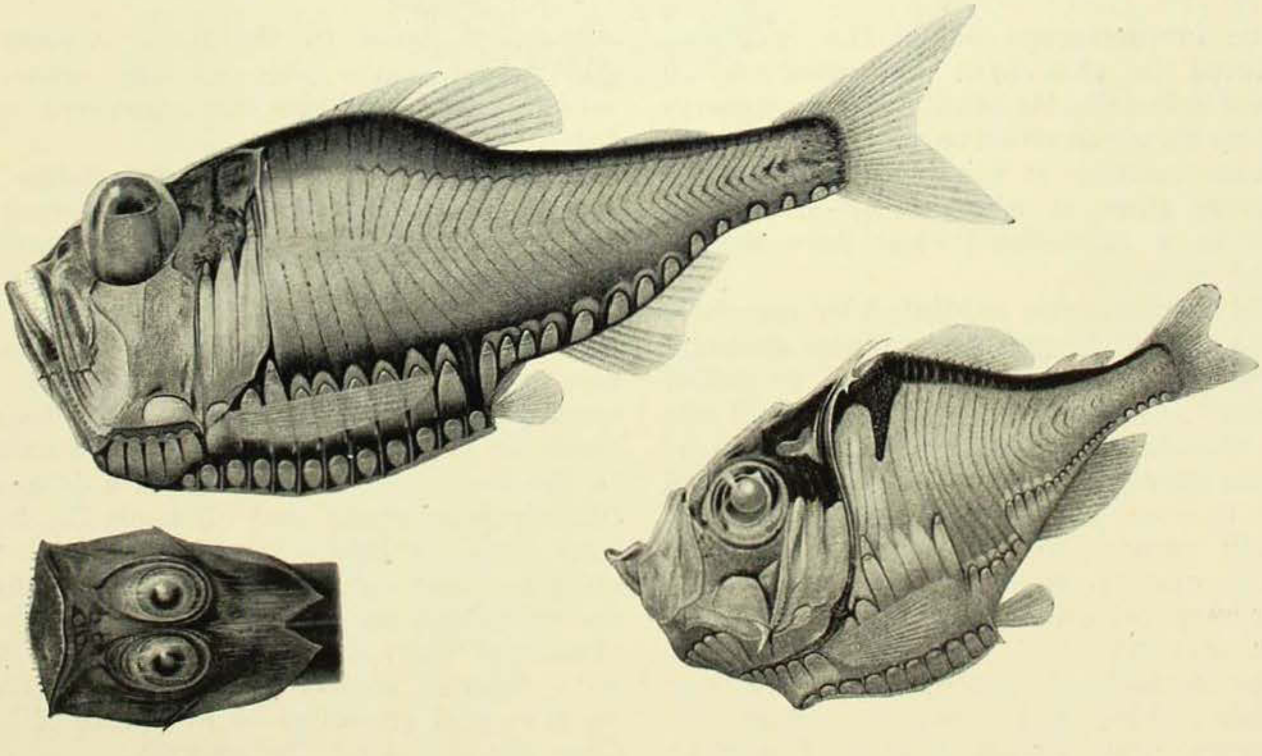
violet and other colours. It has been found that all these rays do not penetrate the same distance into the water. The red rays are most quickly absorbed, and therefore penetrate less than the others, very few being found, even at mid-day, at a depth of 100 metres. At 500 metres the green rays give out, and at a depth of about 1,500 metres (less than a mile) even the blue rays are absent, and the water below that level is in utter darkness and is icy cold. This accounts for the fact that the animals of the deep are, roughly speaking, of different colours at different depths.

The surface fishes, down to about 150 metres, are either colourless or mostly blue; from 300 to 500 metres, the fishes are silvery or grey; and at depths from 1,000 to 2,000 metres, they are black or dark coloured, and are associated with red-coloured crustaceans, which, in the absence of the red rays in the light, appear black; they appear red only when brought to the surface. At night, however, when the water is everywhere dark, they migrate much nearer the surface, and may be captured at depths as shallow as 200 metres. On the approach of day they make for the deeper, darker water.



Long teeth, large eyes, feelers, soft bodies, and rows of light-organs are characteristic of many deep sea fishes. This species (Idiacanthus fasciola) has been caught in North Australian waters.

[After *A. Brauer*.



The silvery-sided Hatchet Fishes swim in schools in deep water. On the left is Argyropelecus with its eyes directed upwards, and on the right the more normal Polyipnus.

[After *A. Brauer*.

Thus, under the different light conditions, these animals are probably practically invisible; it is only when they are taken from the water that their actual colours in daylight can be appreciated.

LUMINESCENCE.

Before we examined the *Dana's* catch in detail, the lights of the ship's laboratory were all extinguished. Many of the fishes then gave off flashes of ghostly luminescence, whilst the prawns ejected phosphorescent puffs like smoke from cannon. If a prawn were lifted from the water, part of its surface would glow with a faintly bluish or greenish light and the puffs of luminous matter would drip in lambent flames into the water, where they floated away.

a luminous mucus, which may flow from them like a cloud, while in others the light-producing organs are conspicuous highly organized structures, comparable in some respects to an eye or a bull's-eye lantern, having a source of light with a reflector behind and a lens in front.

Perhaps the finest adaptation of luminosity is to be seen in some angler fishes, which possess a flexible rod extending forward from the top of the head, the tip itself being luminous. Smaller fish and other animals are attracted by the lure and disappear down the angler's capacious mouth.

Much knowledge has yet to be gained before we know the reasons for and the purpose served by luminous organs. The animals which possess them are not always confined to the dark abysses of the ocean, and some of the creatures which live there are not provided with luminous organs at all.

This fish (Macropharynx longicaudatus) has a tremendous gape and an extensible stomach so that it can actually swallow animals larger than itself. The eye occupies most of the tiny head.
[After *A. Brauer*.

The luminescence of all the creatures captured in this haul was generally a blue of indescribable beauty, but luminosity is by no means confined to a blue coloration; in some animals it has been observed as a silvery glow, in others as green or lilac, while in a cuttlefish it has been seen a bright ruby red.

The luminescence exhibited by members of the animal kingdom is unique amongst all lights, inasmuch as it is produced without the formation of heat, and for this reason is the most efficient form of illumination known. It has been recorded that two or three prawn-like crustacea, freshly caught, gave sufficient light to enable one to read for a few seconds the newspaper on which the jar containing them was placed.

The methods of emitting lights are very varied. The light organs range in structure from simple groups of surface cells to the most complicated eye-like internal organs. Many crustacea secrete

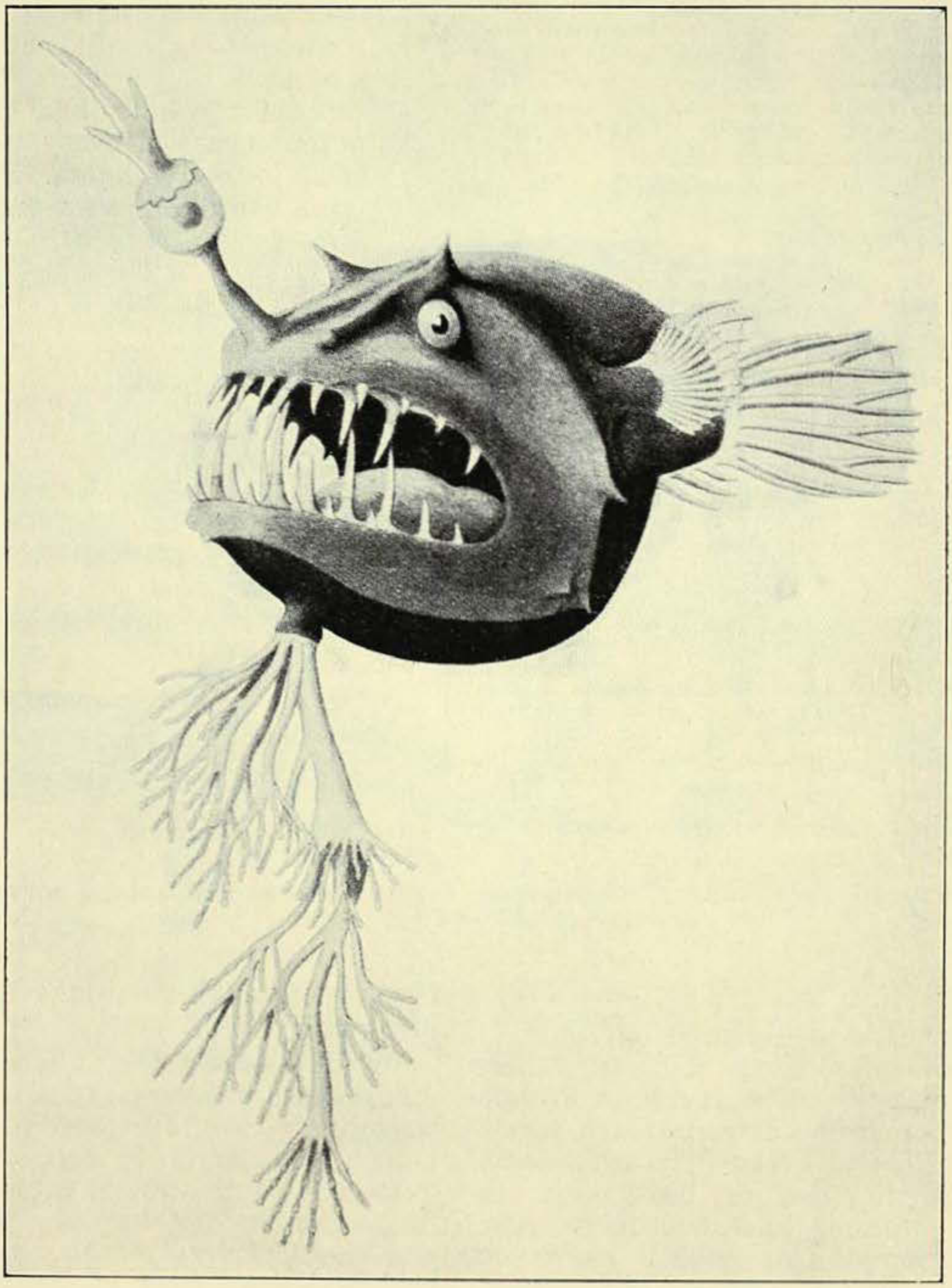
It is probable that in some fishes the luminous lure serves as an attraction or bait for prey; that the regular arrangement of the lights may serve as recognition marks for fishes of the same species for mating purposes; that the luminous clouds of secretion may distract an enemy and allow the pursued to escape; that the surroundings may be illuminated in the search for food; or that a detached luminous fragment cast off from the body may be a "sacrifice lure" to deceive the enemy. One can picture a fish chasing a delicious-looking prawn tearing away as a streak of light ahead of it, and at last with intense anticipation thrusting forth its jaws and grabbing—a mouthful of cold light discarded by the animal.

Beebe, in his "Arcturus Adventure," advances some interesting theories concerning the objects served by the luminosity of some of the fishes he captured. He states:

Scattered over the body [of the slender-tailed lantern fish] are many small, round, luminous organs, which we may divide into three general sets. First, thirty-two ventral lights on each side of the body, extending from the tip of the lower jaw to the base of the tail; second, twelve lateral lights arranged irregularly along the head and body, and third, a series of four to eight median light scales, either above or below the base of the tail. . . .

The lower battery, when going full, cast a solid sheet of light downward, so strong that the individual organs could not be detected. Five separate times when I got fish quiet and wonted to a large aquarium, I saw good-sized copepods and other creatures come within range of the ventral light, then turn and swim close to the fish, whereupon the fish twisted around and seized several of the small beings. Once it turned completely on its back. . . . Whether this is the chief object of the ventral lighting I do not know, but it is at least occasionally effective.

Perhaps the best distinction between various species of this group of lantern fish is the arrange-



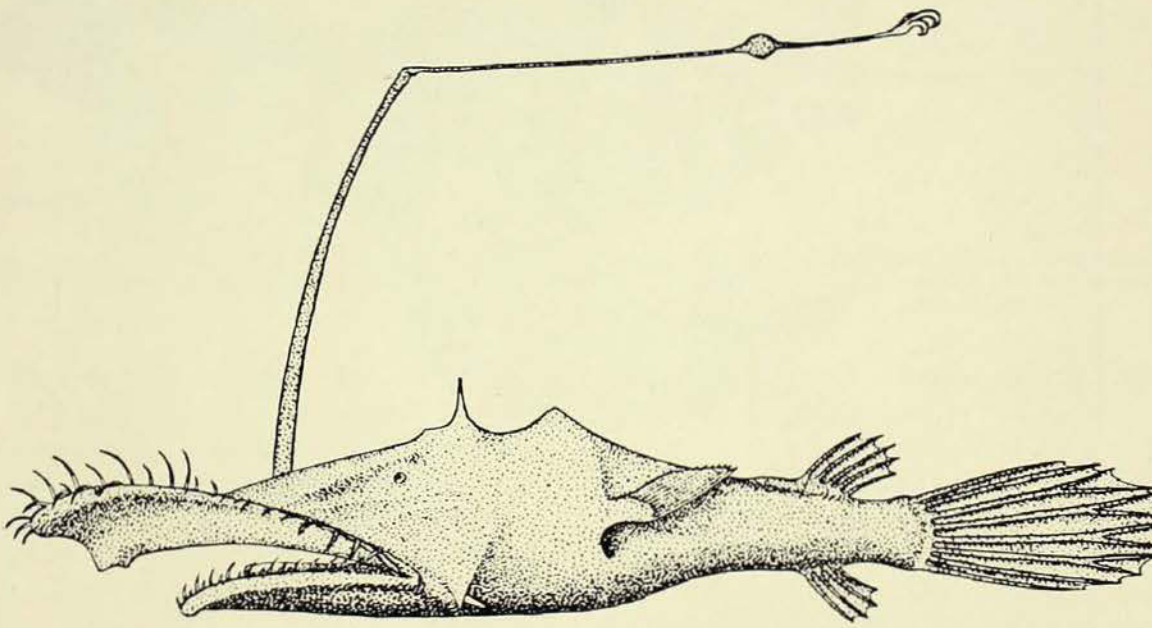
An Angler Fish (Linophryne arborifer), natural size. The fishes of this genus are remarkable for their beard-like appendage, which in this species resembles a piece of seaweed. Its use is unknown.
[After *W. P. C. Tenison*, in the *Natural History Magazine*.

ment of the lateral light spots,—indeed, in the dark room I could tell at a glance how many species were represented in my catch by their luminous hieroglyphics. When several fish were swimming about, these side port-holes were almost always alight, and thus it seems reasonable to suppose that they are recognition signs, enabling members of a school to keep together, and to show stray individuals the way to safety.

The light scales of the tail are apparently of great importance. . . .

Although it is very evident that the caudal flashes have some sexual significance, yet another very important function seems that of obliteration. . . . When the ventral lights die out they do so gradually, so that the eye holds the image of the fish for a time after their disappearance, but the eye is so blinded by the sudden flare of the tail lights that when they are as instantly quenched, there follow several seconds when our retina can make no use of the faint diffused light remaining, but becomes quite blinded. A better method of defence and escape would be difficult to imagine.

of animals from even the Australian cruises of the *Dana* will be worked out, and it would be premature to discuss any of the novelties in this article. The accompanying illustrations of deep-sea fishes which have mostly been taken by other expeditions in other parts of the world will, however, indicate some of the strange types which were revealed to us; silvery hatchet fishes with telescope eyes, horrid little black angler fishes like imps of the deep, fishes of such elastic structure that their paunches hung like bags beneath them, enclosing a swallowed fish almost as big or even bigger than the aggressive little monster which had devoured it, and lantern fishes of every graceful shape with their jewel-like lights. Some curious fish-larvæ had their eyes on long stalks,



The Compleat Angler. This extraordinary fish (Lasiognathus saccostoma) is provided with rod, line, bait and hooks.

[After *Tate Regan*.

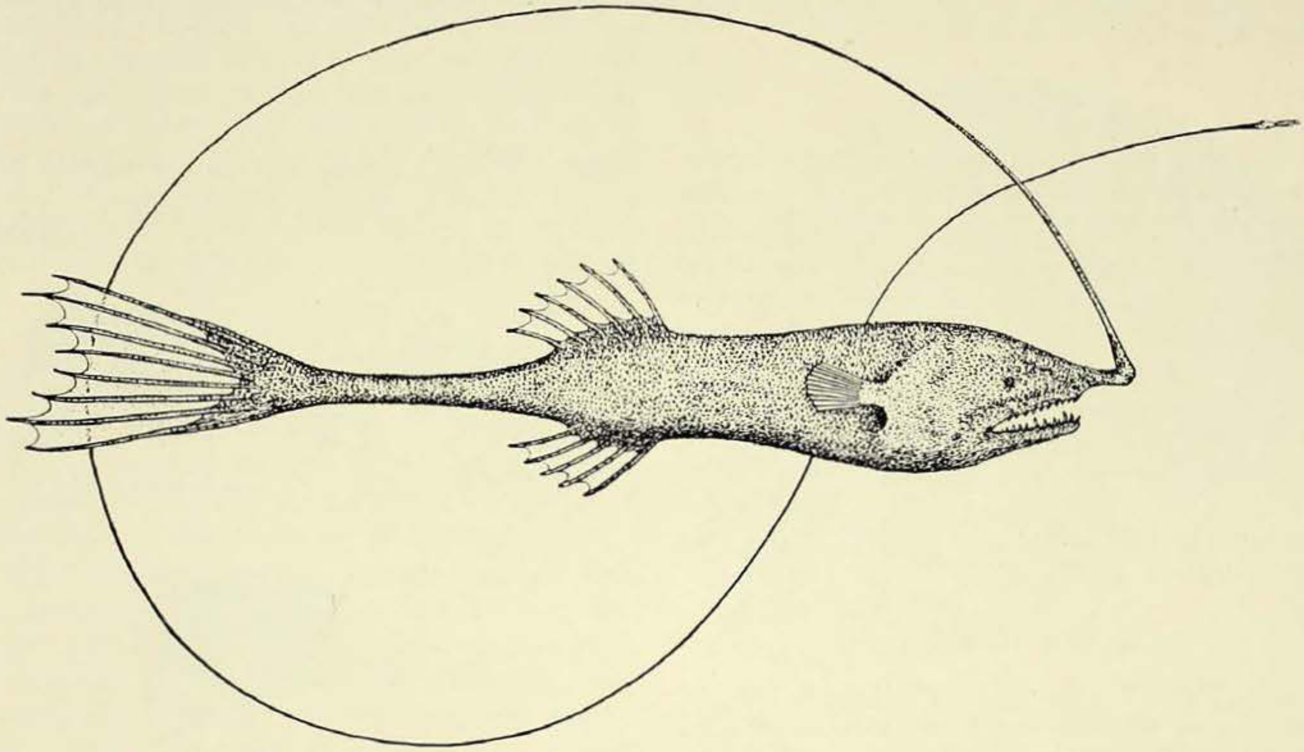
NEW AND RARE SPECIES.

Most of the fishes captured by the nets of the *Dana* were small lantern fishes, of which many species are known, but here and there some extraordinary forms occurred. Nearly every fish that was caught had not before been seen in Australian waters, and so many new species appeared that one's ignorance of the fauna of the Tasman Sea seemed more colossal than ever. Many years will no doubt elapse before all the species

the use of which it is quite impossible for us to conjecture.

In depths of less than 100 metres many glass eels were found. These pale wriggling ghosts were the transparent, leaf-shaped larvæ of eels, and were all examined with much interest, for one of the main objects of the expedition was the discovery of the marine young of the freshwater eels of Australia. None, however, answered their description, and each glass eel proved to be the young of some marine species or other. Young and larval fishes, some with long trailing thread-like fins, and eggs of various kinds, floating with pelagic jelly-fishes and Portuguese men-o'-war, often found their way into the nets as they entered the surface layers of the water.

and the fish becomes dependent on the blood of the female for its nutriment. The male, relieved of all anxiety for procuring its own food, becomes a mere degenerate, and its sole mission in life is to provide the milt necessary to fertilize the eggs of the female.



Nature has provided this Angler Fish (Gigantactis macronema) with a great length of permanently baited fishing line.

[After *Tate Regan*.

A constant watch was always kept for specimens of the "parasitic" angler fish. This fish is one of the most remarkable yet recorded, as the male is entirely parasitic on the female. The diminutive male attaches itself by means of its jaws to the body of the female; the tissues of the female at the point of contact break down, and the male then receives its blood circulation from that of its host. The stomach of the male degenerates,

Unfortunately, no specimens of this extraordinary fish were captured during this cruise, but a preserved specimen on board, with three such males attached, was an object of constant interest. This along with others was caught in the Pacific earlier.

It is hoped that models of the parasitic male angler fishes will shortly be procured for exhibition in the Australian Museum.

The Antiquity of Man

By A. R. Radcliffe-Brown, M.A.,
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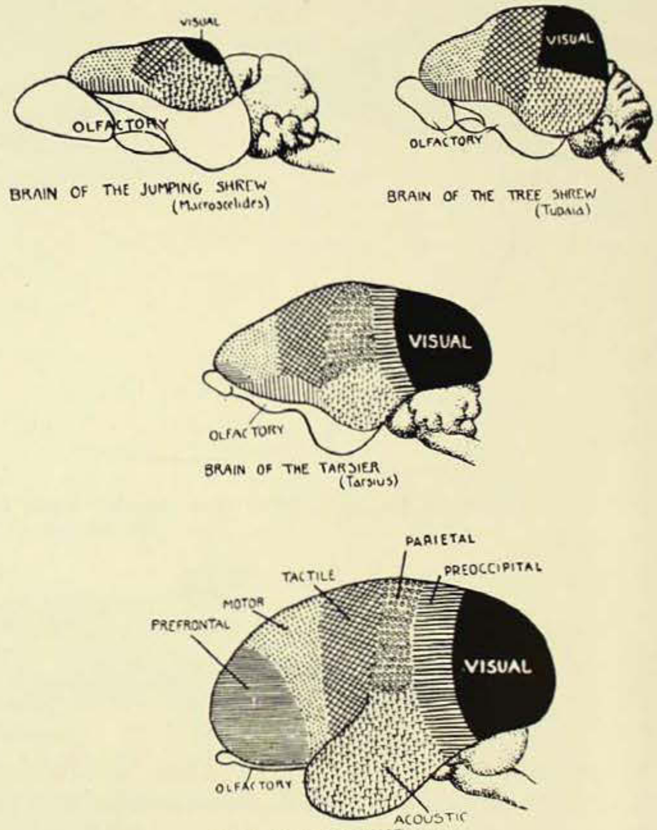
[This article contains the substance of a lecture recently delivered at the Museum and is based on notes taken during the lecture. The article was submitted to Professor Radcliffe-Brown for approval before being printed.—Editor.]

It is a matter of some interest to know how long man has been living on this earth, and it is proposed to discuss in this article the evidence, such as it is, for the antiquity of man, and to show that it is greater than many people suppose. The time involved is so vast that it is not possible to state it in years with any degree of exactness; it is rather to be reckoned in terms of geological periods, which are measured by the changes recorded in the rocks and deposits forming the crust of the earth.

EARTH HISTORY.

The history of this earth, so far as known, is obtained by a study of the sedimentary strata, which are arranged in series of varied thickness, the oldest at the bottom. The relative ages of rocks are determined by the fossils they contain, that is, by the remains of animals and plants which were living at the time when the rocks in question were being formed, and which became embedded in the sand, mud, or clay, which subsequently became consolidated into rock. Each geological period is characterized by its own special fossils, and by studying these we are able to trace the history of life on the earth, though it is not possible to fill in all the details.

Geologists divide the sedimentary rocks into various systems which are grouped into major divisions. Of these the lowest and therefore oldest is the Archæan, followed in order by the Primary, Secondary, Tertiary, and Quaternary, the last being that in which we are now living. Each of these divisions represents a certain lapse of time, indicated roughly by the thickness of the deposits assigned to each. It is difficult, however, to estimate how many years are represented by any geological period, that is, the time involved in the formation of the strata laid down



Brains of the Jumping Shrew (Macroscelides), Tree Shrew (Tupaia), Tarsier (Tarsius) and Marmoset (Hapale). The figures show a progressive reduction of the olfactory area and a corresponding advance in the visual, parietal, pre-occipital and prefrontal areas.
[After *G. Elliott Smith*.

during that period. A rough approximation may be made by observing the rate of sedimentation at the present day and estimating therefrom the time necessary for the accumulation of the deposits formed during a given geological period. This method is admittedly inexact, but chemists and physicists have in recent years discovered a more reliable means of computation based on the rate of radioactive change. It is found that minerals containing uranium undergo a very slow transformation through the loss of radioactive substances by which uranium becomes finally converted into lead. The rate of change may be supposed to be uniform and can be measured, and the amount of change can also be determined, so that we are able to form an estimate of the geological age of strata, though this is still no more than an approximation.

A conservative estimate of the duration of the various geological periods is as follows:

Quaternary ..	200,000 years.
Tertiary ..	2,500,000 years.
Secondary ..	3,750,000 years.
Primary ..	18,750,000 years.
Archæan ..	?

We have no means of estimating the duration of the Archæan, but we know it represents a vast period of time.

The earliest forms of life have left no traces, either because they had no hard parts which could be preserved, or because they have been subsequently destroyed by the vicissitudes to which they and the rocks containing them have been subjected. Life certainly had its beginnings in the Archæan, and in the lowest Primary rocks we find the remains of a large assemblage of organisms, either plants or members of the great division of backboneless (invertebrate) animals. Fishes, the earliest and lowliest vertebrates, came into existence about the middle of the Primary, and, apparently, have not increased or diminished greatly in number of kinds since. Amphibians came shortly after the fishes, and in the later Primary appeared the first reptiles. These increased rapidly and reached their zenith, both in size of individuals and number of kinds, towards the end of the Secondary period. This was the so-called Age of Reptiles, some of the dinosaurs or "Terrible Lizards," which lived at this time, being the largest terrestrial animals this earth has ever seen.

The reptiles then dwindled in numbers and importance, one of the reasons for their decline being, no doubt, the appearance of an important new group, the mammals. The earliest birds date from about the middle of the Secondary, and the oldest fossil mammals are found in the early Secondary. These earliest mammals were small creatures, and they remained unimportant until the end of the Secondary and the beginning of the Tertiary, when they underwent an enormous development,

Skull of Neanderthal Man, found at La Chapelle-aux-Saints, France. The forehead is receding, the eyebrow ridges large, the jaws project forward, and the chin is not prominent.
[From cast in the Department of Anthropology, University of Sydney.
[Photo.—*G. C. Clutton.*

and attained a dominant position which they have maintained ever since. Finally came the particular mammal which we call Man.

WHEN DID MAN FIRST APPEAR?

When we inquire at what point in geological time man made his first appearance we must rely on fossil evidence; otherwise we can but speculate, and speculation is always uncertain and unsatisfactory.

But first we must have a clear idea of what is man and what is not, and must have criteria by which we can recognize human remains when we are fortunate enough to find them. It is easy to distinguish man from other animals if we consider existing forms only, but when we go back in geological time discrimination is not so simple.

CLASSIFICATION OF ANIMALS.

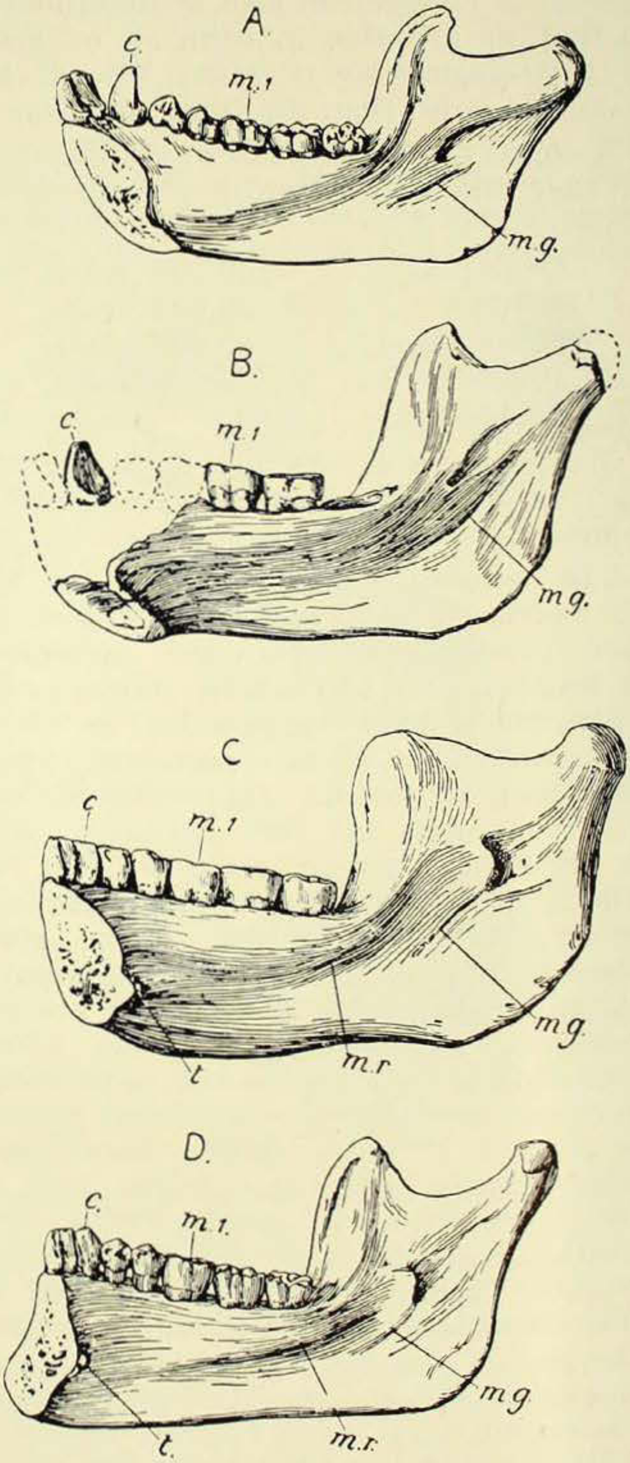
Man is an animal and is therefore to be classed among other animals. Zoologists divide animals into a number of divisions, first separating the vertebrates from the invertebrates. The vertebrates are grouped into classes, of which one is the class Mammalia, consisting of warm-blooded animals which suckle their young. Mammals are further separated into two sub-classes, the Prototheria or monotremes, of which the platypus and the echidnas of the Australian region are the only survivors, and the Theria or higher mammals, which produce their young alive. The Theria are divided into two sections, the Metatheria or marsupials, the young of which are born in a helpless, immature condition, and the Eutheria or placental mammals, in which the new-born young are more highly developed; man is included in this last section. The Eutheria are divided into a number of orders, one of which is the Primates. This order has as sub-orders the Lemuroidea or lemurs, and the Anthropoidea, including the monkeys, apes, and man. One of the families of the sub-order Anthropoidea is the Hominidæ, or Family of Man. If we consider only living races of men we find that the family Hominidæ contains but one genus *Homo* and one species *Homo sapiens*. Fossils, however, have been found which belong to the genus *Homo*, but differ from living men in certain respects, so that they are not regarded as members of the species *sapiens*, and other specific names have been given to them, indicating that, though they were definitely human and had human characteristics, they were different from living men.

HUMAN CHARACTERISTICS.

What do we mean by human characteristics, or, in other words, how is man distinguished from other animals? One distinguishing feature of man is that he walks erect on two legs and uses his other two limbs as arms. Man has two feet used exclusively for locomotion and two hands used exclusively for grasping. But the chief difference between man and the lower animals is to be found in the brain, which in man is proportionately larger and also more complex. It is essentially the brain which determines whether an animal is human or not.

THE PRIMATE BRAIN.

If we take a series of animals belonging to the order Primates we find that the brain shows a progressive evolution and

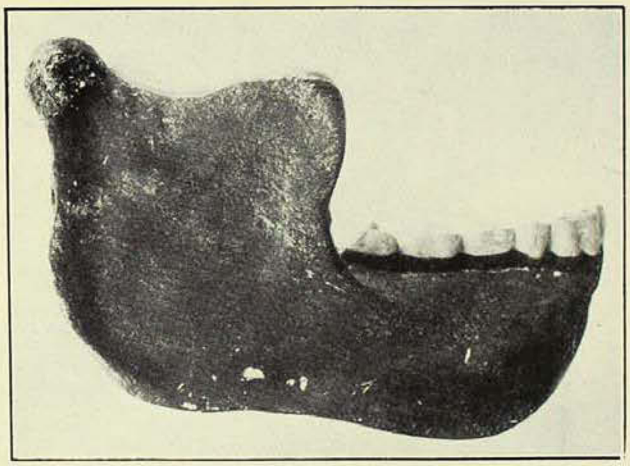


Right lower jaw from inside of (A) Chimpanzee, (B) Piltdown Man, (C) Heidelberg Man, (D) Modern Man. Note the difference in chin slope and the gradual reduction of the canine tooth (*c*); *t.*, genial tubercle; *m.g.*, mylohyoid groove; *m.r.*, mylohyoid ridge.

[After *W. K. Gregory*.

improvement as we proceed from lower to higher forms. In lower animals the functions of the brain are mainly two, namely, to receive impressions from the sense organs and to send messages to the muscles. One part of the brain, for example, is concerned with the sense of smell, another with the sense of sight, and the proportions of the brain devoted to these and other special senses differ in different animals, as shown in the illustration. The olfactory or smell sense is very important in the lower animals; a dog, for example, practically lives in a world of smells, and the portion of his brain devoted to the perception of smells, the olfactory region, is very highly developed. In the Jumping Shrew (*Macroscelides*), an animal which lives on the ground and requires a good sense of smell, the olfactory region of the brain is comparatively large, while the portion devoted to sight is relatively small. In the Tree Shrew (*Tupaia*) the sense of smell is not so important, and a much larger proportion of its brain is concerned with the senses of sight and hearing. This is in harmony with its mode of life, for an arboreal existence calls for a different type of brain, and our ancestors in taking to life in the trees initiated a series of evolutionary changes which culminated in man. It will be noticed that right in front of the brain of *Tupaia* there is a new area, the prefrontal (indicated by horizontal lines). In the Tarsier (*Tarsius spectrum*), one of the lowest Primates (the Tree Shrew is not a Primate, though it is related to the animals comprised in that order), the olfactory area is still smaller, while the portions devoted to sight, hearing, and touch are larger than in the lower forms. More important still is the expansion of the prefrontal and the appearance of two new portions, the parietal and pre-occipital, which are not connected with any special sense but have a co-ordinating or association function, and are concerned therefore with processes of thought.

In the Marmoset (*Hapale*), the most primitive surviving monkey, the olfactory area is very much reduced, though not so much as in man. The brain is larger in proportion to the animal, and the association areas, on the development of which the power of thinking is dependent, are highly developed as compared with the lower forms of brain previously considered. If we continue the series by comparing the brains of the other monkeys, the apes, and then man, we find a continuation of the process that is illustrated in this diagram. The brain increases in size, the olfactory portion becomes more and more reduced, and the areas that are concerned not with directly receiving sense-impressions but with linking together impressions from different senses and co-ordinating them and movement, and which are therefore the organ of intelligence, undergo a great increase in size and complexity.



Jaw of Heidelberg Man. This is the largest and most powerful human jaw ever discovered. The chin is less prominent than in living races of men.
[From cast in Australian Museum.
[Photo.—*G. C. Clutton.*

The last stage of this development of the brain in the order of the primates is that which takes place when the power of speech is acquired, that is, the ability to communicate with one's kind by a conconventional system of uttered sounds. Certain important areas of the human brain are concerned with speech. The possession of speech and the presence of these speech-centres in the brain may be taken as the distinctive mark which separates man from all other animals.

Again, man is the only animal that makes and uses tools. This is of great assistance in determining the antiquity of man, for, even though we may find no human bones, we may find tools in some geologically old strata, and from these infer the former existence of the tool-making animal man.

If, therefore, we find the fossil remains of an animal of the sub-order of Anthropoidea, about which there is satisfactory evidence that it made and used tools and possessed the power of speech, we must regard such a fossil as being human, or at any rate very closely related to man.

THE HUMAN SKULL.

The development of the brain has led to important changes in the skull or brain box, and, since we cannot hope to find fossil brains, we are obliged to give careful study to skulls, their shape and relation to the other bones of the skeleton.

In the lower animals, which walk on all fours, the backbone is habitually more or less parallel to the ground, the skull too occupies a horizontal position,

Skull of Rhodesian Man. This skull is remarkable for the enormous brow ridges and muzzle and the low cranial dome.

[From cast in Australian Museum.

[Photo.—*G. C. Clutton.*

and its articulation with the backbone is at the back of the head, so that the foramen magnum, or large opening through which the spinal cord connects with the brain, looks backwards. In man, on the contrary, the foramen magnum opens downwards when the face and eyes are directed forward, and the skull is poised on its middle on the top of the spinal column and the face occupies a vertical position. Apes have a relatively large brain and skull, but the front of the skull has a low slope with receding forehead and projecting jaws, nor is its head balanced on the top of the backbone. In man the skull projects forward and the muzzle has receded. The human face compared with that of the ape is in some respects degenerate ; it has decreased in size and is less important as an adjunct in animal life. The gorilla has a large and useful face, for he employs his powerful jaws not only for eating and for breaking objects, but in fighting. Man no longer fights with his teeth (except on rare occasions), and he uses nutcrackers and eats soft cooked food. The human nose is a degenerate organ compared with that of a horse or an antelope, but man has benefited by this degeneration of the nose, for it has enabled him to acquire stereoscopic vision, which is not possible for an animal whose eyes are separated by a large nose.

In man the muzzle has disappeared on account of the degeneration of the jaws and man's face is upright. Man has acquired a chin, found in no other animal ; the chin, too, is the result of degeneration, for the reduction of the dental arch, the upper part of the lower jaw, has not been accompanied by an equivalent reduction of the lower part of the lower jaw, so that the chin projects forward. Man's teeth are smaller than those of the apes and of somewhat different shape. His grinding (molar) teeth, apart from the differences in cusp development, have their longest diameter in the transverse direction, while in the ape the longest diameter is from front to back. Teeth are very important in the investigation of fossils, because, being exceedingly hard and resistant, they are sometimes the only evidence available.

NEANDERTHAL MAN.

As has been said, all living men belong to the species *Homo sapiens*. But we are acquainted with fossil men who belonged to other species, differing from existing men in brain, skull, jaw, and other characters. For example, there is Neanderthal man, of whom about thirty examples are known by skulls and skeletons found in France, Belgium, Germany, Gibraltar, Galilee, and other places. In

Neanderthal man the face and jaws are larger and more forwardly projecting than in modern man, except perhaps in some Australian aborigines and natives of New Caledonia. He had a receding forehead and projecting brow ridges, but he had human teeth. He belonged to the genus *Homo*, but differs in species from modern man and is called *Homo neanderthalensis*. His jaw compared with that of a chimpanzee is degenerate, yet it is not like a modern human jaw, and his chin is not so prominent as that of existing races of men. In living men, with a well-developed chin, the genioglossus muscle, by which chiefly the tongue is moved, consists of several more or less separate strands, which permit rapid and co-ordinated movements, and this muscle is attached to two little tubercles on the inner side of the chin known as the genial tubercles (Fig. *t*). In the apes these tubercles are absent, the tongue attachment is farther back, and the tongue itself rests on a shelf of bone ; on this account, the tongue has little freedom of movement. The power of speech is correlated with free movement of the tongue, which depends upon a forward and high attachment to the jaw. In *Homo neanderthalensis* the chin slopes backwards, though not so much as in the chimpanzee, but the tongue attachment is not quite as in modern man. Yet we feel certain that he could talk, for casts of the interior of his skull show that the speech centres of his brain were well developed. He could also make tools, for in the caves where he dwelt we find his flint implements, finely fashioned by spalling and chipping.

The skeleton of Neanderthal man shows us that he did not walk quite upright, for his thigh-bone was curved and the structure of his knee-joint indicates that his legs were always bent at the knees. Examination of the back part of his skull and of his neck vertebræ reveals that his head was not balanced upright on his backbone, but was thrust forward and supported by a mass of muscle at the back of his head.

We know almost exactly when Neanderthal man lived. At the end of the Tertiary, Europe enjoyed a warm climate and was covered with forests, in which lived lions, elephants, rhinoceroses, and other animals related to the fauna now inhabiting the warmer parts of Africa, and in the rivers was to be found the hippopotamus, not identical with, but resembling the living hippopotamus now found only in much warmer latitudes. At the beginning of the Quaternary period the climate of Europe grew colder, and the ice cap spread

Piltdown Man (Eoanthropus dawsoni). This restoration, by Sir Arthur Smith Woodward, shows the combination of human and simian characters. The skull is of human type, but the jaw is ape-like. The dark areas represent fragments actually found ; the jaw is restored from the right side.
[From cast in Australian Museum.
[Photo.—*G. C. Clutton.*

southwards and crept down the mountains towards sea-level, until northern Europe, like Greenland today, became covered with a sheet of ice. The warmth-loving animals retreated southwards and their place was taken by hardier creatures, such as the woolly mammoth, the woolly rhinoceros, and the cave bear. But again the climate became milder, the ice retreated and the fauna changed once more. There were four major glacial epochs during the Pleistocene, as it is called, separated by mild interglacial periods. Each of these alternating cold and warm periods had its characteristic animals, which migrated south or north with the advancing and retreating ice sheet.

Neanderthal man lived in Europe during the last ice age or Würm glaciation, for we find that he was contemporaneous with the last sojourn in middle Europe of the woolly mammoth, cave bear, the Scandinavian reindeer, the Arctic fox, and other animals adapted for existence in a cold climate. At the end of the Würm glaciation Neanderthal man disappears and is succeeded by *Homo sapiens*, who entered Europe, coming probably from Africa, and we are able to fix a date for his coming into Europe. This is rendered possible by the work of the Swedish geologist, Baron Gerard de Geer, and his assistants, who for years gave close study to the laminated clays deposited in Swedish lakes which laved the retreating ice front of the last continental glacier. These glacial clays show seasonal bands or layers, and the deposit formed in winter differs in thickness and appearance from that formed in summer, when melting was greater and the supply of sediment more plentiful. Two successive layers represent one year's deposit, and by counting the number of layers it was found possible to ascertain the time of the last retreat of the ice, just as the age of a tree may be calculated by counting the annual rings of growth. This method of computation has been extended and its accuracy confirmed by researches on lake deposits outside of Sweden, and the results therefore may be regarded with confidence.

It is found that the last recession of the ice sheet began about 35,000 B.C., and hence we may say that modern man became an inhabitant of Europe about 25,000 B.C., displacing Neanderthal man. But modern man must be older than that, for before that time he was living somewhere else, probably in Africa, and for thousands of years prior to that date Neanderthal man was in Europe, living in caves and hunting the animals which inhabited the country during the Würm ice age.

HEIDELBERG MAN.

In 1907 there was found in a sandpit at Mauer, near Heidelberg, Germany, a massive jaw, which is the only relic we have of another fossil man. The teeth prove that this jaw was human, but it has several ape-like characters. It was found at a depth of thirty feet, associated with bones of animals characteristic of mild interglacial times. The jaw is practically chinless, and is the heaviest and most powerful human jaw ever discovered. It is possible that *Homo heidelbergensis*, as he is called, is really an exceptionally robust example or variety of the Neanderthal race, in which case he is not a separate species nor entitled to a different specific name; it is at any rate probable that he was closely related to Neanderthal man. We do not know whether Heidelberg man could talk, as his skull has never been found, and we know nothing of his brain, but it is probable that he made tools, for, in the valley of the Thames, the Seine, and the Somme, we find flint tools in deposits containing the remains of animals which lived during the third interglacial period. These Chellean tools, as they are called, are of crude workmanship, but are undoubtedly of human origin. It is true, however, that these Chellean implements have been found only west of the Rhine, while the Heidelberg jaw was found east of the Rhine. It is unfortunate that the men who lived at this period had not yet taken to life in caves, for then we should find their bones in abundance. Chellean man lived in the open, for the climate was warm, and we find only his tools in river deposits.

RHODESIAN MAN.

Another species of fossil man, *Homo rhodesiensis*, was found in 1921 in the Broken Hill Mines, Rhodesia. This interesting find consists of a skull with immensely heavy eyebrow ridges, a receding forehead and an enormous muzzle-like face. It was found embedded in lead and zinc ore, and only a lucky chance saved this precious relic from being passed through the smelter, as was doubtless the fate of other human and animal remains which would have given us very valuable information.

Examination of the skull, in which the foramen magnum has a forward position, indicates that the skull was poised on an erect spine, and the conformation of the brain, as indicated by the skull, suggests that *Homo* *rhodesiensis* had the power of speech. He was therefore definitely a man and belonged to the genus *Homo*.

We cannot date this prehistoric man, for Rhodesia, unlike Europe, did not suffer a series of climatic changes at the beginning of the Quaternary, hence the animals which inhabited the country then were much the same as those of the present day. He may have lived 2,000 years ago or 100,000 years ago.

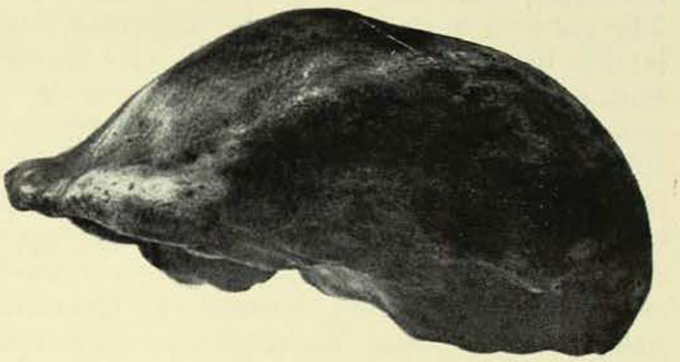
PILTDOWN MAN.

In 1912 a fragmentary skull and jaw were found at Piltdown, in Sussex, England. These remains caused much controversy, because it was evident that the skull was human, while the jaw strongly resembled that of an ape. It was thought, therefore, by continental and American anthropologists that the skull was that of a new species of man, and the jaw that of a new species of ape. However, it seemed improbable that two new species, one a man and one an ape, should leave, the one its skull, the other its jaw, in the same deposits in Sussex. It is more reasonable to believe that the skull and jaw belonged to one individual, and this is confirmed by a more recent discovery in China. We may safely conclude, therefore, that Piltdown man had a human brain case, though he had a chinless ape-like jaw and the teeth were not of a definitely human type. We cannot therefore place him in the genus *Homo*, and this interesting and important specimen has been described as a new genus and species, *Eoanthropus dawsoni*, the specific name being given in honour of the discoverer, Mr. Charles Dawson.

Piltdown man was perhaps a tool-using animal, for in the same deposit were found a worked bone and stone flakes, which, however, were not definitely fashioned and the shape of which may be accidental. The brain, however, as evidenced by an actual cast of the skull, is definitely human, and has association areas not found in apes.

PEKIN MAN.

A most important discovery has recently been made in China. Dr. Andersen, a Swedish scientist, when examining some Chinese flakes and stone tools, found two teeth, which were studied in Upsala and pronounced to be hominid teeth of a new type. Dr. Davidson Black, of Pekin University, examined similar teeth and declared them to be those of a new hominid genus, which he named *Sinanthropus pekinensis* (Chinese man of Pekin). Anthropologists are chary of accepting new genera on the evidence of isolated teeth, and at first looked askance on Pekin man. But Dr. Davidson Black, with splendid persistence, continued his search for further evidence, and last year a block of stone containing the remains of several skulls and jaws of the new



Skull-cap of the Ape-man of Java (Pithecanthropus erectus). This figure shows that this animal had a low type of brain compared with that of true man. Its brain indeed was in size about midway between that of man and one of the higher apes.
[From cast in Australian Museum.
[Photo.—*G. C. Clutton.*

form were discovered. These are embedded in a very hard matrix, and it will be some considerable time before the bones are disentangled so that they can be studied in detail. Already, however, jaws have been revealed, and these are ape-like and similar to the Piltdown jaw. Portions of skulls are also visible in the matrix, and, according to Dr. Davidson Black, these are of human type. This new find justifies the association of the Piltdown skull and jaw, and the two finds are of the same geological age, namely, the beginning of the Quaternary or Pleistocene, or possibly a little later, carrying us back to a period about 150,000 or more years ago.

Are *Eoanthropus* and *Sinanthropus* men? Professor Elliot Smith, from examination of the brain case of Piltdown man, concludes that he could talk, and, if that is so, we must regard him as a human being.

TRINIL MAN.

There is still another find that must be considered, namely, *Pithecanthropus erectus*, of Trinil, Java. This "Erect man-ape" is known by the skull cap, two teeth, and a thigh-bone. The question again arises whether all the parts found belong to one and the same individual; the probability is that they do. The skull is hardly human, and, in fact, is just about midway between the skull of a man and that of an ape. It has the heavy eyebrow ridges of an ape and a receding forehead, but the thigh-bone is human. The general opinion is that *Pithecanthropus* is not entitled to inclusion in the family Hominidæ, but should be placed in a new family, Pithecanthropidæ. Professor Elliot Smith has recently examined an internal cast of the skull cap, and thinks that we may have to regard *Pithecanthropus* as definitely human, because its speech centre shows a certain amount of development; it is more satisfactory, however, to exclude it from the human family. The age of *Pithecanthropus* is the same as that of *Eoanthropus* and *Sinanthropus*, that is, it dates from the early Quaternary.

CONCLUSION.

Summing up, we may now present a tabular statement showing the classification of man and *Pithecanthropus* in the animal kingdom as follows:

Phylum, Vertebrata.
Class, Mammalia.
Sub-Class, Theria.
Section, Eutheria.
Order, Primates.
Sub-Order, Anthropoidea.
Families, Pithecanthropidæ and Hominidæ.

The family Pithecanthropidæ consists of the single genus and species, *Pithecanthropus erectus*, but the family Hominidæ contains three genera and six species as follows:

Hominidæ—
- —*Eoanthropus dawsoni.*
- —*Sinanthropus pekinensis.*
- —*Homo*—
  - —*heidelbergensis.*
  - —*neanderthalensis.*
  - —*rhodesiensis.*
  - —*sapiens.*

The family Hominidæ dates back at least 150,000 years. But we do not know how long the human family existed before that, perhaps in the Tertiary, though there is at present no fossil evidence of the existence of Tertiary man. It is clear, however, that the ancestors of the hominid family must have existed long before man himself came upon the scene. It is necessary therefore that we study the geological history and evolution of other anthropoids, namely, the apes. It is quite likely that the earliest human ancestor was a contemporary of the early ancestors of the apes, and these we find in the lower Oligocene (Tertiary) of the Fayûm, in Egypt. The lower Oligocene deposits were laid down approximately 1,500,000 years ago, and we may therefore say that the Hominidæ, the family to which we belong, made its first appearance between 1,500,000 and 200,000 years ago. Several different genera developed and passed away, and the sole surviving genus *Homo* must be at least 50,000 years old. This genus divided into several species, such as *Homo neanderthalensis* and *Homo rhodesiensis*. Finally, we are the only survivors of a large family, and no doubt we survive because we are *sapiens*.