ZOOLOGY LIBRARY
UNIVERSITY OF TORONTO
3 1761 03673199 0

HANDBOUND
AT THE

UNIVERSITY OF
TORONTO PRESS

DEPARTMENT OF ZOOLOGY
LIBRARY

552
(7) 9403

A TEXT-BOOK

OF

ZOOGEOGRAPHY.

London: C. J. CLAY AND SONS,
CAMBRIDGE UNIVERSITY PRESS WAREHOUSE,
AVE MARIA LANE.

AND

H. K. LEWIS,
136, GOWER STREET, W.C.

Glasgow: 263, ARGYLE STREET.
Leipzig: F. A. BROCKHAUS.
New York: MACMILLAN AND CO.

Map showing Zoogeographical Regions.

Cambridge Natural Science Manuals
BIOLOGICAL SERIES.

GENERAL EDITOR:—ARTHUR E. SHIPLEY, M.A.
FELLOW AND TUTOR OF CHRIST'S COLLEGE, CAMBRIDGE.

A TEXT-BOOK

OF

ZOOGEOGRAPHY

DEPARTMENT OF ZOOLOGY
LIBRARY
BIOL. DEPT.
UNIV. TORONTO.

BY

FRANK E. BEDDARD, M.A. (OXON.), F.R.S.

PROSECTOR OF THE ZOOLOGICAL SOCIETY OF LONDON, AND
LECTURER ON BIOLOGY AT GUY'S HOSPITAL.

CAMBRIDGE:
AT THE UNIVERSITY PRESS.
1895

[*All Rights reserved.*]

Cambridge:
PRINTED BY J. & C. F. CLAY,
AT THE UNIVERSITY PRESS.

PREFACE.

IN this volume I have attempted to give the principal facts and conclusions of Zoogeography, without an undue profusion of detail. A few examples only have been selected to illustrate the principles. As far as possible I have endeavoured to use instances that have not been made use of by Mr Wallace in his two works upon this subject. I have taken Kerguelen Island and Fernando Noronha as examples of oceanic islands; the facts of distribution and the inferences to be drawn are illustrated largely by the earthworms; and in other places I have availed myself of some of the more recent sources of information. Naturally a large portion of this book, as must be the case with any book upon Geographical Distribution, is based upon the two indispensable treatises of Mr Wallace. I have also found great assistance in Prof. Heilprin's work upon Distribution in the International Scientific Series, and in an excellent manual

upon the same subject by M. Trouessart; I have checked and added to the facts that I had accumulated by a careful comparison of them with the article Geographical Distribution in Prof. Newton's *Dictionary of Birds*. Numerous special memoirs have also been laid under contribution, a reference to which will be found in the proper place.

FRANK E. BEDDARD.

LONDON.
November, 1894.

CONTENTS.

CHAPTER I.

THE GENERAL FACTS OF THE DISTRIBUTION OF ANIMALS.

Introductory.

THE entire world both land and sea supports everywhere animal life. The extreme cold of the arctic regions is not too intense to permit of the existence of at least a few forms of life, while the warmer regions of the globe have everywhere an abundant fauna, which increases towards the tropics; it is even probable that the icebound antarctic continent, if it could be explored, would be found to possess some inhabitants.

The most elementary knowledge of Zoology is sufficient to enable us to see that, while terrestrial life is as abundant as marine, the kinds of animals inhabiting these diverse situations are different. We can distinguish in fact between purely terrestrial and purely aquatic animals. The latter group can be again divided into two great classes, those which inhabit the sea and those which inhabit the fresh waters of the land. There is however no absolute break between these various groups. The

fresh waters themselves gradually pass into salt at the mouths of rivers; while a marsh, particularly one that is subject to periodical drying up, is to some extent intermediate between the land and the water.

Corresponding to this absence of hard and fast lines in inorganic nature we find a similar absence of definiteness in the animals which frequent the waters, the dry land, and the transitional areas. The duck tribe are equally at home when swimming in a lake and when flying from one pool to another. There are even ducks which perch on trees. Closely allied Crustacea may be marine, estuarine, fresh water or terrestrial in habit. Certain sharks, normally marine, ascend rivers for some distance, and the Manatee of the west coast of Africa and the east coast of America is quite as much at home when browsing upon the marine algae of the coasts of those continents as when living in their rivers. Though we may broadly separate animals into terrestrial and aquatic, there is no large group of animals which is exclusively terrestrial. Even insects which approach nearest to this condition have plenty of aquatic representatives; there is even a peculiar genus of bugs, *Halobates*, which inhabits the open sea far from land.

On the other hand, there are groups which are purely aquatic, and even some which are only marine, being never found in fresh water; but these are few. Among Vertebrates fishes are the only group which can be said to be almost absolutely aquatic; and here too there are some slight exceptions. The well-known Climbing Perch, *Anabas scandens*, can with impunity leave the streams which it

inhabits; the mud fish of Africa and America has lungs as well as gills, and can suffer with equanimity the drying up of the rivers in which it lives. Eels are said to move from one pool to another across the intervening grass. The curious little fish *Periophthalmus* voluntarily leaves the sea and hops along its margin on the look-out for the Mollusc *Onchidium* upon which it largely feeds. Among Invertebrates there are more purely aquatic groups; and these are exclusively marine. No Ascidian, no starfish, brittle star, sea urchin, or sea lily has as yet been met with except in the sea. Sponges and Cœlenterates are without exception aquatic and for the most part marine, their delicate organisation not being able to withstand continued dryness. But these are positively the only large groups which are purely aquatic. Many others are principally aquatic, such as the Flat worms, with terrestrial allies in the land Planarians, the Crustacea, the Annelids and some others.

Not only can we draw these broad distinctions between the habitats of different animals, finding one to be terrestrial, another aquatic and a third amphibious; we can also assign to each a definite place upon the land or in the waters. The Indian Ocean is frequented by creatures which are unknown in the colder waters of the North Sea; the Mississippi has alligators which the Thames, for example, has not. It is a matter of common knowledge that the tiger is restricted to Asia and the puma to South and certain parts of North America; the elephant is unknown beyond the old world, and it has even there a limited area of range. It would be as surprising to meet with an

elephant even in the most secluded of Brazilian forests as to meet with a tiger genuinely at home in the neighbourhood of a peaceful English village.

That branch of Biology which is termed Geographical Distribution, or, when applied to either animals or plants only, Zoogeography and Phytogeography, is concerned with facts such as the above; it has also to do with the solution or attempted solution of the various problems to which these facts give rise. The science is not limited to a consideration of the animals which inhabit dry land. But this volume will only deal with those forms, touching incidentally upon some of the fresh water species, whose distribution is apparently governed by the same laws as those which govern the distribution of the purely terrestrial animals.

We shall now commence our survey of the chief facts in the distribution of land animals. It has been said that every animal has its place in the world, which may be wider or narrower. The country which is inhabited by a given animal is called its area of distribution, its habitat or locality. The converse follows that every tract of the earth's surface is inhabited each by its peculiar set of animals. But they are not met with everywhere in that area. Almost every year a new volume is published giving a list of the birds of a particular county or it may be district; anyone who will take the trouble to inspect and compare a series of these volumes dealing with many different counties will be struck by the fact that a given species of bird may be absent from one list or stated to be uncommon, while numerous records of its discovery will be

found in another. The same thing holds true of other groups; the badger, for example, will be found in one wood but will be absent from another; nevertheless generally speaking this animal may be said to inhabit the greater part of England, not to mention foreign regions in which it is also found. Were we to put together all that has been recorded of the range of this or any other animal and colour a map of England in correspondence with those facts, we should find that a large map would be coloured by a series of closely set but separate patches of colour; on the other hand a small map would practically have to be coloured all over to indicate the range of the animal. The reason for this is that the badger can only live in certain kinds of country. It is not at home for instance in bare chalky downs or on the tops of high mountains; it prefers woods and the immediate neighbourhood of woods.

Locality and Station.

We must carefully distinguish between locality and station. While the area inhabited by a species is usually continuous, it by no means always happens that the station consists of one continuous tract. Animals inhabiting forests or moorland or pools are only found where the suitable circumstances occur. But in such instances the habitat of the animal may be wide, only broken up into a series of stations. We should not regard a case of this kind as one of discontinuous distribution. Often however the local phenomena of distribution have not so clear an interpretation. Every entomologist is aware of the often

capricious occurrence of butterflies and moths; we do not now refer to marsh-loving or wood-loving species or to any intelligible restriction of this kind. Out of a dozen fields, to the eye equally well suited for the maintenance of a given species of moth, in which for instance the food plant is equally abundant, two or three or it may be only one will be inhabited by the insect in question, which will there perhaps swarm. Some years since a small moth was found at Folkestone only in a particular tract of grass with no obvious advantages—indeed the reverse, as it was scanty and trodden under the feet of passers by—to the exclusion of neighbouring grassy areas; this insect, known as *Tapinostola bondii*, was abundant in this particular locality but nowhere else in the neighbourhood. In every local faunal list such and such a wood or field is given as the locality for a particular insect, which would be equally at home in other woods and fields, but is not as a matter of fact found in them. To get the particular insect we have perhaps to journey to another county or even to another part of England; possibly a particular wood is the only part of England where it is to be met with and the next locality will be on the Continent. No doubt some of these apparently capricious variations are to be explained by advancing civilisation. Building, draining and the gradual reclamation of the country are fatal to insect life as a rule. But this will not explain every case of capricious restriction to a few separated stations, such as are so commonly met with among the Lepidoptera of this country.

The Range of Animals.

In the range of species we meet with every condition, from world-wide distribution to the most restricted habitat. It has been said that man is the only animal (with the exception perhaps of his parasites) which is literally found in every habitable part of the earth's surface; but a few others are almost as widely scattered. Among mammals only certain bats are in this position, for though the common mouse and the rat are found nearly everywhere, it is very possible that man is responsible for this wide dissemination. The Barn Owl (*Strix flammea*) occurs in most parts both of the new and old worlds. It is true that in different countries it has received different names; but the opinion of many is that these are at the most local races which are hardly deserving of being separated as species. The Painted Lady (*Vanessa cardui*) is an example from another class of animals which has an equally wide range. This butterfly extends from Europe to the Islands of the Pacific and to New Zealand, but is not found in the West Indies and certain parts of South America. The common Red river Worm (*Tubifex*) seems to be universally spread. At any rate examples from so distant a spot as New Zealand do not differ in any appreciable point from those of England. A species belonging to another family of Oligochæta, *Henlea ventriculosa*, occurs in Europe, in the territory of the Khirghese Tartars, and in New Zealand.

The now extinct Large Copper Butterfly was formerly found in abundance in the Cambridgeshire fens, but found

nowhere else in the world. The limitation of particular species of humming-birds to particular peaks of the Andes, and of snails to particular valleys, are other examples. *Francolinus Kirki* of the island of Zanzibar is almost as striking an instance of the same phenomenon. The Vendace (*Coregonus vandesius*) restricted to Loch Maben in Dumfriesshire is an animal with a still more limited range, and several other examples might be given, particularly from the faunas of islands. The two extremes are naturally connected by numerous intermediate stages, where an animal has a more or less limited habitat.

Cosmopolitan groups.

There are comparatively few groups of terrestrial animals which are truly cosmopolitan. As the groups get smaller the number of those that are cosmopolitan decreases. That is to say, there are more cosmopolitan families than genera, and more genera that are cosmopolitan than species.

Mr Wallace enumerates in his work upon Geographical Distribution no less than sixteen families of birds which are really cosmopolites; they are, *Corvidæ* (Crows) and *Hirundinidæ* (Swallows) among Passerines; Kingfishers among Picariæ; among other land birds, *Columbidæ* (Doves), *Tetraonidæ* (Grouse), *Falconidæ* (Hawks), *Strigidæ* (Owls); among waders *Rallidæ* (Rails), *Scolopacidæ* (Snipe), *Charadriæ* (Plovers), *Ardeidæ* (Herons); among aquatic birds *Anatidæ* (Ducks and Geese), *Laridæ* (Gulls), *Procellaridæ* (Petrels), *Pelecanidæ* (Pelicans) and *Podici-*

pedidæ (Grebes). Only one family of mammals are really cosmopolitan, namely, the *Vespertilionidæ*. There are several families of butterflies and moths which are in this position and nearly all the families of beetles. The *Helicidæ* alone of the terrestrial Mollusca are universally distributed, and among earthworms the two families *Lumbricidæ* and *Cryptodrilidæ*. It is a significant fact that of these families by far the majority are winged creatures, which are naturally less restricted by barriers. The earthworms form an apparent exception which is not really so; for it is highly probable that the universal range of these families is due to human agency. Again, it is important to notice that of the cosmopolitan birds at least eight are largely aquatic in habit or frequent the margins of streams and lakes. The conditions of life for aquatic birds are more similar in different parts of the globe than those of purely land birds. Moreover all these families are numerous in genera and species.

Cosmopolitan genera are fewer in proportion. Among birds we have *Hirundo* (Swallow), *Pandion* (Osprey), *Strix* (Barn Owl), *Rallus*, *Porzana* (Rails), *Gallinula*, *Fulica* (Coots), *Numenius* (Stilt Plovers), *Limosa* (Godwits) and several other Scolopacidæ, *Charadrius* (Plovers), *Ardea* (Heron), *Nycticorax* (Night-heron), *Anas* (Duck), *Stercorarius* (Skua), *Larus* (Gull), *Sterna* (Tern), *Puffinus* (Puffin), *Procellaria*, *Fulmarus* (Petrels), *Pelecanus* (Pelican), *Phalacrocorax* (Cormorant), *Podicipes* (Grebe). Among butterflies the genera *Pyrameis* (Painted Lady), *Polyommatus* (Blues), *Pieris* (Whites), *Papilio* (Swallowtail), *Pamphila* and *Hesperia* (Skippers) are universally distributed.

Macroglossa, *Chærocampa* (Hawkmoths), *Macrosila* (Clear wing) among moths are also cosmopolitan.

As to species there are comparatively few that have a world-wide range; the most striking example among birds is the Osprey. *Gallinula chloropus* and *Totanus incanus* have the same distribution. Among insects it is more difficult to discount the interference of man, which may be responsible for a world-wide distribution. *Anosia plexippus* is a butterfly which appears to be found almost everywhere. I have dealt on another page[1] with those species of earthworms which are cosmopolitan or nearly so and arrived at the conclusion that it is in those cases really a question of transport by man. The same argument seems according to M. Trouessart to apply to the cosmopolitan Gecko, *Platydactylus facetanus*. Even the *Lepidoptera* above mentioned are not above suspicion on this score; the pupæ could so easily be accidentally conveyed to the most distant countries. The common bee-fly (*Eristalis tenax*), which so closely resembles to the superficial inspection a honey-bee, has reached as far as New Zealand, doubtless by the same agency.

Restricted groups.

We have besides universally distributed groups some of which are remarkably limited in their range. Naturally this applies most of all to species and least to families. The majority of species have a more or less restricted range, so much so that it would be impossible to give any

[1] *v. infra.*

catalogue of them. A few of the more remarkable examples may however be referred to. The most striking of these are certain fishes which are limited to a single lake; thus the Lough Killin Charr is confined to the lake of that name. A small moth, *Ornix devoniella*, was once only found in Devonshire. The monkeys of the genus *Brachyurus*, comprising three species, are limited each to a moderately small forest tract in South America. The majority of examples of species with a limited range are of course to be found upon oceanic islands. Not only are there species with a very small range in space but also genera. Here again the most numerous examples are to be found on oceanic islands such as the now extinct Starling, *Fregilupus*, of Reunion. But there are other cases of genera which have facilities for a wider range, but which for one reason or another (to be considered later) have been unable to extend that range. The genus *Opisthocomus* (containing by the way only a single species, being the type of a distinct family) is limited to a portion of British Guiana; the Gorilla to the forest tract of the west coast of Africa; here again there is but one species. Among families there are also a few with an exceedingly restricted distribution. The Rhinochetidæ, containing only one genus and species, *R. jubatus*, the Kagu, is only found in the island of New Caledonia; the Trumpeters or Psophiidæ are confined to certain districts of the Amazons, and the four or five species of the genus might be quoted as a case of very limited range in species. In Madagascar the family Chiromyidæ is represented by but one species. Cases of limited range among groups that may be regarded

as higher than families are naturally not common. The most striking perhaps is that of the Rhynchocephalia; this group has but one species, the well-known *Hatteria*, which is only found in a few small islands off the coast of New Zealand. Not quite so striking from some points of view, but perhaps more so in another, in that the group is a higher one, is the case of the Monotremata; the two or three genera are limited to certain parts of the Australian region.

The facts just enumerated lead us to one of the axioms of the science of Zoogeography, which was formulated by Mr Sclater[1] in the following words. "Every species occupies a definite area on the world's surface; and in like manner every genus and family, or other higher assemblage of species, occupies a definite area on the earth's surface; or more shortly, locality or existence in a certain spot is quite as much an attribute of animals as structure or the possession of a certain form or shape."

The meaning of a restricted distribution.

It does not, however, by any means follow that this area is now as it always has been. To study Zoogeography properly a knowledge of the extinct forms of life is not only desirable but necessary. By the aid of Palæontology various facts, at first sight dark and meaningless, become clear, or at least clearer. We must imagine each species setting out from its centre of origin and gradually ex-

[1] "The Geographical Distribution of Mammals," Manchester Science Lectures, 1875.

tending itself by actual or passive migration right and left and in every possible direction from this focus. Gradually the form will be modified, or by competition or for some other reason become extinct, leaving perhaps descendants scattered here and there to tell the tale of a formerly wide range. A guess can be made as to the comparative age of a species or a genus by comparing such facts.

In all probability these instances of a restricted distribution are to be explained in one of two ways; either the form is a new one or it is an ancient one. A new species recently come into existence would naturally, at least on any theory of evolution, have a limited range because it would have come into being at one locality and not have had time to extend its range, supposing an extension to be possible and not barred by impassable barriers.

The former alternative applies probably to most of the examples that have been used, particularly perhaps to the peculiar species often found upon oceanic islands. There are however numerous species, as limited in their range, which are in some cases certainly vestiges of races once universally or widely distributed.

The Chimpanzee tribe is at present limited to the forest region of central Africa. Its utmost range is nearly across that continent. But the palæontological records of India contain a description and figures of a portion of a skull evidently belonging to a chimpanzee which at one time existed in India. Probably that indicated the high-water mark of the extension of the chimpanzee, which has since retired to more restricted boundaries. We know from historical records that the lion used to occur in

Greece as well as in India and Africa, where it is now alone met with. And at an earlier period still it was found in this country. The hippopotamus, now limited to Africa, was once found in Madagascar, and probably the same species in Europe.

In such cases however the species in question are generally also of generic, even of family, rank. The remarkable lizard *Hatteria*, as already mentioned, is confined to one or two islands off New Zealand; this lizard, as the fossil remains of its allies tell us, is the sole survivor of the Rhynchocephalia, a race of Saurians found in the Mesozoic rocks of this country. The Viverrine Carnivore *Cryptoprocta*, found at present only in Madagascar, is held by some to be the last surviving remnant of the extinct Creodonta; in any case it is generically distinct from any other carnivorous animal. The same arguments may be applied to the Thylacine of Tasmania, to the Aye-Aye (*Chiromys*) of Madagascar, and to many other animals. An apparently similar series of facts is therefore probably to be explained in quite a different manner, an instance of extremes meeting. The same mode of distribution is indicative either of great antiquity or of extreme modernity.

A comparatively restricted range however may be also due to incapacity for migration. The converse is perhaps more obvious. Widely distributed animals are either flying animals independent of barriers which impede the purely terrestrial species, or possess some special facilities for voluntary or involuntary translation from country to country. An entirely arboreal creature cannot pass across

a level tract of country with no trees; nor can an Amphibian whose skin requires to be kept moist cross an arid desert. This consideration leads to an important matter, the capacities for migration possessed by different animals which will be discussed later.

Discontinuous distribution.

On the hypothesis that each animal has had its centre of dispersal, that it came into existence once and at a definite place, it is clear that originally at least the area inhabited by a given species must have been perfectly continuous. As a matter of fact it is generally the case; the remarkable thing appears to be not that there are occasionally breaks in the continuity of the area inhabited by a certain species but that it is so difficult to find instances to illustrate the breaks. Mr Wallace explains the rarity of discontinuous distribution among the species of birds by the suggestion that they are possibly "more rapidly influenced by changed conditions, so that when a species is divided the two portions almost always become modified into varieties or distinct species." It must be borne in mind also that birds are a modern group, and the very difficulty of classifying them satisfactorily indicates that there are but few breaks in the series; they are possibly still in a condition of perpetual modification; they have not so to speak become fixed and crystallised, like some of the older and in a sense more effete groups of animals. However this may be, Mr Wallace quotes from Mr Seebohm a highly remarkable instance of discontinuous

distribution in a species of Tit. The Marsh tit, *Parus palustris*, has a range nearly co-extensive with the Palæarctic region; but it is known throughout this immense tract of country in certainly three varieties. One of these is found in Southern Europe, in Italy, Turkey, Greece, and Asia Minor. The same variety does not crop up in the intervening country but again appears in South China. Whether this variety is entitled to specific rank or not, the fact is remarkable and really of equal value. It almost suggests an explanation that has been sometimes advanced to account for discontinuous distribution in the species of Mollusca. No great difficulty could be felt in the assumption that the same variety had been twice produced in localities of a somewhat similar climate. Mr Wallace refers to one or two other examples of a somewhat similar nature; the Reed bunting of this country reappears in Japan, being absent from Asia. To take an instance from another class, Dr Scudder records the existence of the butterfly *Œneis jutta*[1] in the Rocky Mountains of British Columbia and in Hudson's Bay, and its absence from the intervening tract.

The genus *Peripatus*[2] offers an example of a genus with an exceedingly wide and at the same time discontinuous distribution. *Peripatus* is universally regarded as a very archaic form of Arthropod, which has preserved certain characters of the worm-like ancestor from which it is presumed that the Arthropods have been derived. There are, for example, a series of paired excretory organs

[1] Butterflies of E. United States.

[2] *Quart. Journ. Micr. Sci.* vol. 28, 1888.

like those that occur among the segmented worms. On the other hand it has the tracheæ of the tracheate division of the Arthropods, and at least rudimentary appendages of the Arthropod type. The genus has been recently the subject of a careful monograph, so that we are in possession of the facts of structure and distribution of a good many species. Mr Sedgwick allows eleven species as well founded, and there may be others. The genus occurs in South Africa, South America and the West Indies, in New Zealand and in Australia; one specimen is found in Sumatra; otherwise it is absent from the Oriental region. The species of the genus are mainly distinguished from each other by the position of the generative aperture, by the number and structure of the legs and by colour. Mr Sedgwick divides them into four groups which correspond to their range; the Australasian species, for instance, form one group, the neotropical another, and so forth. These four main groups are largely separable on account of the varying position of the generative pore, which may be between the last or the penultimate pair of limbs or altogether at the end of the body. There are differences too in the structure of the generative organs, and the eggs show characteristic variations; thus, in the Australasian species the ova are large and full of yolk, in the Cape species though the ova are large the yolk is not abundant, and finally in the neotropical species of *Peripatus* the ova are quite minute, and without food yolk. The single known species from the Oriental region is more imperfectly known than many of the others; but it seems to resemble the neotropical

rather than the Ethiopian species, which is not a little remarkable. It has, as have the neotropical forms, the generative openings between the legs of the penultimate pair.

Separate areas of the species of a genus.

It sometimes happens that the area of distribution of a genus is perfectly continuous but traversed by large rivers or other checks to distribution. A genus occupying a group of islands, for example, may be said to have an unbroken range so far as is possible; but here under similar circumstances it is frequently the case that the isolation has been accompanied by the breaking up of the genus into a number of species, perhaps corresponding with the subdivisions of the area. The islands of the group which together constitute the Sandwich Islands are often inhabited by particular species belonging to a genus common to the whole archipelago; the huge tortoises of the Galapagos are in the same condition. A large tract of country is often similarly inhabited by a series of species belonging to the same genus; but each of these keeps rigidly to its own particular territory: an intermingling is rendered difficult perhaps by the infertility of the species with each other, and partly also by the fact that, the ground being already taken up, there is no room for the inroad of a closely allied form, which has presumably the same or nearly the same mode of life and would therefore seriously compete. The twelve species of Jays belonging to the genus *Garrulus* range over the greater part of the Palæarctic region; but nearly every species

has its own particular habitat, and does not interfere with its neighbours. In the map which Mr Wallace gives in illustration of the facts of distribution of this genus it is seen that two species overlap just at the confines of Europe and Asia, while the former of these, the European *Garrulus glandarius*, is also overlapped by one species in the south-east of Europe and by another in Algeria. It is far more usual for species to occupy in common a given area, than for a division of the territory to have taken place. Nevertheless the example just quoted is by no means unique, even among birds whose powers of flight set ordinary barriers at defiance. But a rigid partition of the area of a genus is more commonly met with among animals which have not these exceptional means of disposal. This will now be illustrated by three examples.

Distribution of Rhea.

The distribution of the species of *Rhea*[1] illustrates the limitation of the species of the same genus each to its own particular tract. The genus itself occupies a considerable area of S. America, to which continent it is absolutely confined. The three species of the genus have been lately subjected to a careful comparison by Dr Gadow, who has plainly differentiated the three recognised species, viz. *Rh. americana*, *Rh. macrorhyncha* and *Rh. darwini*. The anatomical characters which distinguish them are not of course very marked, but they are amply

[1] See Gadow, "On the Anatomical Differences in the three species of Rhea," *P.Z.S.* 1885, p. 308.

sufficient for the purpose. *Rh. darwini* and *Rh. americana* agree to differ from *Rh. macrorhyncha* in having only 15 (instead of 16) cervical vertebræ and in having a broad skull. They differ from each other principally in the fact that the metatarsus in front has scutes on distal half only in *Rh. darwini; Rh. macrorhyncha* agreeing with *Rh. americana* in having transverse scutes along the whole length of that part of the leg in front.

The range of the three is as follows:—*Rh. americana* extends from Bolivia through Paraguay into Uruguay and southward to the Rio Negro. Its head-quarters seem to be the pampas of Argentina.

Rh. darwini is restricted to the eastern half of Patagonia and to south-eastern Argentina. It overlaps the last species about the Rio Negro.

Finally *Rh. macrorhyncha* occurs in the provinces of Pernambuco and Bahia but does not overlap *Rh. americana.* Dr Gadow intimates that on the whole *Rh. darwini* is the best marked species. Hence possibly its overlapping is less remarkable, since the greater difference in organisation may go with a greater difference in habits.

Distribution of Ibexes.

There are altogether eleven species of Wild Goats as allowed by Mr Sclater[1], to which may be added a twelfth[2].

(1) *Capra pyrenaica,* the Spanish Ibex, is not only Pyrenean, but is found, slightly altered in character, in the mountain ranges of other parts of Spain and Portugal.

[1] *P.Z.S.* 1886, p. 314.

[2] There are probably however more names than species.

"It is curious," remarks Mr Sclater, "that it is more nearly allied to the Caucasian ibex than to the ibex of the Alps."

(2) *C. ibex, the* ibex or steinbok found in the Alps and Tyrol, but rare and needing artificial preservation.

(3) *C. ægagrus*, the true wild goat, is probably the origin of the domestic variety. It is now found only in Crete and some of the smaller Cyclades as regards Europe, but also extends through Asia Minor and Persia to Sind and Baluchistan.

(4), (5) *C. caucasica* and *C. pallasii* are restricted to the Caucasus, where they do not appear to overlap greatly.

(6) *C. sinaitica.* This ibex is found only in the mountain ranges of Upper Egypt, the Sinaitic peninsula and Palestine.

(7) *C. walie* is a distinct though rare and little known species, from the highest mountain ranges of Abyssinia.

(8) *C. sibirica.* It is remarkable that this species should occur in two such distant localities as the Altai mountains and the Himalayas. But it appears that a thoroughly careful comparison of examples from the two localities has not yet been made. This may very possibly reveal differences.

(9) *C. falconeri.* This ibex is popularly known as the Markhore, it lives in the Pir-panjab and Sulaiman ranges in Cashmere and Afghanistan.

(10) *C. jemlanica.* The "Tahr" occurs along the whole range of the Himalayas.

(11) *C. hylocrius.* This species of wild goat is found in the Neilgherries and some other ranges of southern India.

(12) *C. severtzowi.* This is another Caucasian ibex which Dr Menzbier has added to the two already referred to.

Here we have an instance of a genus of tolerably wide distribution, but discontinuous. The discontinuity is entirely due to the mode of life of the genus, which frequents high mountains and cannot tolerate the level plain. The mountains are comparable to oceanic islands which can only be reached from time to time and under favourable circumstances. This naturally results in the isolation of those individuals which have migrated from their original home to a neighbouring mountain range; and as a consequence of this isolation, which precludes admixture with the parent stock, we have the production of new forms, just as in the case of oceanic islands. With this may be compared the distribution of such a genus as the giraffe, which has, or had until very recently, a range of nearly the same extent as measured by miles. But this range is uninterrupted by many tracts of country that are uninhabitable to the animal; hence there are at most two forms of giraffe. Even the true bears (genus *Ursus*) may be contrasted. Dr Grevé allows nine species and five varieties, hardly more than there are of goats. But the range is enormously larger—nearly the whole of Asia and Europe and nearly the whole of America—and there is nowhere a gap of any kind.

Distribution of the Cassowaries.

The species of the genus *Casuarius* present an excellent instance of the specialisation of a genus when its region is broken up by barriers into detached areas. There appear to be altogether eleven or twelve species of cassowary that are well ascertained; there may even be one or two more; at any rate there are more than twelve names distributed among the cassowaries. I shall not enter into the characters which distinguish the species beyond remarking that they can be readily defined by the shape of the "casque," by the presence or absence of wattles depending from the patch of naked skin upon the throat and by the particular tints exhibited by the generally brilliant colouration of the latter. The cassowaries are entirely limited in their distribution to the Australian region and do not range over the whole of that region. They are absent from New Zealand and from many other outlying islands. But although the cassowaries are of bulky form and like other Struthious birds, quite incapable of flight, they are by no means limited to the continent of Australia itself. The following is a list of the properly defined species and their range:

Casuarius australis, Australia.

C. picticollis,
C. Edwardsi,
C. Westermanni,
C. uniappendiculatus,
C. Salvadorii,
} New Guinea.

C. galeatus, Ceram.

C. Beccarii, Wokan.
C. bicarunculatus, Aru.
C. Bennetti, New Britain.
C. laglaizei[1], } Jobi.
C. occipitalis, }

This case is analogous in many ways to that of the goats already dealt with. Isolation has led to the differentiation of species from a presumably identical stock. Furthermore, where the area is large it has proved capable of sustaining several species, which is not the case with those islands of limited extent, such as Ceram, which harbour cassowaries. With this fact may be compared the presence of only a single species of *Ibex* in the comparatively small tract of country occupied by the Pyrenees, and the presence of this species in the more extensive Caucasus. The existence of five out of the ten species in New Guinea marks this large island out as the head-quarters of the group from whence they have migrated elsewhere, or perhaps, if the islands are to be regarded as a broken continent, have been isolated. That New Guinea is to be regarded as the original home of the cassowaries is perhaps also shown by the fact that the species now existing there present in themselves most of the important modifications of structure which the genus exhibits. In his most recent revision of the cassowaries Mr Sclater divides those without wattles from those which have these appendages. Both kinds occur in New Guinea. On the other hand this con-

[1] The editor of the *Ibis* (Oct. 1894, p. 560) is inclined to doubt the distinctness of these two species.

sideration is to be qualified by the fact that no cassowary with a laterally compressed casque (another character made use of by Mr Sclater) exists in New Guinea. In all the New Guinea species the casque is transversely compressed.

Classification and Distribution.

The facts of distribution are constantly liable to be misunderstood through ignorance of classification. Not only is a serious error in the actual facts of the distribution of a particular group caused by wrongly assigning to it some individual genus or species, but the significance of the facts is by this largely, sometimes totally, obscured. A knowledge of comparative anatomy is absolutely essential to the student of distribution. It used to be supposed that the central American Carnivore *Bassaris* was a member of the family Viverridæ; the genus therefore was believed to be the only Viverrine found in the New World, a singular anomaly in the distribution of the group. But Sir William Flower in his paper upon the skull in the Carnivora showed that this animal is really an ally of the Raccoons, which are purely an American family. Everybody is acquainted with the fact that monkeys are found both in the old world and in the new. But the fact gets a far larger significance when it is realised that the new world monkeys form a group by themselves which differs from that of the old world monkeys in a number of important anatomical characters. The wide distance and the absence of means of transit

within recent times has brought about the great divergence which is now seen between the two sections of the Primates, the new world Platyrrhines and the old world Catarrhines. It has been already pointed out in dealing with the distribution of the archaic *Peripatus* that the species of different parts of the world form natural assemblages separable from those of other parts of the world by definite anatomical characters. This is the case too with many other genera and families of animals. We invariably find that when a group, which Palæontology—or in the absence of direct evidence from fossils, other considerations derived from anatomy or embryology—proves to be an ancient group, has a tolerably wide and discontinuous distribution, marked differences in structure distinguish its representatives in different parts of the world. This is more marked still in the case of a group which has but limited powers of dispersal. We shall now illustrate the connection between distribution and anatomical structure by a few examples, which are of course few among many; in other pages other instances have been or will be treated of and reference may be made to those places for further illustration of the general fact.

Distribution of the Gallinaceous birds.

The Gallinaceous birds (Alectoromorphæ of Huxley) offer an exceedingly instructive example of the connection between anatomical structure and geographical distribution. There can be no doubt that this group is a natural one. It is divisible into the following seven

families[1]:—Grouse, Turkeys, Guinea-fowls, Pheasants, Megapodes, Curassows and the aberrant Hoatzin (Opisthocomus). They are thus distributed:

1. Tetraonidæ (Grouse). Palæarctic and Nearctic.
2. Phasianidæ (Pheasants). Oriental.
3. Numididæ (Guinea-fowls). Ethiopian.
4. Meleagridæ (Turkeys). Southern Nearctic.
5. Cracidæ (Curassows). Neotropical.
6. Megapodidæ (Mound-builders). Australian.
7. Opisthocomidæ (Hoatzin). Neotropical[2].

They are not, however, in every case absolutely confined to these regions as defined by Mr Sclater. Thus among the Megapodes one species gets into the Indian region, and the Phasianidæ stray into the Palæarctic. The Tetraonidæ are really almost cosmopolitan, though mainly massed in the two northern regions of the earth's surface. The Curassows extend into the southern parts of the Nearctic, occurring as they do in Mexico and in California. Such briefly are the facts of the distribution of this group of birds; it now remains to enquire into the mutual relationships of the several families or subfamilies. Mr Huxley unites the Megapodes with the Cracidæ into a group Peristeropodes, and separates them from all the rest which constitute his Alectoropodes. The former division has a sternum with less deeply marked notches, the vomer is well-developed, and the hallux is attached to the foot on a level with the other toes. These characters look as if they were more primitive than the deeply

[1] *P.Z.S.* 1868.

[2] These terms are explained later; see Chap. II.

notched sternum, the more rudimentary vomer, and the abnormal position of the hallux in the Alectoropodes. This is very likely so, but as Fürbringer[1] has pointed out, the structure of the soft parts of the Megapodes are more different from what is found in the Curassows. The latter often have a convoluted windpipe, which does not occur in the Megapodes, but is met with in some Guinea fowls and in the Grouse (*Tetrao urogallus*). The Megapodes have lost one of the two carotid arteries, and their oil gland has not the tuft of feathers found in other Gallinaceous birds; in fact, as regards internal structure other than that of the skeleton, the Cracidæ are not so very near to the Megapodes. All these structural features will seem perhaps of small moment to the student of invertebrate anatomy; but it must be remembered that birds form a very circumscribed group; the anatomist is glad of the smallest characters upon which to found differences; and the differences enumerated are not small, considering the characteristics of the order. Apart, however, from these differences it does appear the two families Cracidæ and Megapodidæ are the most primitive Gallinaceous birds now in existence; not only do the two points referred to above tend to show this, but we might also perhaps urge the "reptile-like habit" which the Megapodes have of laying their eggs in a heap of dead leaves and abandoning them to the kindness of nature—a habit which of course recalls that of nearly all Reptilia. Moreover neither the Curassows nor the Mound-builders show to anything like so great a degree that difference in

[1] *Untersuchungen zur Morphologie der Vögel.*

plumage between the sexes which is often developed to so extraordinary an extent in the other members of the group. In many birds which are presumed to be of an ancient type, for instance the Ostrich tribe, there is the same absence of strongly marked secondary sexual characters in colouration. In this particular enquiry we cannot unfortunately get any assistance whatsoever from Palæontology; the only fossil Megapode recorded in Lydekker's Catalogue of Fossil Birds is *Talegalla lathami*, a species now living; there is no information as to extinct Cracidæ. The Alectoropodes on the other hand, are much more nearly connected among themselves. Fürbringer, indeed, does not divide them further[1]. The Guinea-fowls perhaps are the most distinct group; but the Argus, Pheasant and the Peacock are looked upon by Fürbringer as somewhat intermediate between them and the more typical Phasianidæ. About this group of Gallinaceæ there is some palæontological information; a few existing species (*Lagopus albus, Francolinus pictus*) have been described from the Pleistocene of Europe and India respectively; the extinct genus *Palæortyx*, "Partridge-like birds," containing eight species, occurs in the Eocene and Miocene of Europe; three species of an allied genus, *Palæoperdix*, are also found in the Miocene of Europe; five species of Phasianus have been found in the Pliocene and Miocene of Europe; four species of *Gallus* occur in the "superficial deposits" of New Zealand, the "Cavern-deposits of the Lahn valley, Germany" and the Pliocene of France; of greater interest is the genus *Tao-*

[1] Nor Gadow with any confidence, see Bronn's "Thierreich." Aves.

perdix (one species only), from the Eocene of France, which is said to present affinities with *Numida* and *Meleagris*, i.e. with African and American forms. The facts which have so far been enumerated enable us to draw some interesting conclusions; the first is indisputable; each of the great divisions of the globe is tenanted by a special group of Gallinaceous birds, which is with the exception of the nearly cosmopolite Tetraonidæ, confined to that particular region. There are some reasons for considering that the cosmopolitan Tetraonidæ are of a less ancient stock than the restricted Cracidæ and Megapodidæ. There is a closer structural connection between the Gallinaceous birds of the three great continents of Europe, Africa and Asia, than between any one of them and the Gallinaceous inhabitants of South America or remote Australia. The two latter regions, being truly the ends of the earth, are populated by the two most ancient types of Gallinaceous bird, which however are not very closely allied.

In a very tentative way we may point out another possible conclusion. We may presume that the earth was possessed, as regards Gallinaceous birds, by an ancient stock of which the Cracidæ and Megapodidæ are the only survivors; later on, from the ancient stock, arose other families which increased and multiplied so much as to drive their forerunners into the more remote corners, where an inroad of the sea preserved them from further competition; as the remnants of the more ancient race came thus to be widely separated and exposed to divergent conditions they would naturally get to be more

and more unlike each other; hence the differences between the Cracidæ and Megapodidæ. We find in fact the presumably younger race spreading over the whole earth, while the remnants of the older race are limited to the more remote parts. All this fits in well, as will be remarked later, with the Polar theory of the origin of life.

Distribution of the Edentata.

The Edentata are a group of mammals in which the distribution has a very strong relation to anatomical structure. That there is this intimate connection has been shown by recent anatomical investigation, which is summed up and its purport explained in a paper by Sir William Flower[1], from which the information upon the subject can be most conveniently got. Formerly the members of this group were divided into families not at all consistent with deep lying structure but rather with superficial modification depending upon similar habits and ways of life. Before examining the rational classification of the group as proposed by Sir William Flower, it will be convenient to briefly pass in review the different genera and families into which the Edentata may be divided.

The living members of the group readily separate into five families, which are the following:—Bradypodidæ, or sloths, containing the two genera *Bradypus* and *Cholœpus*.

Myrmecophagidæ, or anteaters, with the genera *Myrmecophaga, Tamandua* and *Cycloturus*.

Dasypodidæ, or Armadillos, with the six genera,

[1] *P.Z.S.* 1882, p. 358.

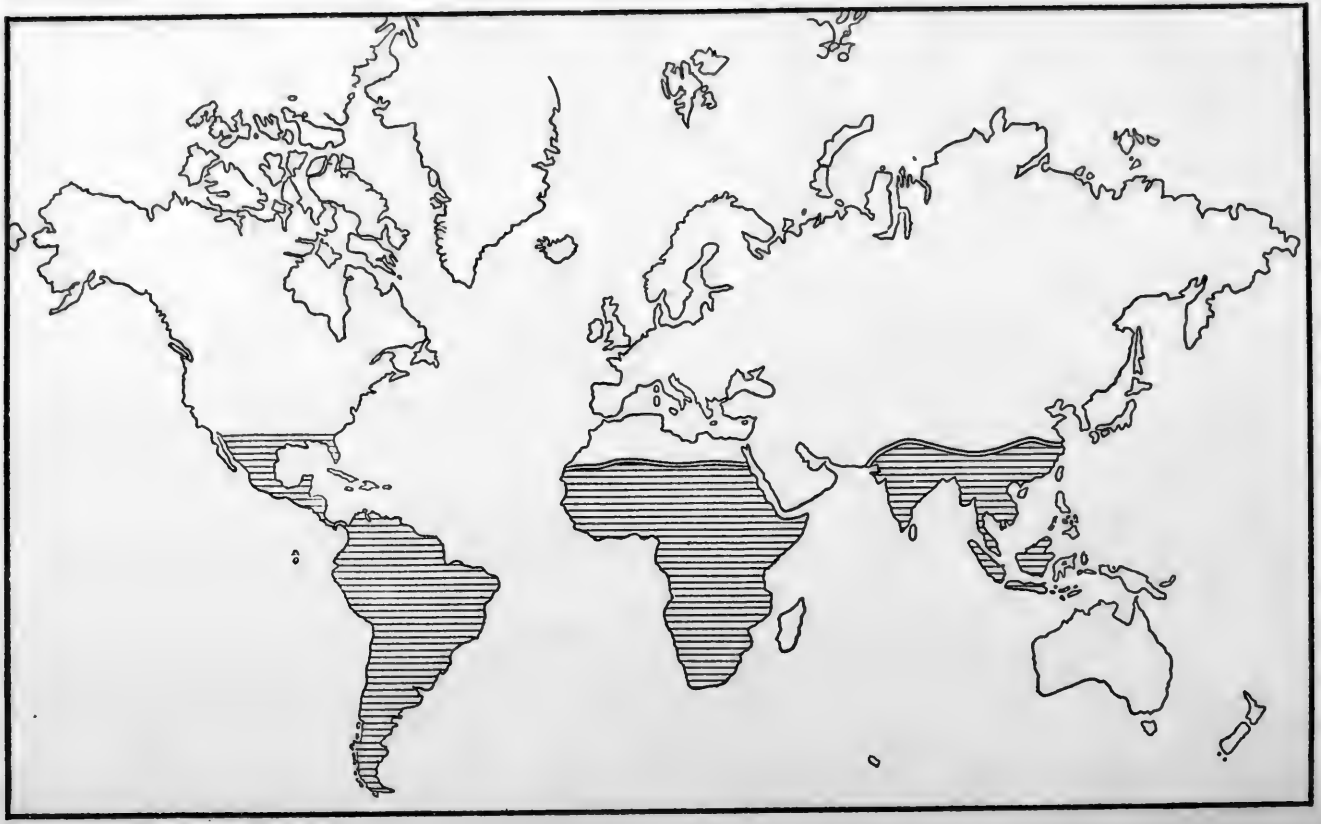
Tatusia, *Dasypus*, *Xenurus*, *Priodon*, *Tolypeutes* and *Chlamydophorus*.

Manidæ, or scaly anteaters, with really only one genus *Manis*, though more have been allowed by some systematists.

Orycteropodidæ, or Cape anteaters, containing but a single genus *Orycteropus*.

Now it has been customary to associate together the anteaters of both the old and the new world, separating them on the one hand from the sloths and on the other from *Orycteropus*. We thus get a group ranging over South America, the greater part of the Oriental region, and a large tract of the Ethiopian region, for *Manis* is found in both of the last named regions. The *Manis* of the old world has a strong superficial likeness to the anteaters of the new world. The same long tongue and well-developed salivary glands are present in both, while neither of them have any teeth; correlated with this likeness in structure is the fact that both feed upon ants. The Australian anteater, *Echidna*, was on this account placed by Linnæus in the same great group as that containing the Edentata; it has in the same way a long tongue and well developed salivary glands. There is, however, of course no intimate connection between the animals; we have here merely a case of modification to the same end, the utilising of an abundant ant or termite supply. The Woodpecker and the Chamæleon show a remarkably analogous modification of the alimentary organs. This is really the only reason, apart perhaps from a general similarity in form, which has led to the

DISTRIBUTION OF EDENTATA.



To face p. 32.

uniting of the Old World with the New World anteaters. But an examination of other structures does not show any likeness between the *Manis* and the *Myrmecophaga*, but does reveal an unmistakeable resemblance between the latter and the sloth, to which it is so unlike in external form and in habits. In the American anteater the vertebræ to a large extent interlock with each other by an additional series of articular processes, not found in other mammals, excepting only the Dasypodidæ, and the extinct Megatheriidæ, and which is to a less extent but still obvious in the sloths. This structural resemblance found in animals of such diverse habit must have a significance in considering their affinities. The fact that the processes in question are in a rudimentary condition in the sloths is correlated with the fact that in those animals which depend from the branches of trees, and use the muscles of the back but little, the articular processes generally of the spine are poorly developed; the fact is they are of even greater importance as evidence of real blood relationship. As Sir William Flower says, the fact may be almost said to prove "that the sloths are descended from animals in which they existed in a fully developed form." Neither in *Manis* nor in *Orycteropus* are there the slightest vestiges of these additional articular processes. It is also pointed out that the shape of the sternum is characteristic of the New World and the Old World Edentates respectively. When we come to other details of structure there is the same alliance to be noted between the various families of Edentata found in America, more particularly is this to be seen in the anatomy of the

reproductive organs. On the other hand, the Orycteropodidæ are not so nearly allied to *Manis* as are the different genera of New World Edentates among themselves. But though this is the case it does not show any special affinities with the New World forms. It may be temporarily regarded as a distinct family having (at present) problematic relations to the Manidæ, which it resembles by what are principally negative characters. The placenta is an organ which is of great assistance in bringing out affinities between various groups of mammals; unfortunately it is not known whether the placenta of *Orycteropus* is deciduate or the reverse; if non-deciduate there is a likeness to the *Manis* and not to the New World Edentates. At any rate it is clear that *Manis*, even if it be not a close ally of *Orycteropus*, is still further removed from the Myrmecophagidæ, Dasypodidæ or Bradypodidæ. A glance at the structure of the fossil members of the order entirely confirms the broad lines of classification thus laid down by Sir William Flower. The Megatheriidæ are in some respects intermediate between the anteaters and the sloths; the teeth are those of the sloths, but the diminution of their number in the genus *Cœlodon* "leads towards their total suppression in *Myrmecophaga*." The lengthening of the skull in *Megatherium* is another step in the direction of *Myrmecophaga*. On the other hand the Old World Edentates of the tertiary period, so far as they are known, lend support to the view that they are more nearly related to the existing Edentates of that part of the world. We have therefore in this group the closest relation between the

geographical range of its members and their structure; there is no confusion possible between the anteaters of the Old World and those of the New, while, unlike though they are outwardly, all the Edentata of the New World form a natural assemblage; the Edentata of the Old World form perhaps two natural assemblages of equal value to the one of the Old World, but there is no hint of any special resemblance between either and the New World group.

Though the Gallinaceæ and the Edentates thus show a decided relation between distribution and structure, the same is not the case with other plentifully distributed groups of birds.

Distribution of the Cuckoos.

The cuckoos will serve as an instance to the point. This family has been investigated anatomically[1] to as great an extent as the Gallinaceous birds; and the mutual affinities of the numerous genera is to some extent plain. Fürbringer is of opinion that the genus *Phœnicophaës* represents more nearly than any other existing form the primitive cuckoo. This is chiefly on account of the fact that it possesses the complete muscle formula, none of the typical muscles of the thigh being absent, and has a syrinx constituted on what must be regarded as the typical plan for birds, viz. the "tracheo-bronchial." The remaining genera have diverged from this in two ways; either the accessory femoro-caudal muscle has disappeared,

[1] See Beddard, *P.Z.S.* 1886.

or the voice organ has moved down the bronchus producing that form of syrinx known as the "bronchial." These two changes have in no case occurred simultaneously. We find either the one or the other. But there is no correspondence between the change in structure and range in space. In both the Old and the New World we meet with cuckoos like *Crotophaga* and *Geococcyx* (America) and *Centropus* (Old World) in which the syrinx is bronchial and the muscles all present. In both hemispheres are cuckoos like our common *Cuculus canorus* and the American *Piaya*, in which the trachea has retained the typical form, while the accessory femoro-caudal muscle has completely vanished. If M. Milne-Edwards is right in identifying a fossil cuckoo from the Miocene of France as a Coucal (*Centropus*) the problem is not rendered any easier. It shows, however, that at this period the two main divisions of the family were differentiated in Europe, whence they may have spread over the world. It must be noted that the genera of the New World are nearly all distinct from those of the Old World, and that it is possible, so far as our present knowledge goes, to distinguish into sub-families by the differences in the arrangement of the feather tracts the New World from the Old World representatives of the two chief subdivisions of the group. This affords an example of a frequently recurring series of facts. It is not of any interest to point out that the American genera are in every case distinct from the African or Indian genera and then to leave the matter. We have to account for, or to attempt to account for, the mutual relationships

between the genera of the different parts of the world. So far as our knowledge of living cuckoos goes the facts have no significance in this connection. Presuming with Wallace that they originated in the tropics of the Old World and thence spread to the New World we have the remarkable fact that in the lengthy journey to South America the two main types already differentiated before migration took place, have been equally successful in colonisation, and have advanced equally far. Fürbringer holds, and with some justice, that a country inhabited by the oldest form of the group in question is more likely to be its original habitat than elsewhere. In this case Wallace's view that the cuckoos sprang into existence in the Oriental region is supported. But quite recently the whole matter has been put in a rather clearer light. Milne-Edwards has found[1] the remains of a cuckoo which he has relegated to a new genus and which he is unable to distinguish from the living *Phœnicophaës*. In this case Fürbringer's belief that *Phœnicophaës* is the nearest approach to the archetypal cuckoo is to some extent justified; and we have a family formerly of wide range, which is a further proof that it is an ancient form. Moreover if we can now assume that the parent stock of the cuckoos was differentiated in Europe and thence spread over the New as well as the Old World, the difficulties in the way are at least rendered less.

We shall now indicate briefly the distribution of a few of the principal groups of animals. The mammals and

[1] *Comptes Rendus*, 1894.

birds are dealt with later in giving the characters of the different regions and sub-regions.

Distribution of Chelonia.

When Mr Wallace wrote his text-book upon Geographical Distribution he was able to make but few remarks upon the distribution of the Chelonia, since the classification was in a very imperfect state, and therefore the bearing of the facts of distribution were not apparent. Now however, thanks to Mr Boulenger's catalogue of the order, we are in a position to deal with the distribution of the group in a manner more satisfactory than was open to Mr Wallace.

Mr Boulenger divides the Chelonia primarily into two great groups, the Athecæ and the Thecophora. The first group is distinguished by the fact that the vertebræ and ribs are free and not connected with the bony exoskeleton. As it only contains a single family, genus, and species, *Sphargis coriacea* of entirely marine habitat, it need not concern us any further here. The second division of the Chelonia is made up of three super-families, the Cryptodira, the Pleurodira and the Trionychoidea. These together contain eleven families, of which there are seven in the Cryptodira, three in the Pleurodira and only one family in the Trionychoidea.

Of the first super-family the families Chelydridæ (two genera), Dermatemydidæ (three genera), Cinisternidæ (one genus) are confined to the American continent. The Platysternidæ (one genus) range over S. China, Siam and Burma; there is but a single species which has this wide

range. The Testudinæ is by far the largest family of the Chelonia; Mr Boulenger divides it into 20 genera, containing between them 113 species which are cosmopolitan with the exception of Australia and Papuasia. Eleven of these genera are Oriental in distribution. Three are American only. One, *Pixys*, is confined to Madagascar. Two are confined to Tropical and Southern Africa. Three have a wide range over both the Old and the New World; among these is the genus *Testudo* which includes the gigantic tortoises of the Galapagos and the Mascarene islands. The last family is exclusively marine and may therefore be left out of consideration.

The Pleurodira contains, as already said, three families.

The Pelomedusæ have a curious distribution; its three genera, *Sternothærus*, *Pelomedusa*, and *Podocnemis* being found respectively in Tropical Africa and Madagascar, Africa and Madagascar, South America and Madagascar.

The family Chelydidæ contains eight genera. Of these five are South American; two range through Australia and New Guinea, while one, *Elseya*, is only Australian. The family Carettochelydidæ contains but a single genus and species found only in the Fly river in New Guinea.

The Trionychoidea includes only one family which is made up of six genera. Of these three are East Indian, two tropical African, while the remaining genus *Trionyx* ranges through Africa, Asia and North America.

It is obvious from the above summary which I have made complete, owing to the advantage of having Mr Boulenger's list, that South America is the principal home of the land and fresh-water tortoises. The American

continent has altogether fourteen peculiar genera. The Oriental region which comes next has fifteen peculiar genera. It may be thought that the Oriental region ought to have been placed first; but it seems less important than the Neotropical, inasmuch as the latter region has a larger number of peculiar families. The resemblances shown between South America and Madagascar (in the case of the genus *Podocnemis*) is noteworthy, and has been commented upon elsewhere. The Australian region is poor in tortoises; it has only three genera, of which, however, one is the type of a special family, confined to New Guinea. Africa is also poor; it has but seven peculiar genera, of which several range also into Madagascar, and one is limited to that island.

The group also shows some remarkable instances of discontinuous distribution. The Chelydidæ are limited to the Neotropical and Australian regions; but, as Mr Blanford points out, this is to be possibly explained by the fact that members of this family are met with in a fossil condition in Europe. It will have been noticed that they are totally absent from New Zealand.

Distribution of Lizards.

In this group again the facts have been collected by Mr Boulenger in his British Museum catalogue. The genus *Hatteria* is excluded from the Lacertilia; the facts of its distribution have been already considered. The true Lizards contain altogether, according to Mr Boulenger, twenty families. Of these only two approach to being cosmopolite, the Geckotidæ and Scincidæ; but the former

appear to be often accidentally conveyed on ships, which at least shows that they have facilities for becoming cosmopolite; also they have many archaic points in their structure which point to a long existence in the world. The vertebræ are biconcave and have considerable remains of the notochord between the centra; this is a character which occurs in many ancient forms of vertebrates. Though there are not any other families of Lizards which are so widely spread as those which have been just mentioned there are a few others which have a moderately wide range. This may perhaps be partly attributed to the small size as a rule of the lizards and perhaps to their largely insectivorous habits, which renders them more independent of locality, than if they were vegetarian. The fact that many occur upon oceanic islands is a fact which shows that they have greater powers of dispersal than many other groups of animals, and at the same time necessarily renders the study of their distribution less interesting.

The families Eublepharidæ, Iguanidæ, Anguidæ, Amphisbænidæ, and Anelytropidæ are found in both the Old and the New Worlds. The bulk of the Iguanidæ are, however, tropical American, and are very characteristic of the region. The Chamæleons have a distribution which is remarkably parallel, as M. Trouessart has pointed out, to that of the Lemurs. The bulk of them are found in Madagascar only, but they also range into Africa and the East Indies. Their arboreal habits, as also in the case of the Lemurs, is perhaps to be compared with their comparatively limited range. A very characteristic Old

World family is that of the Monitors (Varanidæ); there are a large number of species which range over the Oriental, Ethiopian and Australian regions; the group comprises some of the largest of lizards, and some of them, such as the Nilotic Monitor which lives upon the eggs and young of the Crocodile, are aquatic in their mode of life. The structure of the Monitors is such as to separate them very widely from other lizards; but they have no particular relationship, as was at one time held, to the peculiar American family of the Teiidæ, of which the Teguexin is an example. The Lacertidæ are also a peculiarly Old World family. To them belong two out of the four indigenous lizards of this country. The fourth, the Blind worm, is the representative of the family Anguidæ. The most limited range of any family is afforded by the Helodermatidæ, containing but one genus, *Heloderma*, the Gila monster of the state of Arizona. With one possible exception, it is the only poisonous lizard. Australia has one peculiar family of lizards, the Pygopodidæ. America has two others besides those mentioned, viz., Xenosauridæ and Xanthusiidæ. The distribution of the lizards undoubtedly shows a marked difference between the Old and New Worlds. Moreover the Old World is more logically to be divided perpendicularly than horizontally according to Dr Günther. He would divide the world into six regions, (1) America, (2) Africa and Europe, (3) India and the Mantchurian sub-region of the Palæarctic, (4) Madagascar, (5) Tropical Pacific, and (6) New Zealand, characterised of course as far as the true lizards are concerned by negative characters. It is

interesting to notice that the lacertilian fauna of Africa attaches itself to that of the western Palæarctic region; it has often been remarked that Europe is really African in its affinities; this however has been to a large extent disguised by the destruction of animal life or its removal due to the glacial period. It will be remembered that before the glacial period and during the interglacial periods (?) there were Hippopotami, Hyænas &c. in Europe. Mr Boulenger unites Australia with the Oriental region, an union which is confirmed by the consideration of other groups of animals of some age, e.g. earthworms and crocodiles, and is accepted by botanists.

The Distribution of Crocodiles.

The distribution of the Crocodilia is very interesting, and on the whole fits in with the known laws of the distribution of animals. Fortunately one of our foremost authorities on the system of reptiles, Mr Boulenger, has recently summed up the existing knowledge of the range of the group in the British Museum Catalogue. He allows seven genera, *Gavialis*, *Tomistoma*, *Crocodilus*, *Ostolæmus*, *Alligator*, *Caiman* and *Perosuchus*. There are eleven species of *Crocodilus*, three of *Alligator*, and five of *Caiman*; the remaining genera consist of a single species apiece. As might be supposed from the large number of species into which it is divisible, the genus *Crocodilus* has the widest range of all the Crocodiles. It occurs in all the tropical regions of both the Old and the New World. *Alligator* was believed until recently to be confined to America; but the existence of a Chinese

species, *A. sinensis*, was made known in 1879. The Caimans and *Perosuchus* are exclusively tropical American. *Ostolæmus* is West African. *Gavialis* is confined to some of the rivers of India, while *Tomistoma* has only been met with in Borneo.

Though the two latter genera by their elongated snouts suggest the Mesozoic Teleosaurians, it seems probable that *Caiman* and *Perosuchus* represent the most archaic among the existing Crocodilia. The reason for this opinion is that they alone possess a ventral as well as a dorsal armature of scutes, such as were developed in forms like the Wealden *Bernissartia*, in which the ancestor of both Crocodiles and Alligators is seen by some. To a feeble extent the ventral scutes are to be found in *Alligator*, and also apparently in *Ostolæmus*. This, it will be noticed, is quite in accord with the wide but discontinuous distribution of those genera, which might almost on this account be put into a separate family. The presumption would be that formerly they were more widely spread, but that the process of time produced gaps in their ranks, leaving the present detached fragments. The existence therefore of an Alligator in China is not so remarkable if this point of view be borne in mind.

As to the true Crocodiles of the genus *Crocodilus*, they are characterised also by the fact that there are constantly fifteen teeth only in the lower jaw; the old idea that a Crocodile could always be distinguished from an Alligator by the fact that the fourth tooth in the lower jaw was received into a notch instead of into a pit in the upper jaw has been exploded by the discovery that in an

undoubted Crocodile, *C. palustris*, both conditions may occur. The reduced number of teeth is another indication of the more modern character of the genus *Crocodilus*. The wide distribution of the genus is indicative of a younger and more vigorous stock, as is also perhaps the larger size of many Crocodiles as compared with Alligators. In Mr Boulenger's catalogue the measurement of no Alligator is stated to exceed $4\frac{1}{2}$ metres, and they are generally much smaller than this; on the other hand the Crocodile of Madagascar is said to reach a length of thirty feet, and generally the Crocodiles are large. If this view respecting the geographical and structural relations to the Crocodilia be the correct one it is significant that in this case as in so many others the archaic forms have chiefly gravitated towards South America.

The bearing of the facts in the distribution of this order upon the generally recognised zoo-geographical regions seems to comply with a primary division of the earth's surface into Palæogæa and Neogæa; there is apparently less difference between the Oriental and Australian regions than between either of them and the Ethiopian, though the difference here is but slight. The fact that Crocodiles can traverse the sea is perhaps partly responsible for the absence of peculiar types in the Australian continent, which is connected with Asia by so many intervening islands. It is also perhaps a testimony to the age of the group as contrasted for example with the more modern mammals and birds.

The Distribution of Snakes.

The following account of the range of this order will be limited to the Colubrine section, since Mr Boulenger's catalogue, whence my information is derived, has not yet reached the Vipers. The Colubrines, which are chiefly though not entirely non-venomous serpents, may be divided into seven families, the Typhlopidæ, Glauconiidæ, Boidæ, Ilysiidæ, Uropeltidæ, Xenopeltidæ and Colubridæ. Two of these families, the Uropeltidæ and Xenopeltidæ, are entirely confined to the Old World; the former family contains only seven genera of burrowing snakes which are limited in range to Ceylon and other regions of India. The Xenopeltidæ is a still smaller family, for it contains only a single genus and species, which occurs in S. E. Asia. The other families are more or less cosmopolitan. The two largest of these are the Boidæ and the Colubridæ. The Boidæ are again subdivisible into two groups, the true Boas and the Pythons. The latter are nearly entirely Old World in habitat, the only exception being the Mexican *Loxocenius*. On the other hand the Boinæ are nearly as exclusively American; out of the thirteen genera which Mr Boulenger allows in the sub-family six are purely American, one belongs to the Australian region, one is common to Asia and Africa, and two genera, *Casarca* and *Bolieria*, consisting of a single species apiece are restricted to Round Island near to Mauritius; there remain the two genera *Corallus* and *Boa*; these are remarkable for the fact that while both are almost entirely American or Antillean in range they contain one or two species which

are found in Madagascar, a state of affairs which is paralleled in some other groups.

On the whole the snakes emphasise the necessity of drawing a sharp line between the Old and New World, as indeed do all the reptiles.

Distribution of Batrachia.

While the Urodele Amphibia are limited to the northern hemisphere, the frogs and toads have a nearly world-wide range; the only places where they are uniformly rare are true oceanic islands; as will be explained, facilities for crossing the sea are entirely wanting. The occurrence therefore of a true frog in the Solomon islands is one of the chief proofs, from the zoological side, that this island is not a real oceanic island; a species which occurs in that island (there are eight others) is the largest of all existing frogs and toads and is known as *Rana guppyi*. The Fiji islands possess three species of the genus of frogs *Cornufer*. This family, the Ranidæ, is nearly cosmopolitan; but the toads comprised in the family Bufonidæ are more nearly completely cosmopolitan. The tree frogs, Hylidæ, are also very widely distributed; but as is natural they find their greatest development in "Dendrogæa," the Neotropical region. Oddly enough these often purely arboreal creatures, some of which do not even lay their eggs in pools, are totally absent from the forests of Africa, indeed from the Ethiopian region altogether. The lowly organised group of frogs, Aglossa, comprise two families, the Pipidæ and the Dactylethridæ; the latter are in more than one particular near to the tailed Amphibians; they are, for

instance, more thoroughly aquatic than the Ranidæ; they sprawl about awkwardly on land instead of sitting up in the alert though broken-backed fashion of other frogs; the eggs too are laid not in masses as are those of the common frog, but singly as in the newt. This family is restricted to tropical and southern Africa; the Pipidæ including only the genus *Pipa*, in which the female harbours the young in holes in the skin, is Brazilian. Two families, Amphignathodontidæ and Hemiphractidæ are peculiar to the Neotropical region. The family of the Cystignathidæ are remarkable in being found in the Neotropical and Australian regions; the family contains a large number of species of which several have the habits of the tree frogs; and one genus has been on this account termed *Hylodes*. A very characteristic member of this family is the "Barking toad" of South America, *Ceratophrys ornatus*, of which specimens may be always seen at the Zoological Society's gardens. Another instance of discontinuous distribution is offered by the family Discoglossidæ, which occurs in all the sub-regions of the Palæarctic region and has a single representative in New Zealand, viz. *Liopelma hochstetteri*. Resemblances between South America and Madagascar are shown here, as in some other groups of the animal kingdom. The family Dendrobatidæ are represented by two genera *Mantella* and *Stumpffia*, comprising five species, in Madagascar, and by the genus *Dendrobates* in South America. On the whole the Neotropical region is most abundantly inhabited by peculiar forms. Out of the fourteen families allowed by Mr Boulenger no less than ten are found in that realm and

as already mentioned four are absolutely confined to it. No other region has more than seven of the families found in it. And the Ethiopian is the only other region which has a family all to itself, viz. the Dactylethridæ.

The Ethiopian and the Oriental regions are allied by their Batrachian fauna. Madagascar for example shares with the Oriental region nearly all its genera; the Ranid genus *Rhacophorus* is characteristic of the east, where it is represented among other species by the flying frog, *R. reinwardti*, the size of whose hind limbs and the amount of webbing between them is said to have increased progressively in illustrations of the animal. The family Discophidæ is limited to these two regions; indeed but for a single Burmese species it is purely Mascarene.

The Distribution of Scorpions.

It is greatly to be wished that other specialists would do as Mr Pocock has done and put together a brief account of what is known respecting the geographical range of their groups. In a recent number of *Natural Science*[1] we have an epitome of the distribution of scorpions. The existing genera, 60 in number, are divided among eight families. All of these are tropical or sub-tropical in range. No scorpions are found in the more northern latitudes and they are entirely absent from New Zealand. On the other hand they occur in Patagonia. In Europe the northernmost limit is the south of France and the shores of the Mediterranean generally. In Asia lat. 40°

[1] May, 1894.

marks their northern limit. In America they do not, according to Mr Pocock, get quite so far north as this. Although the scorpions are an extremely ancient race, beginning in the Silurian, and occurring there and in the Carboniferous in the shape of forms which hardly differ from existing species, the modern representatives show a range which corresponds with that of existing continents. The existing scorpions are nearer to the carboniferous Anthracoscorpii in that the feet terminate in two claws instead of in the single claw of the Silurian *Palæophonus*, which Thorell has relegated to another group, the Apoxypodes, reserving the name Dionychopodes for the others. Mr Pocock deduces from a comparison of the slight differences in structure between the ancient and the modern forms certain facts of structure which may be looked upon as archaic; though these seem to those accustomed to the structure of other groups very minute it is evident that we must be content with them owing to the already mentioned homogeneity of the group. In the most ancient scorpions the lateral eyes are behind the median eyes, which are placed at the front edge of the thorax. We should regard therefore those scorpions in which the eyes approximated most to this primitive position as the oldest. Another point is the pentagonal sternum which though lost in many adults reappears invariably in the young. Finally the existing Buthidæ contain genera in which there is a spur upon the fifth joint of the last two pairs of limbs, a structural feature which gets its importance from the fact that it has also been described in the Silurian *Palæophonus*. Indeed it is the Buthidæ which show to a

greater extent than any other family all these three archaic characters. And in correspondence with this we find them ranging widely with many peculiar genera in different parts of the world. The different regions differ considerably in the richness of their scorpion fauna. Naturally—considering the tropical proclivities of the family—the Palæarctic region shows the fewest peculiar generic types; Mr Pocock only enumerates eight; but some of these range further into Africa than it is customary to allow the Palæarctic region to extend, the northern limit of which is placed considerably below the tropic of Capricorn. Africa is very rich in scorpions; unfortunately those of Madagascar are but little known; what is known however tends to emphasise the peculiarities of this great island; two peculiar genera *Grosphus* and *Tityobuthus*, belonging to the Buthidæ, are there to be found. In the Ethiopian region, apart from Madagascar, there exist no less than nine peculiar genera exclusive of the two just mentioned besides four that get into other regions. The Oriental region is on the whole very distinct from the Ethiopian though naturally they have some forms in common. Six genera are confined to the region. Of the five that are not, three are also partly Ethiopian; two of those are also Australian, viz. *Isometrus* and *Archisometrus*; while *Hormurus* just gets across "Wallace's line." In the Australian region there are altogether seven genera, of which only three are peculiar and all of these three are limited to what Mr Pocock calls the Australian sub-region, i.e. the continent of Australia. The range of the scorpions in fact rather supports what I have said concerning the

range of earthworms—that the Australian region should be limited to the continent of Australia itself. It has been mentioned that several of the genera of Old World scorpions range into as many as three regions. We find however no community at all between the scorpions of the Old World and those of the New, excepting in the single case of *Cercophonius* which has an Australian representative. There is too a considerable difference between the Nearctic and the Neotropical. Only two genera are common to the two, viz. *Centrurus* and *Diplocentrus*. The Nearctic which is only that portion of the Nearctic termed Sonoran by Hart Merriam is inhabited by three other genera. On the contrary the Neotropical region is exceedingly rich in scorpions. Mr Pocock mentions twenty-two genera. As to families there is one, that of the Chactidæ, which is absolutely confined to the Neotropical region.

To express the distribution of the scorpions in accordance with the facts it would therefore be necessary first of all to separate the Old from the New World and then to divide them into regions which apart from details resemble those of Mr Sclater. The distribution of these animals lends no assistance whatever to some of the suggested continents that have been referred to. There is no resemblance between those of South America and South Australia. And as already mentioned there are no scorpions at all in New Zealand. But it must be borne in mind that at present there is no information concerning the scorpions of Patagonia, whence information of an important character may come. There is however a close

resemblance between the South African genus *Opisthocentrus* and the Panaman *Opisthacanthus*, and between the only two genera of the Diplocentridæ, *Diplocentrus* and the Arabian *Nebo*. This may be merely a relic of former warm periods prevailing in the north, of which the existence of *Tityus* in amber of the Baltic is a further indication. This genus now occurs south of the tropic of Capricorn, thus indicating a state of climate favourable to the migrations of scorpions by Behring's Straits.

The Distribution of Land Planarians.

This group of worms is one that should be of great use to the student of geographical distribution. The land Planarians are of course of an ancient stock though the modern representatives may be recently derived from some one branch of this stock. They are purely terrestrial animals, always an advantage in considering the problems of Zoogeography; and finally it is probable, though it is uncertain whether there are any actual facts that can be alleged in support of the contention, that the animals, having a coating of cilia and secreting from their skin a slimy mucus, would be destroyed by contact with salt water. It is however only recently that attention has been actively directed towards the study of this group of the Planarian worms. The late Prof. Moseley took advantage of the opportunities afforded him during the cruise of the "Challenger" to collect and describe a considerable number of new forms; the literature which he gives of the subject in his paper[1] shows

[1] *Quart. Journ. Micr. Sci.* Vol. XVII.

how little had been done in the matter before his time. Nevertheless what was accomplished by him and by Dendy, Spencer, von Graff and the others who have succeeded him has brought to light a good deal; we are in a position to say something about the range of the group. The land Planarians are as is known an artificial group; they embrace the terrestrial forms among the Triclad Turbellaria. The most familiar form in the whole group is the celebrated *Bipalium kewense*, which is an absolute cosmopolite; it has been found in many localities in England such as Kew whence it was first obtained, the Zoological Gardens, &c. It has turned up on the continent, in Brazil, Australia and elsewhere; but its real home appears to be the Fijis. With this exception, which is probably due to artificial importation, there is no species of land Planarian which is so widely spread, indeed no species has a great range at all even in the country which it inhabits. Mr Dendy has[1] pointed out from his study of the Australian species that "out of twenty-nine known Australian species, nearly equally divided between the colonies of Victoria and New South Wales, only three have been found in both colonies"; he goes on to remark with justice "that the land Planarians however widely they may be distributed as a class do not enjoy wide specific area of distribution." This fact of itself makes them exceedingly valuable as examples of the importance of an invertebrate group in contributing towards the solution of the problems of Zoogeography. So far as we know at present there are three

[1] *Trans. Roy. Soc. Vict.* 1890, p. 66.

main groups of these worms; the Rhynchodemidæ, with two eyes, the Geoplanidæ with many eyes and the Bipaliidæ with four eyes and a hammer-shaped head. *Bipalium*, with the exception of the probably accidentally imported *B. kewense*, already referred to, is confined to China, Borneo, Bengal, Ceylon and the Oriental region generally. *Geoplana* is Australian, S. African, Japanese, New Zealand, South American; and recently two species have been described among the rich material collected by Dr Max Weber in the Dutch East Indies. Curiously enough that naturalist, so Dr Loman[1] tells us, was quite unable to discover any land Planarians of any kind in the island of Celebes, although he searched for them with great care. *Cotyloplana*, also belonging to the same division of the genus, is confined to Lord Howe Island, whence it was brought by Prof. Spencer. The genus *Coeloplana* of Moseley is included by recent writers in *Geoplana*. A species of *Geoplana* was described by the late Dr Gulliver from the island of Rodriguez. In all probability this genus of such wide range will bear splitting up. But in the meantime Prof. von Graff notes that it is mainly developed in South America. Not less than 68 of the 125 species known to Dr v. Graff are inhabitants of the continent of South America. *Rhynchodemus* has also a wide range. It is met with in Europe, at the Cape of Good Hope, in Australia, in North and South America, Ceylon, Samoa, and the Dutch East Indies. Other genera are the European *Geodesmus*, *Microplana* described by Vejdovsky from dung hills, *Geobia subterranea* of Brazil which as its

[1] *Zoolog. Ergebn. Max Webers Reise.*

name denotes lives under ground and subsists upon earth-worms—as do indeed many of the species, which are for the most part carnivorous. A species in Europe which nourishes itself upon fungi has however been recorded. The two genera *Leimacopsis* and *Polycladus* are recorded from the Andes[1], and the former at any rate is the type of a group distinct from any of those that have been mentioned. Moseley described from the Philippines the peculiar genus *Dolichoplana*. Now it will be observed that the bulk of the species belonging to the Geoplanidæ are South American and Australian. Only a few range to the north of those land masses. This may be a fact of some importance. The reader will have already made himself acquainted with the division of the earth proposed by Mr Huxley. The Geoplanidæ are almost exclusively restricted to his Notogæa; and this restriction agrees with that of certain other ancient forms of terrestrial animals such as the Marsupials. The distinctness of the Oriental region as shown by the land Planarians is also remarkable. It would not of course be remarkable if we were dealing with a modern group; but the wide range of *Geoplana* is so far an argument that we are dealing with a fairly ancient group.

Altogether it seems to be evident that when the land Planarians come to be more extensively known they will yield a highly valuable body of facts; in the meantime this slight sketch of their distribution may serve to illustrate the impossibility of laying down hard and fast regional districts to apply to every group.

[1] Schmarda, *Neue wirbellose Thiere*, 1861.

The Distribution of Earthworms.

The geographical distribution of the earthworms offers an instance of a group that is now fairly well known and is at the same time in all probability a moderately ancient group. It has too exceptional qualifications for careful consideration in relation to the theories of past changes of land in connection with the range of existing forms. As a rule earthworms are killed by salt water; there are exceptions such as the genus *Pontodrilus* which actually lives upon the sea shore within range of at least the splashing of the waves, and it has been asserted that a few species in Ceylon (not named) can withstand the action of sea water. But with these exceptions the ocean, even when in the form of a narrow strait, is an insuperable barrier, which is more effective than any other. As worms have been met with at great heights upon the mountains, there seems to be no particular difficulty in their extending their range by crossing mountain chains; probably also rivers and large lakes are not untraversable; experiments show that earthworms can be kept for some days immersed in fresh water and yet retain their vitality, while there are a good many instances not only of true earthworms (in structure) which habitually live in the water, but there are species which live with equal ease in water and on dry land. This is true of the European *Allurus tetrædrus* and of several species of *Acanthodrilus*. An arid desert would doubtless prove as effectual a barrier to migration as the sea. The only defect in this group with

regard to the problems afforded by geographical distribution is the entire absence of any knowledge whatsoever about extinct forms. We cannot therefore compare the past with the present.

Earthworms are divisible into seven families:—Cryptodrilidæ, Perichætidæ, Acanthodrilidæ, Eudrilidæ, Geoscolicidæ, Moniligastridæ, and Lumbricidæ. Of these the first three are very nearly related and may be united into one super-family Megascolicidæ, which possibly is really equivalent to any of the other families Eudrilidæ &c.

The Cryptodrilidæ are world-wide, but most abundant in the Australian region and in South America. The Perichætidæ are chiefly Australian and Oriental, but occur in the Neotropical and Ethiopian regions. The Acanthodrilidæ are mainly massed in New Zealand, South America, and Africa; they are also found, though rarely, in Australia, Malaya and North America. The Eudrilidæ are absolutely confined to Tropical Africa, the Geoscolicidæ to Tropical South America, Tropical and Southern Africa, just reaching Europe and Malaya. The Lumbricidæ are probably only indigenous in the Nearctic and Palæarctic regions.

But it is necessary to go into further details to bring out the salient facts in the distribution of the Oligochæta.

The list, which I shall now give, is freed from obvious importations like the Lumbricidæ of exotic range dealt with elsewhere. The same kind of argument removes the Perichætidæ from the Nearctic and Palæarctic regions. Two genera belonging respectively to the Geoscolicidæ and Eudrilidæ, viz. *Pontoscolex* and *Eudrilus* are

of world-wide range; but it is to be noted that the same species exists everywhere, and that they are among the most abundant of species in accidental or purposeful importations of worms, thus arguing not only great probability of their accidental introduction but showing clearly that they can easily survive a long journey. This is as far as I think it safe to go at present, but Michaelsen goes further and would confine the genus *Perichæta* to the Old World and the genus *Benhamia* to the Ethiopian region. The genera of earthworms are thus distributed:—

Palæarctic. *Lumbricus, Allolobophora, Allurus* (L)[1], *Pontodrilus, Microscolex* (C), *Hormogaster* (G).

Nearctic. *Lumbricus, Allolobophora, Allurus* (L), *Megascolides, Ocnerodrilus, Microscolex* (C), *Diplocardia, Benhamia* (A).

Oriental. *Perichæta, Megascolex, Pleionogaster, Perionyx* (P), *Benhamia* (A), *Glyphidrilus, Annadrilus* (G), *Typhœus, Deodrilus* (C), *Moniligaster, Desmogaster* (M).

Ethiopian. All Eudrilidæ, *Microchæta, Kynotus, Siphonogaster, Ilyodrilus, Bilimba, Callidrilus* (G), *Benhamia, Acanthodrilus* (A), *Megascolex, Perionyx* (P), *Millsonia, Ocnerodrilus, Gordiodrilus* (C).

Neotropical. *Rhinodrilus, Anteus, Geoscolex, Tykonus, Urobenus, Pontoscolex, Onychochæta, Diachæta, Trichochæta* (G), *Microscolex, Ocnerodrilus, Gordiodrilus* (C), *Acanthodrilus, Kerria* (A), *Perichæta* (P), *Moniligaster* (M).

[1] The capital letters in brackets indicate the family.

Australian. *Perichæta, Megascolex* (P), *Cryptodrilus, Megascolides, Dichogaster, Microscolex* (C), *Acanthodrilus, Octochætus, Deinodrilus* (A).

The above list shows how well marked the regions are; but it loses half its significance without further explanation. New Zealand is really very different from Australia; it has practically only Acanthodrilidæ; confined to it are the genera *Octochætus, Plagiochæta* and *Deinodrilus*, and out of the eleven species of *Acanthodrilus* found in the region eight are New Zealand and only three Australian; *Microscolex* only just gets into Australia, which is characterised by its Perichætidæ (feebly represented in New Zealand), and by the genera *Cryptodrilus* and *Megascolides*. The Neotropical region is really divisible into two; the southern half including the greater part of the Argentine and Chili has only *Acanthodrilus* and *Microscolex*, while the Geoscolicidæ are confined to the tropical regions. There is thus the closest resemblance between South America and New Zealand which is accentuated by the fact that in intervening localities—South Georgia, the Falklands, Marion and Kerguelen islands—only *Acanthodrilus* exists. These evidences in favour of an antarctic continent are referred to again later. The tropical regions of Africa and America agree in the presence of the Geoscolicidæ which only just reach Europe and the Oriental region; moreover the African genera fall into a natural sub-family distinct from that which contains the American forms. This fact again has its counterpart in the Edentata among Mammals and in some other groups.

The family Perichætidæ shows some remarkable distributional facts. It may be divided perhaps into five genera all of which have the complete or nearly complete circle of setæ which characterise the family; but they differ in other particulars. *Megascolex* and *Perichæta* have the nephridial system arranged in what I have termed the diffuse fashion; they are in Mr Benham's terminology "plectonephric." In them there is not a definite series of paired nephridia, but an infinity of minute tubes which open on to the exterior by innumerable pores in each segment. On the other hand *Diporochæta* and *Perionyx* have the normal paired nephridia. The genus *Perichæta* is also to be distinguished by the fact that very nearly all the species of the genus have a pair of cæca arising from the intestine at about the twenty-fifth segment. Now in Australia the prevailing forms are *Megascolex* and *Diporochæta*. *Perichæta* does occur, but there are not more than two or three species. *Diporochæta* just gets into New Zealand. As we pass from Australia into the Oriental region the genus *Megascolex* is replaced by *Perichæta* which is the prevalent type not only of the family but of earthworms in general in the islands of the Malay Archipelago and the continent of India. *Megascolex* however lingers on, just fading away in Madagascar. The Oriental region is further characterised by another genus *Perionyx* which agrees with *Diporochæta* in the regularly paired nephridia but differs in the fact that the glands into which the sperm ducts open before reaching the exterior have a coarsely lobate arrangement instead of being coiled tubes

of equal calibre throughout. This genus just gets into the Ethiopian region where it is represented by the species *Perionyx zanzibaricus*, and possibly by another at Durban. The true *Perichæta* is rare in Africa but reappears on the opposite side of the Atlantic in Tropical America and the West Indies. As there are a considerable number of species on one side of the Atlantic which are not found upon the other it seems likely that the genus is indigenous in the New as in the Old World.

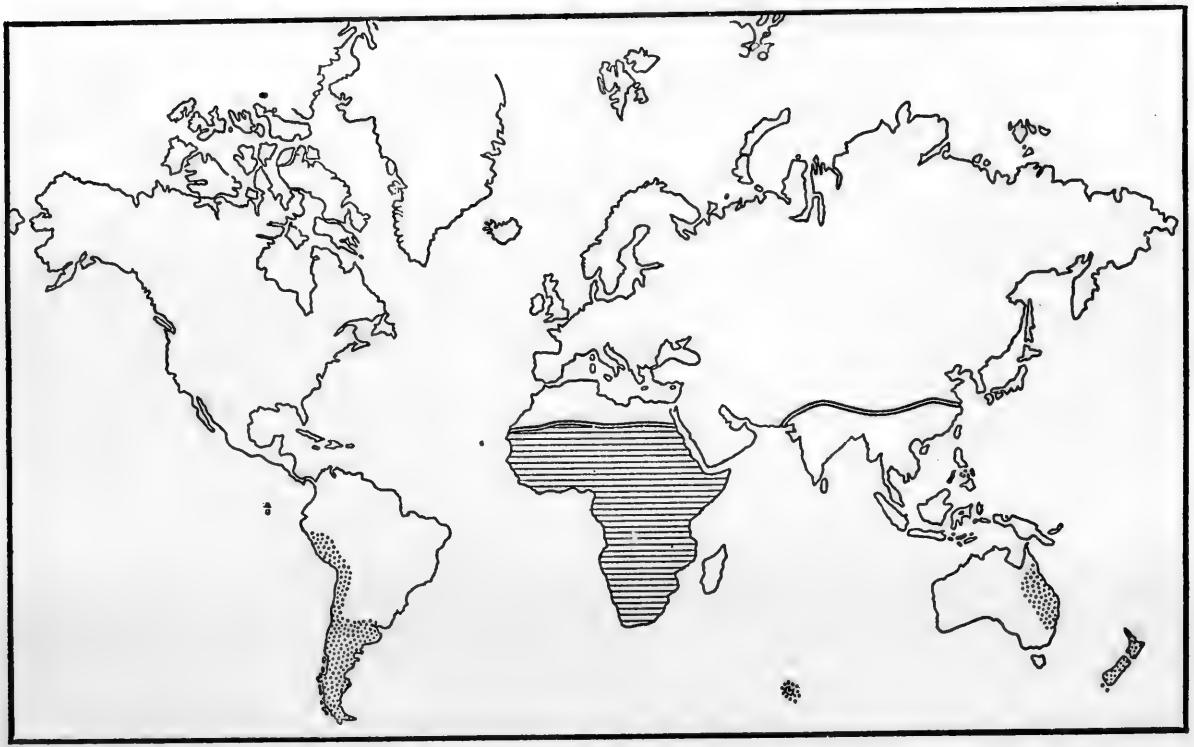
It is held by some that the characteristic mark of the Perichætidæ, the continuous circle of setæ amounting often to more than one hundred in a single segment, is a primitive arrangement from which the more general eight setæ per segment can be derived by reduction; at present however the matter is one which cannot be definitely decided. If it prove ultimately to be the correct view, it is noteworthy that the genus, like other ancient forms, has a wide and discontinuous distribution, starting in the Old World, and skipping Africa and Europe almost entirely to reappear in the more tropical parts of America. Moreover it is significant that in this group, as with the mammals, Australia has the more ancient forms.

The family Geoscolicidæ present some interesting facts in their distribution. The family is one of the more modern, on the view that I take myself of the affinities of the group. The spermathecæ have lost or at any rate do not possess the diverticula so characteristic—practically universal—in the Megascolicidæ. In this they agree with the European Lumbricidæ—our common earthworms

in this country—in which the spermathecæ are oval or roundish pouches without any cæca attached to them. But the Geoscolicidæ agree with the majority of earthworms to differ from the Lumbricidæ in that the gizzard is as it were strung upon the œsophagus, instead of lying, as it does in *Lumbricus*, at the junction of œsophagus and intestine. The nephridia are always paired; but the setæ differ from those of the Lumbricidæ in being nearly always ornamented with raised ridges or sculpturing of some sort; moreover there is frequently a difference between those which occur on the segments of the clitellum and those which are found elsewhere upon the body. The Geoscolicidæ of Africa belong to the genera *Microchæta, Siphonogaster, Ilyogenia* and *Callidrilus*. I have already referred to *Kynotus* of Madagascar which is allied to these but still is different from any of them. The family extends in the Old World into the Malay region where it is represented by the two allied forms, perhaps hardly generically separable, *Glyphidrilus* and *Annadrilus*. It is represented in Europe by *Hormogaster*, whose affinities are uncertain. Putting aside *Siphonogaster*, which is a remarkable and isolated type with two extraordinary processes of the ventral body wall which may be of the nature of penes, and *Ilyogenia* which may be, as has been suggested by Dr Michaelsen, really a representative of another family which has got to resemble the Geoscolicidæ by convergence, all these Ethiopian and Oriental genera are alike in having a great number of small spermathecæ in several segments of the body and in having for the most part a glandulo-muscular structure at

the outlet of the sperm ducts and often a series of glands which have been called for want of a better name "copulatory" glands which show a structure identical with that of the glands at the end of the male ducts. In tropical South America and in the West Indies are the following genera belonging to this family:—*Geoscolex, Anteus, Rhinodrilus, Urobenus, Pontoscolex, Onychochæta, Trichochæta, Diachæta, Tykonus.* These genera, if they possess spermathecæ, which they do as a rule, have them paired as in the majority of earthworms. A representative of this group *Sparganophilus* has been lately discovered by Dr Benham in the Thames, and *Criodrilus*, usually referred to the Lumbricidæ, perhaps belongs to the group, though its position cannot be at present regarded as certain. It is likewise European. It is a remarkable fact that the West Indian genera present considerable differences from the genera found on the mainland of South America. All of them, viz. *Pontoscolex, Onychochæta, Diachæta* and *Trichochæta* have always, or nearly always, the setæ throughout the body or of the posterior segments arranged in an irregular fashion though there are only the usual eight per segment. The existence of peculiar American forms in the West Indies and of peculiar African forms in Madagascar is paralleled in other groups of the animal kingdom. *Pontoscolex* it is true also occurs in South America; but it is so universally distributed a form that its exact habitat is a matter of some doubt and may as well be the West Indies as any other place. On the hypothesis that the Geoscolicidæ are comparatively speaking a modern group, their total absence from the

DISTRIBUTION OF EARTHWORMS.



EUDRILIDÆ (EXCLUSIVE OF EUDRILUS).

ACANTHODRILUS.

To face p. 65.

Australian region is a matter of moment, and recalls other distributional facts.

Not less interesting are the distributional facts concerning the Acanthodrilidæ. This family is divisible into the following genera:—*Acanthodrilus, Benhamia, Octochætus, Diplocardia, Deinodrilus, Kerria* and *Plagiochæta.* The family itself is separable from all other earthworms by the fact that, with the single exception of the species *Acanthodrilus monocystis,* formerly placed by me in a distinct genus *Neodrilus,* there are two pairs of spermiducal glands, which have not, as they have in nearly all other earthworms, a near connection with the sperm ducts, but open actually on to different segments from them; these segments are XVII. and XIX. the sperm ducts reaching the exterior by a pore situated upon segment XVIII. The two pairs of glands as well as their position are the distinguishing features of the family. The further division of the family into genera is in some respects not an altogether easy task. *Deinodrilus* is to be at once distinguished by the fact that it has the unique character of having twelve setæ in each segment of the body; *Plagiochæta* has a larger number still, as in the Perichætidæ; but the genus could not be confounded with a Perichætid by reason of the fact that these setæ are disposed in pairs. *Benhamia, Acanthodrilus* and *Octochætus* are with more difficulty separable; *Benhamia* and *Octochætus* have the excretory organs on the same plan as those of the majority of the Perichætidæ; they are extremely numerous in each segment of the body and open on to the exterior by very numerous pores on each

segment. *Acanthodrilus* has the usual paired series of nephridia. *Kerria* is a genus which is absolutely restricted to America; it is noteworthy on account of the fact that it shows in several particulars evidence of degeneration. Thus there is only a single pair of calciferous glands in the ninth segment, a character which it shares with several of the more simplified genera of Cryptodrilidæ, such as *Gordiodrilus*; the tubular glands which open in common with the sperm duct are lined by a single layer of cells instead of the thick layers so closely resembling those of the clitellum which are found in the majority of the remaining genera of earthworms.

The three genera *Octochætus*, *Deinodrilus* and *Plagiochæta* are absolutely limited in range to New Zealand, which may be considered to be the head-quarters of the family, as it also possesses a fair share of the known species of *Acanthodrilus*. Only three species of the latter genus are found in Australia, and it is a noteworthy fact that these three exist in Queensland and the neighbourhood of Torres' Straits, on the side in fact which is turned towards New Zealand and which has been probably at one time, no doubt remote, joined to New Zealand. The remaining species of *Acanthodrilus* are with a very few exceptions inhabitants of the more southern regions of the South American continent. They abound in Patagonia; but they do not, on the east side of that continent, get further north than Montevideo; on the other hand in Chili the genus extends considerably further north. The exceptions that have just been referred to relate to Kerguelen, Marion Island, the Cape of Good Hope, and

New Caledonia; in all of these countries there is one species apiece of *Acanthodrilus*. This genus is unusual though not unique among earthworms by reason of the fact that it is largely aquatic in habit though mainly terrestrial; even the same species, as for example *Acanthodrilus georgianus*, may be at once aquatic and terrestrial. This naturally adds to their facility for dispersal. The genus *Benhamia* is almost entirely African, that is to say "Ethiopian," in range; it is true that one species, *Benhamia bolavi*, has been met with in Europe; but there can be hardly any doubt that this species has been accidentally imported; there are also two or three species in Mexico and the East Indies; Dr Michaelsen thinks that these owe their presence in the countries mentioned to the effects of commerce and not to their own unaided exertions. Finally in North America there is the singular and somewhat aberrant genus *Diplocardia*, which consists of but a single species.

The most remarkable case of a restricted distribution among the Oligochæta is the family Eudrilidæ, which with the single exception of the genus *Eudrilus* is not to be met with outside of the Ethiopian region. As this genus *Eudrilus* is one of the commonest forms in gatherings of earthworms from several parts of the world, and as the species found outside Africa do not differ specifically, I am disposed to regard Africa as the proper home of this genus also, and to look upon the exotic specimens as having been accidentally carried thither. So far as our present knowledge goes, there are no forms outside of Africa which show any particular resemblance to the Eudrilidæ. This family

is marked out from all others by the fact that the ovaries are nearly always contained in special sacs, which are developed at the expense of the septa, and whose cavities therefore are true body cavities; and that these sacs communicate with the exterior by the oviducts or by special orifices or by both. In several genera the nephridia, which are, as in the Lumbricidæ, paired structures, a pair to each segment of the body, branch copiously in the thickness of the body wall, opening on to the exterior by many pores in a single segment. There are other peculiarities of structure which mark out the Eudrilidæ as one of the most isolated of families and therefore the Ethiopian region as, from the point of view of its earthworm inhabitants, one of the most peculiar of regions. It is noteworthy, seeing that recently many of the West African animals—for example the Chimpanzees—have been shown to extend into East Africa, that the genera of earthworms belonging to this family are not common to both sides of the continent. We have on the west coast the genera *Heliodrilus, Hypriodrilus* and *Lybiodrilus* among others; on the east coast *Stuhlmannia, Polytoreutus, Eudriloides* and *Notykus*, &c. &c.

The family Cryptodrilidæ is as has been already remarked nearly cosmopolitan. But the various genera of which the family is made up are none of them of so wide a range. Most of the principal regions have their peculiar genera; but the South American forms range also into New Zealand. These species belong to the genus *Microscolex* which occupies pretty nearly the whole of the South American continent and the warmer parts of the Nearctic

region. There are altogether some nineteen species of the genus of which those that are not American are from New Zealand; two species are Algerian, and they are closely allied to two American forms that have been met with in Australia, in Italy, and in the island of Teneriffe. This unusually wide range of the species in question seems to be possibly another case of accidental importation by man. In North America there are a few species assigned by Dr Benham and Dr Eisen to the two genera *Plutellus* and *Argilophilus* which I cannot differentiate from the purely Australian genus *Megascolides*, a genus which contains one of the largest earthworms at present known—the giant earthworm of Gippsland—a creature which grows to a length of six feet. In addition to this genus, which just gets into New Zealand with a single species, Australia has limited to itself the genera *Cryptodrilus, Digaster* and *Trinephrus*; the latter genus I have thought it advisable to separate from *Cryptodrilus* on account of the extraordinary fact that its members have in each segment of the body three pairs of nephridia. The division of the genera of Australian Cryptodrilidæ is however a matter of the greatest difficulty. In any case it appears to be clear that with the exceptions mentioned these genera do not extend beyond the Australian region and hardly beyond Australia itself. The Oriental region is also fairly well off in worms belonging to this family which are referable to the genera *Deodrilus, Typhœus, Microdrilus.* Africa has several peculiar forms, including *Millsonia, Gordiodrilus* and two species which Michaelsen has referred to my Fijian genus *Dichogaster*, but which may be really members of a different genus; at

present our knowledge of their anatomy is not sufficient to decide the point definitely. In America besides the genus *Microscolex* already described we have the bulk of the species of the semi-aquatic genus *Ocnerodrilus*, also found in Tropical Africa, and a species or two of the genus *Pontodrilus*, which is like no other earthworms except the ubiquitous genus *Pontoscolex* in living among the debris of sea-weed on the sea-shore. The other species of this genus live respectively in the Aru Islands, on the shores of the Mediterranean, and the North Sea, affording an example of the frequently wide range of forms whose habitat is a narrow area. This family of earthworms is one that is so difficult to classify in a satisfactory manner that it is not wise to draw any conclusions from its range except to point out the similarity between South America and New Zealand.

CHAPTER II.

ZOOLOGICAL GEOGRAPHY.

In the preceding chapter a few of the more salient facts in the distribution of animals have been detailed. We can define an animal by its geographical position as much as by its structure. It follows that the converse is equally true; each country has its own special inhabitants. One tract of country can be defined by its fauna and flora and thus distinguished from another tract of country.

A passage across the Straits of Dover lands us in a country which would seem at first sight to agree absolutely with our own in its animal inhabitants; a prolonged residence would however reveal the existence of a few species of animals not met with in Great Britain; but the general facies of the fauna would withstand the most prolonged scrutiny with a view to detecting differences.

We may journey across the entire continent of Europe without leaving a fauna generally like that which we have at home; even the traveller in Japan will at once recognize many animals which are either the same or very closely allied to those with which he is familiar at home.

But there are greater differences between Great Britain and Japan than between France and Great Britain.

In fact the more remote the tracts of country are from each other, the more diverse are their faunas. But there is no accurate balancing of distance and diversity of fauna possible; a journey into Central Africa, shorter by hundreds of miles than that to Japan, will bring the traveller into contact with forms of life altogether different from those which occur in these islands. The elephant, the giraffe, and the anthropoid apes will testify to the change which has taken place in a journey comparatively so short. In the Eastern Archipelago are two islands only separated by a few miles, Bali and Lombok; traversing this narrow strait will produce an entire change in the fauna, greater even than that which is experienced by the traveller from Europe to Tropical Africa. An entirely new race of mammals will be met with, the marsupials; while the apes, carnivora, and ungulate animals of the western parts of the Indian Archipelago entirely vanish or get exceedingly rare.

Mr Sclater's regions.

The first real attempt to divide the earth into regions corresponding with the range of its inhabitants is that of Mr Sclater[1].

His results were obtained entirely from a consideration of the Passerine and some of the Picarian birds. Nevertheless the regions thus formed were found applicable to

[1] *Journ. Linn. Soc.*, 1857.

other groups and they have been for the most part accepted. Mr Wallace more than anyone else has written much in their support.

It has however been insisted upon by many that these regions do not fit in with the facts of distribution of other groups. That their applicability to the Passerines and to those groups which they do suit is due to the fact that these groups are modern and that there has in all probability not been much change in the relative distribution of land and sea since the groups in question came into existence. These regions however are more particularly unsuitable to older groups, which retain, so to speak, the impression of earlier conditions of land and sea. So much so that the agreement or non-agreement of a particular group with the regions instituted by Mr Sclater are in some degree a test of its antiquity. Even in the more modern groups the resemblance is not always striking. Nor could we really expect that it would be; for a close resemblance would imply a similar place of origin, an identical series of migrations and backward migrations, and a susceptibility to precisely the same barriers and hindrances; these assumptions are evidently not to be thought of as well founded. So complicated are the conditions which govern the restrictions to migration and the facilitation of migration that it would be impossible to conceive of there being in any one case close correspondence with another case. While therefore we cannot expect to find a series of cut and dried regions which shall express the known facts of distribution of all terrestrial groups, it is of some use to have a convenient system

whereby the facts of distribution may be at once and with ease appreciated.

Mr Sclater founded his regions mainly upon the distribution of Passerine birds; but in a subsequent lecture[1] upon the geographical distribution of the Mammalia he applied the same regions for the purposes of tabulating the distribution of that group of animals also. In considering the distribution of the existing Mammalia four salient facts are at once apparent.

(1) Australia has both Monotremes and Marsupials.

(2) America has Marsupials but no Monotremes.

(3) The remainder of the world has Monodelphian Mammals only.

(4) New Zealand has no Mammals at all.

On this basis Mr Sclater divided the world as follows:

I. Land where Monodelphs only occur; no Marsupials or Monotremes. Europe, Asia, Africa, Asiatic islands down to Wallace's line, North America[2]. This land may be called *Arctogæa.*

II. Land where Monodelphs and Marsupials occur; no Monotremes. America south of the Isthmus of Tehuantepec. This land may be called *Dendrogæa.*

III. Land where Marsupials prevail; no Monodelphs but rodents and bats; Monotremes. Australia. This may be called *Antarctogæa.*

IV. Land without Mammals (except bats)[3]. New

[1] "The Geographical Distribution of Mammals." *Science Lectures for the People*, 1874.

[2] The common Opossum ranges however into this region.

[3] For a possible exception see below.

Zealand and the Pacific islands. This land may be called *Ornithogæa.*

Arctogæa is then subdivided into the well known Palæarctic, Ethiopian, Indian and Nearctic regions. But it is pointed out that these sections are not equal to the remaining and undivided Antarctogæa and Dendrogæa. The fourth section, Ornithogæa, is necessarily left out of consideration altogether, as it contains no Mammals (with a trifling exception or two). A better name for this division of the earth's surface is perhaps that suggested by Prof. Lankester, viz. Atheriogæa, since it expresses the cardinal fact in its zoogeography: which is not the possession of a rich bird fauna but the absence of an indigenous Mammal fauna.

Mr Huxley's regions.

A study of the distribution of the Alectoromorpha led Prof. Huxley to suggest a different division of the world into regions.

The Peristeropodes (the Cracidæ and Megapodidæ) are confined to a range of country which includes continental Australia and some of the islands to the north, along with South and Central America; this tract of the earth's surface he termed Notogæa, the part lying to the north being called Arctogæa. Arctogæa is tenanted by the following families of birds which are at most but poorly represented to the south of the line already mentioned:— the Pteroclidæ, Otidiæ, Gruidæ, Vulturidæ, Upupidæ and Bucerotidæ. This area is almost coincident with the range of the Insectivora, and it is the head-quarters of the

Ungulata. Ganoid fishes are not found outside it. On the other hand the southern region has all the Ratitæ (except *Struthio*), the Tinamous, the American Vultures (Cathartidæ), the bulk of the Pigeons and the Parrots including the most peculiar forms of both, and nearly all the Trochilidæ and Aptenodytidæ. Such remarkable and isolated types of birds as the Palamedeidæ, Psophiidæ, Cariamidæ and Opisthocomidæ are also confined to it. Among Mammals it is characterised by the Marsupialia, the Platyrrhine monkeys, the Monotremata, and most of the Edentata. It is poor in Ungulata.

This region of Notogæa is again divided by Prof. Huxley into three divisions, which he names Austro-Columbia, Australia and New Zealand.

The most obvious criticism to apply to these, and which has been applied, is that they are quite out of proportion; this is particularly the case with New Zealand, which has so few types of great importance as compared with Austro-Columbia. I do not however enter into any detailed criticism since the actual way in which the earth is divided up is so largely a matter of convenience—as is admitted on all hands.

Other suggested regions.

Some have wished to make a separate region of Madagascar, which has unquestionably a large number of peculiar types. Arctic and Antarctic regions commend themselves to many.

Quite the most unsatisfactory region, in my opinion,

that has been proposed is the Polynesian adopted by Prof. Heilprin[1]. This is meant to include the scattered islands to the east of Australia, comprised between lat. 20 N. and lat. 40 S. Prof. Heilprin admits that this region is defined "more by negative than by positive characters," a necessary admission, though not convincing of the justice of framing it. He distinguishes it by the absence of all Mammalia except a few bats, Pteropidæ and Vespertilionidæ. The birds include no special families excepting only the Rhinochetidæ and the Didunculidæ and Drepanididæ. All the other families are either exclusively Australian types or are birds of a wider range, including Australia. Among lizards the most remarkable form is the Iguanid *Brachylophus* from the Fijis. The same islands harbour three species belonging to the frog genus *Cornufer* and a toad, *Bufo dialophus*. If he includes, which appears probable though there is no definite statement upon the point, the Solomon Islands in this group, we can add to his list as distinctive of the "region" the huge *Rana guppyi*, a species of the Marsupial genus *Cuscus*, besides a crocodile, several snakes, and some more lizards and Amphibia. There is no remarkable assemblage of peculiar genera such as differentiate the other regions; the differences that do characterise this so-called region are merely due to the isolation of the different islands which are either (as in the case of the Solomon Islands according to Blanford) remnants of former land connection with Australia or New Guinea, or oceanic islands which have been populated from the nearest mainland, i.e.

[1] Called Nesogæa by Prof. Gill, *Proc. Biol. Soc. Washington*, Vol. I.

Australia. That there should be peculiar genera is quite in accord with both these modes of origin; but the fewness of the peculiar genera and their alliance with Australian forms seems to render it necessary to place the entire Polynesian realm within the Australian, and at most to regard it with Mr Wallace as a subregion (exclusive in this case of the Solomons).

Mr Sclater's regions the most convenient.

The question is, What system shall we adopt?

The ideal system would be one which agreed entirely with the distribution of land and sea and their inhabitants; but that is unfortunately impracticable. The next best is obviously the plan to try; and Mr Sclater's regions are, with an exception here and there, coincident with the continents and larger islands. The great thing is not to dispute the standard to be taken, but to agree in holding to one standard. As a mere matter of convenience it is immaterial whether we join Europe, Asia, and North America into one Holarctic region, or use the current terms of Nearctic and Palæarctic for the Old and New World divisions of this extensive tract. What we want to do is to find a common outline into which the details can be inserted. Mr Wallace in a recent lecture upon the regions most convenient for adoption[1] urges the retention of the Sclaterian regions for the following three principal reasons:—

(1) They are founded upon and approximate to the great primary divisions of the earth, which there is reason

[1] *Nature*, 1894.

to believe have been permanent during considerable geological periods.

(2) They are rich and varied in all the main types of life.

(3) They possess great individuality; whether exhibited by the possession of numerous peculiar species, genera, or families, or by the entire absence of genera or families which are abundant and wide-spread in some of the adjacent regions.

Mr Wallace admits that these regions are not quite perfect in all of these requirements, but they are more so than any other arrangement which has been devised. The Nearctic for instance is the poorest and the Neotropical region is the richest; there is not an absolute equality between any two; nor could the world be split up so as to attain to that desirable end. It is a matter of the very smallest importance to wrangle over the division which is most natural; as Mr Wallace says "there is no question of who is right and who is wrong in the naming and grouping of these regions or of determining what are the true primary regions. All proposed regions are from some points of view natural but the whole question of their grouping and nomenclature is one of convenience and utility in relation to the object aimed at."

It is clear that if our Zoological regions were to be constituted on the evidence afforded by the groups of animals whose range has been briefly sketched in its main outlines on previous pages they would not agree entirely with those of Mr Sclater or with each other.

The Herpetological regions show a marked difference

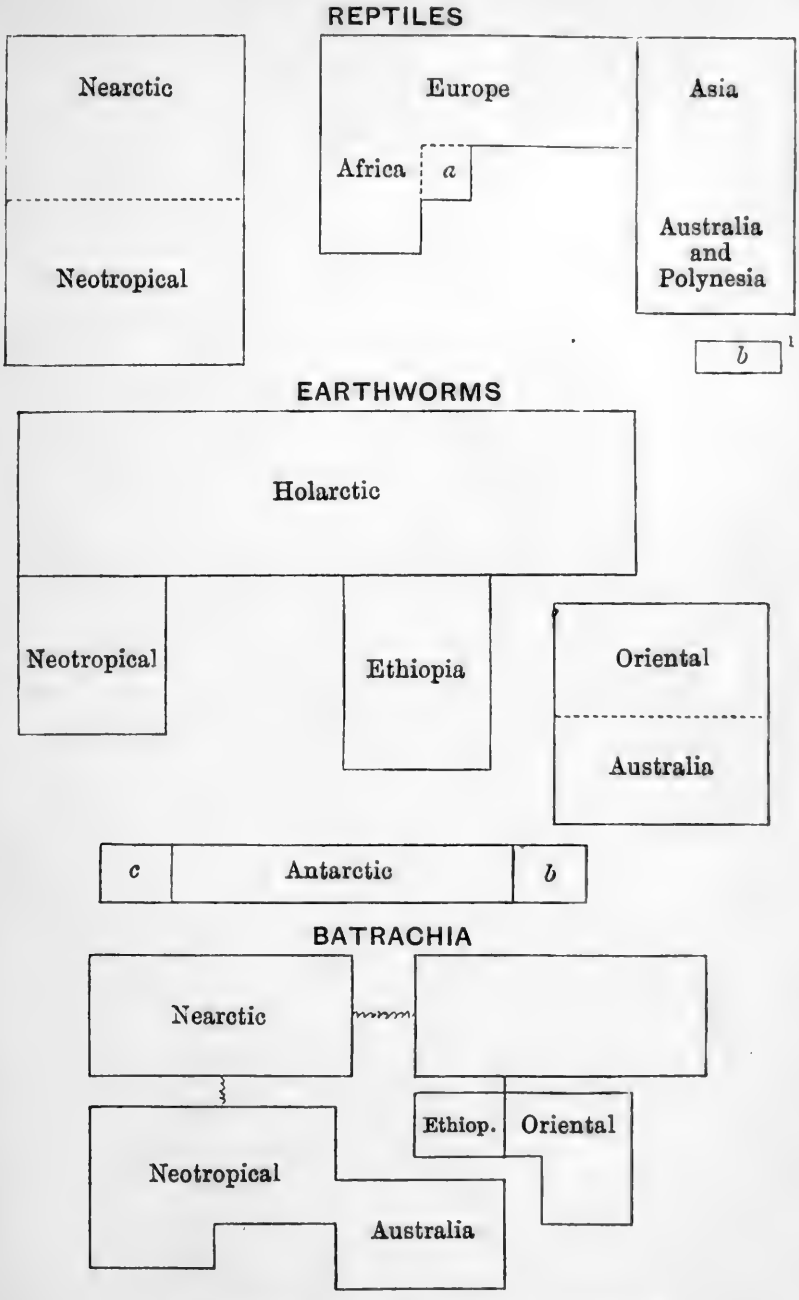
in the first place between the Old and New Worlds: Asia and Australia are nearer together than either of them is to Africa; and Africa is more nearly akin to Europe than to any other region. New Zealand forms a region quite apart from the others.

The earthworms on the other hand do not show so marked a distinction between the Old and the New Worlds; indeed they offer the best evidence of any group in favour of the Holarctic region. The Ethiopian region is very distinct, perhaps the most distinct of all. The Australian region is barely separable from the Oriental. It is quite necessary, in order to emphasise the facts of distribution in this group, to constitute an Antarctic region embracing New Zealand and Patagonia.

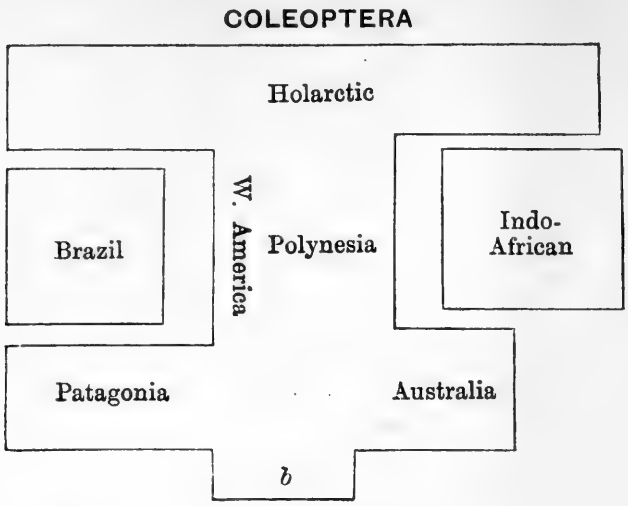
The Batrachians are again quite different from either of the other two groups considered. The Neotropical and the Australian really form one big region; so also do the Ethiopian and the Oriental; on the other hand the Nearctic and the Palæarctic are quite distinct; there can be no question here of a Holarctic realm.

To express in a graphic form the distribution of the land Planarians is a simpler matter than in the case of any of the other groups.

The following pages contain schemes of the distribution of some of these groups which are compared with the Insecta whose range in space and peculiarities of distribution I have not treated of at all. The diagrams of most of these are taken from M. Trouessart's book already referred to more than once and they represent the latest and most reliable information from specialists on the several groups.



[1] *a* Madagascar, *b* New Zealand, *c* Patagonia.



Upon what group then shall we found our divisions of the earth's surface?

The great objection to the birds is that they can fly and are therefore independent of most barriers; with them temperature, food and pre-occupation of the ground must be the chief limitations to universal range. Moreover it will be remembered that this group contains the largest number of cosmopolitan genera and species. All this tends to throw the claims of the birds into the background. Against their exclusive use also is the fact that they are a modern race, and would therefore at best only indicate the present arrangement of land and sea. At the furthest the birds go back to the Jurassic period; while the Carinate birds (speaking zoologically and not etymologically) are not of greater age than the Tertiary period. All curves of development show that birds are now in the ascendant and that they have risen rapidly into prominence. To this is due the variance of opinions

that prevail with regard to their proper classification. So intimately connected are the various types that it is difficult to define the groups; and all classification has to go upon that most unsatisfactory plan, the averaging of a number of structural characters. A thinning out of the numberless existing genera might reveal the main lines of ascent just as the branches of a tree stand out more plainly when they are denuded of the leaves. I have attempted to show elsewhere (p. 81, 82) that it is difficult to get any real justification for the generally adopted regions by the study of the range of different families. All that can be said in most cases is that the various regions have each a certain number of peculiar genera and families; but those facts lose value from the impossibility of making definite statements about the mutual affinities of the genera in question. The Gallinaceous birds which are less endowed with power of wing than many other groups offer the best evidence of a connection between structure and distribution. So too the Struthious birds.

Land Mollusca would appear on many grounds to be exceedingly valuable as furnishing evidence in favour of ancient land connections.

In an interesting paper Prof. Kobelt, a great authority upon the group, urges their claims to be put in the forefront of animals useful for this purpose.

There is however more than one serious objection to their use. As Mr Blanford points out, we are not at present in a very forward state of knowledge as to what conchologists term "the animal"; the anatomy of the group is for a large part ignored by those even who

make the group their special study. The relationships therefore of the different genera is in many cases obscure. They can therefore not be made use of in a strictly scientific comparison of the faunas of various parts of the world. We know how varied may be the structure of other animals—even belonging to the same group—under a superficial similarity; for example the genus *Doriopsis* among the Nudibranchs differs from the genus *Doris* (sensu lato) by the total absence of that most characteristic molluscan organ the odontophore; and yet with this important dissimilarity it would be impossible to separate the two genera by any marked external characters. Were one totally unacquainted with their internal structure the Brachiopods and Lamellibranchs might be, as they have been in the past, associated closely together. Analogous differences may separate some of the genera of Pulmonata whose anatomy is not known.

In the second place they are very capable in some way or other of crossing the ocean, for we find them in oceanic islands which cannot have been stocked independently with them. Mr Wallace remarks that "they have no means of passing over the sea but such as are very rare and exceptional." He quotes however Darwin's experiment to the effect that a Roman snail lived after immersion in salt water for twenty days. For further examples of the ways in which the terrestrial Mollusca can cross the sea the reader is referred to a later chapter.

If it were not for these objections the land Mollusca would be a most important group; they are extremely

ancient, the existing genera *Pupa* and *Zonites* going back to Carboniferous times.

Mr Wallace urges the superior claims of Mammals upon whose distribution to found Zoological regions. He thinks that they are best qualified "to exhibit by their existing distribution the past changes and present physical condition of the earth's surface."

The reasons for this opinion are according to Mr Wallace the following:—(1) They are dependent for their means of dispersal upon continuity of land. At least wide seas would be impassable. (2) They are (with the exception of the bats which fly and might therefore be subject to gales, and the mouse tribe which might be—are in fact—conveyed in ships) too large to be carried accidentally across seas which they could not traverse by their own unaided efforts. (3) Again they are so highly organised as to be largely independent of other animals; though both purely carnivorous and purely vegetarian forms exist there is for the most part no dependence upon any particular kind of animal or plant as food, such as we meet with for example among the insects. Or where there is a restriction in the matter of diet as in the case of the anteaters both of the old and new worlds the food is universally found. (4) The mammalia form a group which is fairly well known anatomically, we can therefore form a tolerably correct judgment as to their mutual relationships. That this is the case is shown by the absence of any differences of opinion as to the outlines of the main subdivisions of the family. (5) The last argument favourable to the Mammalia is the fact that

we have a better knowledge of extinct forms than we have of any other existing group. It is perfectly true that this knowledge will bear increasing and that it is practically limited to the extinct genera of Europe and North America with certain parts of South America and India. But after all compared with other groups the knowledge is undoubtedly considerable.

Though all this is perfectly true, yet the Mammalia are by no means an ideally perfect group for these purposes.

In the first place they are a comparatively modern group, dating back at the furthest to the triassic period. They are therefore perhaps to be regarded as representatives of the present state of affairs in land and sea. They have for example in all probability never reached New Zealand, between which and New Australia there may very likely have been an ancient land connection somewhere in the early secondary period or even earlier. The Mammalia also, although a comparatively modern race, are a waning race; as it has been said, we live in a world which is as regards mammals zoologically impoverished. This has brought about the existence (if the hibernicism be allowed) of so many missing links. The Marsupials for example, though called by Mr Huxley Metatheria and believed by him and by others to stand midway between the Monotremes and the higher Mammalia, with a more near approximation to the latter, cannot be satisfactorily tacked on to any particular group of the Eutheria. The very fact that the living Mammalia can be so easily classified, and that there is so little difference of opinion

about the scheme of classification, shows the breaks that exist between the various families. Though it is true that we have a fair anatomical knowledge of the Mammalia, yet there are plenty of lacunæ; the broad facts are perhaps ascertained, but there are many details of importance which require further elucidation. For instance there is but little knowledge, and that purely osteological, of the structural differences between the different kinds of bears and cats. These two families have a wide distribution and it would be of great interest to know if for example the muscular anatomy of the new world forms is distinctive of them and different from that of the old world genera or species. Besides much of our knowledge of the Mammalia is limited to skins and horns, in many cases necessarily. Unsuspected differences so constantly turn up between superficially very similar forms, that further knowledge is desirable. A noteworthy instance are the discoveries by the late Prof. Garrod in the anatomy of the soft parts of the rhinoceroses.

On the whole, however, it is impossible to avoid agreeing with Mr Wallace that the Mammalia are the most satisfactory group. And moreover the adoption of the regions necessitated by the distribution of this group is in harmony with the distribution of some other groups and does no great violence to distributional fact anywhere.

The six Zoological regions of Mr Sclater.

In the pages that follow I have purposely refrained from a detailed account of the faunas of each; much that is not to be found in the present section will be found elsewhere. I have here simply abstracted from Wallace and other books a list of the genera absolutely confined to each region, and given a few forms which are highly characteristic of, though not absolutely confined to, each region.

I. The Palæarctic region.

This region contains in the first place the whole of Europe with the outlying islands of Iceland in the north and down to the Cape de Verde islands in the south. The north of Africa to the tropic of Cancer is included by Mr Wallace, though others prolong the Palæarctic region further to the south; the Arabian peninsula is divided into two approximately equal halves by the line of division between the Palæarctic and the Ethiopian region. The whole of the north of Asia including Japan belongs to this region, which reaches the Arabian sea along the coast of Persia. The delimitations of the Oriental region are along the southern slopes of the Himalayas, Afghanistan and Baluchistan going with the Palæarctic. In China the limits of the Palæarctic region are at about Shanghai on the coast.

(i) Families of animals confined to the Palæarctic region.

None.

(ii) Genera confined to the region.

Talpa; Scaptochirus; Myogale; Scaptonyx; Anurosorex (Moles).

Lutronectes (an Otter); *Meles* (Badger).

Camelus; Dama (Fallow deer); *Capreolus* (Roe deer); *Hydropotes, Lophotragus, Elaphodus* (Cervidæ); *Bos, Poephagus* (Yak); *Addax, Procapra Saiga, Panthalops, Rupicapra* (Antelopes): *Capra* (Goat tribe).

Myoxus (Dormouse); *Spalax* (Rodentia).

Luscinia, Accentor, Erithacus (Sylviidæ); *Panurus* ("Bearded tit"); *Garrulus, Perisoreus* (Jays); *Nucifraga* (Nutcracker); *Cyanocitta, Fregilus* (Chough); *Fringilla, Acanthis, Montifringilla* (Finches).

Perdix, Tetraogallus (Gallinaceæ).

Ibidorhynchus (Scolopacidæ).

The region is however also characterised by a large number of forms which have their chief development therein, though they extend over its boundaries.

The genus *Phasianus* is nearly confined to the region and other allied genera such as *Thaumalea* the Golden Pheasant, *Ceriornis* the Tragopan, and the Ipeyan Pheasant, *Lophophorus*, have their greatest development within this region, though they do as a matter of fact cross its border and pass into the Oriental region.

A great many of the Mammalia are either specifically identical with North American forms or are very near indeed to them. The Aurochs and the Wapiti are hardly if at all specifically different from Luhdorf's deer and the

American bison. The grizzly bear, though it has received the specific name of *Ursus ferox*, is barely distinguishable from the brown bear *Ursus arctos* of Europe; there is no doubt at all about the identity of the reindeer, the elk, the glutton and the arctic fox which are common to the Nearctic and the Palæarctic regions. The lynx, wolf, marten, beaver and marmot are forms common to both regions without differences at all or showing differences of the slightest possible kind. All these animals are among the most characteristic of those inhabiting the Palæarctic region. The pouched rats *Cricetomys* are, as has been recently shown by the leading authority upon this group, Mr Thomas, hardly generically separable from the American *Hesperomys*. The musk deer, *Moschus*, and the peculiar bear-like creatures *Ailuropus* and *Ailurus* are not confined to the Palæarctic region; they are as characteristic of it however as they are of the Oriental region, in which they also occur. Even the tiger so pre-eminently, according to popular literature, a denizen of the tropics, may be fairly counted as an inhabitant of the temperate or even subarctic Palæarctic region since it has been met with so far north as the Amur. It is but recently that there were similar resemblances between the fauna of the western part of the Palæarctic region with that of Africa; the hippopotamus, the Maltese elephants, the lion and various other creatures have only lately become extinguished in this continent. While the mammoth of Siberia and elsewhere is held by some to be the actual progenitor of the Indian elephant, which is thought by them to hardly rank as a different species but to be rather a variety which

has lost its hairy covering on becoming an inhabitant of a hot climate. The hairy rhinoceros of Europe is another case in point.

The Palæarctic region is divided into (I) *European*, (II) *Mediterranean*, (III) *Siberian*, (IV) *Mantchurian* sub-regions.

I. The *European* sub-region comprises Central and Northern Europe. The only really peculiar genus is the Desman, *Myogale*, found in the streams of the Pyrenees and of Southern Russia. Many other Mammalia however are highly characteristic of the sub-region, though not positively confined to it. Such are the wolf, the mole, the hedgehog, and the dormouse. Not a single genus of birds is absolutely confined to the sub-region. But the Wagtails, the Tits and the Reedling, *Panurus*[1], are genera which are more abundant in this part of the world than elsewhere.

II. The *Mediterranean* sub-region, as might be inferred from its warmer climate, is by far the richest portion of the Palæarctic region. Besides that part of Europe bordering upon the Mediterranean Sea, it includes the north of Africa, down to the desert of Sahara, Persia and Baluchistan. Among Mammalia the Fallow deer (*Dama*) is peculiar to the sub-region; so too are *Psammomys* and *Ctenodactylus*, two genera of rodents. The Civet of the south of France and South Europe generally, the Porcupine and others are among the characteristic though not peculiar genera. These and some others show the African affinities of the Mediterranean sub-region. The *Hyæna*

[1] Sometimes (and inaccurately) called the "Bearded tit."

and the Lion point to the same transitional character. Among birds two warblers, *Lusciniola* and *Pyrophthalma*, are peculiar.

III. The *Siberian* sub-region includes the whole of Northern Asia. Of Mammals the yak and two antelopes, *Procapra* and *Panthalops*, are confined to it; the mole *Nectogale* is another peculiar form and completes the list of genera that are found here and in none of the other sub-regions. The musk deer however, *Moschus*, is nearly confined to the sub-region, while many Arctic animals, such as the sable, the glutton, and the reindeer are highly characteristic of it; the two latter as already mentioned also extending their range into the Nearctic region. Among birds there are few peculiar forms. The only genus that is "most decidedly" confined to the region is a genus of Starlings *Podoces*.

IV. The *Mantchurian* sub-region, bordering as it does upon the tropics, is rich when compared with other parts of the Palæarctic region. It includes all Japan besides Corea and other parts of China. Some of the peculiar deer, discovered by Père David and his associates, are peculiar to this sub-region. Such are *Hydropotes* and *Elaphodus*. The curious *Nyctereutes* and the carnivore *Æluropus* are also peculiar forms or nearly so. The former is often called the "raccoon-like dog"; the latter genus is allied to the Panda, *Ælurus*. Both of these occur also in the Oriental region. A genus of Otters, *Lutronectes*, is also peculiar, and there are a few other genera which are found in this sub-region and not in the other sub-regions of the Palæarctic region. The birds are

represented by an abundant variety of species; but as many of them are common to this and to the Oriental region which borders upon it, it is a little difficult to disentangle the faunas of the two. Some of the magnificent pheasants of the East, the genera *Lophophorus*, *Pucrasia*, *Thaumalea*, and *Crossoptilon*, are characteristic; but these have already been mentioned as among the birds characteristic of the region as a whole. There are also species of *Ceriornis* and *Phasianus*.

II. The Nearctic region.

This region consists of the whole of North America, together with a portion of Mexico, into which, according to Mr Wallace's map of the region, it sends a narrow tongue along the central mountain range. As Mr Wallace has pointed out, the greatest width of the continent in the more arctic parts of it and its narrowness where the climate becomes more congenial is largely responsible for the comparative poverty of the fauna.

List of families peculiar to the Nearctic region.

Saccomyidæ (Pouched rats), *Haploodontidæ* (Rodentia).

Chamæidæ (Passerines).

Genera peculiar to the region.

Synotus, *Autrozous* (Bats).

Condylura, *Scapanus*, *Scalops* (Moles).

Latax, *Taxidea* (Carnivora).

Antilocapra, *Ovibus*, *Haplocerus* (Bovidæ).

Neotoma, Sigmodon, Jaculus, Cynomys, Erethizon (Rodentia).

Salpinctes, Catherpes, Gymnokitta Picicorvus, Centronyx, Neocorys, &c. (Passeres).

Ectopistes (Columbidæ).

Pilohela (Scolopacidæ).

Highly characteristic of the region, among the Mammalia, are in the first place the bison and the grizzly bear; it is not quite certain, as I have already mentioned under the description of the Palæarctic region, whether these animals are specifically distinct from what are at the very least close allies in Europe and Asia. But if so the bison, now limited to a single herd from previously existing thousands, is a noteworthy type of American life, no less than is the formidable "grizzly." *Bassaris,* an animal now known to be allied to the Raccoons, but formerly placed in a different division of the Carnivora, is one of the numerous forms that are so common to the Nearctic and Neotropical regions, but has a larger range in the former. The Puma and the Skunks are other examples of animals which extend northwards from the South American continent. Among birds, humming birds and various members of the families Mniotiltidæ, Vireonidæ and Cærebidæ are examples of Neotropical forms which also extend into the North American continent. The same is the case with the Tanagers and several South American genera of Fringillidæ. The black cuckoo with a deep bill, the ani, *Crotophaga,* is also met with in North America, though more characteristic of South America.

A closer resemblance between the Nearctic and the Palæarctic regions than that which obtains between, say the Neotropical and the Ethiopian, would be expected on the theory of the polar origin of life. That there is a close resemblance has also some relation to the great similarity in climate and physical conditions between the two regions. But the question now for consideration is whether the similarity is such as to warrant the inclusion of the two in one Holarctic realm, as is contended by Dr Heilprin and Prof. Newton. Dr Wallace decidedly thinks not; and his reasons for this opposition are set forth in a special paper devoted to the question[1]. It appears from his tables that there are 43 genera of Mammals which are found in the Palæarctic region but not in the Nearctic. On the other hand 39 are peculiar to the Nearctic; 31 are common to both regions. These estimates, even when slightly edited, as will be indicated immediately, leave a respectable balance of forms peculiar to each region; doubtless the number of forms is poor when compared with other regions; but it must be borne in mind that these two temperate regions do not abound in Mammalian life as do the more tropical parts of the earth's surface. Of the 39 genera peculiar to the Nearctic region seven may be not unfairly deducted in making a final estimate as being largely, if not to a greater extent, Central or South American, i.e. Neotropical, also. The peccary, for example, is an animal which is rather characteristic of the Neotropical than the Nearctic region. The most striking argument however

[1] *Natural Science*, June, 1894.

for the reunion of the regions is afforded by the consideration that out of the 31 genera that they have in common it is only possible to withdraw three, as being aquatic and therefore having a range of less significance, and four which are exclusively or largely Arctic. Removing in addition four genera of ubiquitous bats there are left 16 genera which are common to the two regions. This calculation is made on the basis of genera admitted by Mr Wallace; on a more liberal estimate of what is meant by a genus the number of genera would of course be increased.

The Nearctic region is usually divided into the four following sub-regions: (I) *Californian*, (II) *Rocky Mountain*, (III) *Alleghany*, (IV) *Canadian*.

I. *Californian* sub-region. This includes besides California a considerable part of British Columbia. It has several peculiar genera of Mammals. Among them are *Enhydra* a sea otter, *Urotrichus* a mole and *Neosorex* a shrew. *Haploodon*, a rat-like rodent, is peculiar to this sub-region, as are also the only North American representatives of the bat families Phyllostomidæ and Noctilionidæ. The birds also embrace some peculiar forms. The "road runner" *Geococcyx* and the aberrant Passerine *Chamæa*, which Dr Shufeldt places near to the Tits, are found here and nowhere else in the region. There are other characteristic birds, but few that are absolutely confined to the sub-region.

II. *Central* or *Rocky Mountain* sub-region. The "bighorn" sheep (*Ovis montana*), the *Antilocapra* and the goat *Haploceros* are among the most characteristic Ungulates

confined to the sub-region. The bison so reduced in numbers now-a-days is almost confined to the Rocky Mountain sub-region. The prairie dog, *Cynomys*, a close ally of the marmot, is restricted to the sub-region. Birds contribute their quota toward distinguishing the sub-region from those which border upon it. But they are genera and not families. Among them may be mentioned the following: *Salpinctes*, a wren, *Poospiza*, a finch, and *Pediocœtes*, a grouse.

III. *Eastern* or *Alleghany* sub-region. Mr Wallace remarks that this sub-region "contains examples of all that is most characteristic of Nearctic zoology." But there is only one genus of Mammalia that is absolutely confined to it. This is *Condylura*, the star-nosed mole. Only 30 birds are mentioned by Wallace as peculiar to the region among non-migrants.

IV. The *Subarctic* or *Canadian* sub-region. This naturally presents many features of resemblance to the arctic parts of the Palæarctic region. It is characterised for example by such forms as the glutton, reindeer and elk, which pass into the Palæarctic region also. The musk deer however, *Ovibos*, is limited to this region, having apparently been a few times found outside of it in the Palæarctic region. The birds though numerous are not so peculiar: it upsets the current notions as to the tropical habits of the humming-birds to learn that a species, *Selasphorus rufus*, breeds in Alaska.

III. The Ethiopian region.

The Ethiopian region consists of all Tropical and South Africa, from about the Tropic of Capricorn (see Palæarctic region); it also includes the island of Madagascar and the adjacent Mascarene islands.

(i) Families peculiar to the Ethiopian region.

Chiromyidæ (Lemur).
Potamogalidæ, Chrysochloridæ (Insectivora).
Cryptoproctidæ, Protelidæ (Carnivora).
Hippopotamidæ, Camelopardalidæ (Ungulata).
Orycteropodidæ (Edentata).
Buphagidæ, Philepittidæ (Passeres).
Musophagidæ, Coliidæ, Leptosomidæ, Irrisoridæ (Picarians).
Serpentariidæ (Accipitres).
Struthionidæ.

(ii) Genera peculiar to the region.

Gorilla, Anthropopithecus, Colobus, Cercopithecus, Cercocebus, Cynocephalus (Primates).
Indris, Lemur, Galago, Chirogaleus, Hapalemur, Lepilemur, Perodicticus, Arctocebus, Microcebus (Lemurs).
Epomophorus, Hypsignathus, Macronycteris (Bats).
Petrodromus, Rhynchocyon, Centetes, Hemicentetes, Ericulus, Oryzoryctes, Echinops (Insectivora).
Helogale, Bdeogale, Eupleres, Cynictis, Lycaon, Megalotis, Ictonyx, &c. (Carnivora).

Potamochœrus, Phacochœrus, Oreas, Kobus, Alcephalus, &c. (Ungulata).

Lasiomys, Lophiomys, Saccostomus, Pedetes, Anomalurus, Aulacodus, Pectinator, Bathyerges, Georychus, &c. (Rodents).

Parisoma, Artamia, Hypocolius, Corvultur, Hyphantornis, Vidua, Buphaga, Crithagra, Amadina, &c. (Passeres).

Dendropicus, Geocolaptes, Pogonorhynchus, Buccanodon, Xylobucco, Coua, Atelornis, Ispidina, Bucorvus, Toccus, &c. (Picarians).

Alectrœnas, Œna, Chalcopelia, &c. (Columbidæ).

Agelastes, Numida, Ptilopachus, &c. (Gallinaceæ).

Polyboroides, Lophoaëtus, Melieirax, Nisoides, &c. (Accipitres).

Mesites, Himantornis (Rallidæ).

Scopus, Balœniceps (Ardeidæ).

The lion, panther, elephant, and rhinoceros are also of course among the most characteristic African Mammalia. Of *Rhinoceroses* there are apparently three species, of which only two, *R. simus* and *R. bicornis*, are at all known. The third has been lately reported. Also limited to this region are the zebras and quaggas, the last practically, if not actually, extinct. Of chimpanzees there are two well-marked species, the "common" chimpanzee and *Anthropopithecus calvus*, a species discovered by du Chaillu and until lately represented by a living specimen ("Sally") at the Zoological Society's gardens. It is quite likely that these are not the only two species of

chimpanzee. The Ethiopian region contains the majority of the antelopes; but in contrast to this abundance of antelopes is the total absence of deer. Another group which might be expected to occur, but which is inexplicably absent, is that of the bears. The hippopotamus is represented by two species, one of which, the small Liberian hippopotamus, has been placed in a distinct genus, *Chœropotamus*. This proceeding however according to Sir William Flower is unnecessary. The Lemurs, which form so characteristic a part of the fauna of this region, are nearly all of them limited to Madagascar—as indeed are many of the peculiar Ethiopian genera. They have been treated of in the more particular account which I give elsewhere (below) of the fauna of Madagascar. One or two resemblances between Africa and the Neotropical region have been noted under the account of the latter. Most of the resemblances of Africa are with the Oriental region. Thus the hornbills and barbets range through both regions, as do the panther and lion. The elephant and rhinoceros are only found in the Oriental region outside of the Ethiopian; but the species, and even, according to some systematists, the genera are different in the two cases.

Among birds, the huge whale-bill (*Balæniceps*) is one of the most remarkable of African types. Its ally, the hammerhead (*Scopus*), which seems to stand half-way between the Herons and Storks, is a widely-spread African type. The ground hornbill, which is undoubtedly a hornbill, though a very aberrant one, is almost equally singular. The colies and plantain eaters (Coliidæ and Musophagidæ)

are two groups of uncertain affinities; as the late Prof. Garrod pointed out, the latter has resemblances to the Gallinaceæ. *Mesites* of Madagascar will be found referred to under the description of the fauna of that island. The peculiar types of birds are by no means so numerous or so important as they are in South America.

The Ethiopian region is divisible into the following sub-regions: (I) *East-African,* (II) *West-African,* (III) *South-African,* (IV) *Mascarene.*

East-African sub-region. This sub-region includes not only east but also the greater part of central Africa, and it extends to the north so far as to include Arabia, Abyssinia and the south of Egypt. Below the Sahara it extends right across the continent to the Atlantic, its lower boundary being at about the river Gambia, and again below the West-African sub-region it extends right across. Among the peculiar Mammalia of this sub-region are the Gelada baboon of Abyssinia, the curious little naked and burrowing rodent *Heterocephalus* and another rodent, *Pectinator.* The rhinoceroses and the giraffe are practically confined to it, but this restriction is one of the many cases of the limitation of faunas largely due to man. Among birds the boatbill *Balæniceps* is peculiar, and so is the shrike *Hypocolius.* But on the whole the sub-region is not well marked by its peculiar types, though abounding in the characteristically African forms.

II. The *West-African* sub-region extends as far south as the Congo. It is characterised by the Gorilla and by at least one species of Chimpanzee, the *Anthropopithecus calvus.* The Potto, *Perodicticus,* and the nearly allied, if

not generically identical, Angwantibo (*Arctocebus*), are the lemurs which are confined to this sub-region. *Potamogale*, an Insectivore with the appearance and the habits of an otter, and *Hyomoschus* complete the list of the more salient mammalian types which are West-African. Among birds perhaps the most remarkable form is a species of *Pitta*, the only species of this oriental genus which reaches Africa at all. The birds are on the whole not remarkable or distinctive.

III. The *South-African* sub-region is bounded to the north entirely by the East-African region, which here as well as to the north of the West-African sub-region extends right across the continent. The sub-region has one family to itself, the Chrysochloridæ or Golden moles. The Hyænoid genus *Proteles* and the Hunting dog *Lycaon* are peculiar to it. *Bathyerges* and the jumping hare *Pedetes* are among the eighteen genera of mammals which are peculiar to South Africa. The birds are not remarkable.

IV. The *Mascarene* sub-region is dealt with below.

IV. The Oriental region.

To this region Mr Sclater at first gave the name of "Indian"; but Mr Wallace proposed to replace this name by the more general expression "oriental," a suggestion which has met with Mr Sclater's approval. This region comprises not only the peninsula of India and the more tropical parts of China, but it includes also a large proportion of the islands of the eastern archipelago. The

boundary between it and the Australian region has been termed "Wallace's line," and divides the island of Bali from that of Lombok to the south, and the island of Borneo from Celebes on the north.

(i) Families peculiar to the Oriental region.

Galeopithecidæ, Tupaiidæ (Insectivora).
Phyllornithidæ, Eurylæmidæ (Passerines).

(ii) Genera peculiar to the region.

Simia, Hylobates, Siamanga, Presbytes (Primates).
Nycticebus, Loris (Lemurs).
Megærops, Aquias, Phyllotis, &c. (Bats).
Gymnura (Insectivora).
Viverricula, Arctogale, Cyon, Arctonyx, Mydaus, &c. (Carnivora).
Tragulus, Cervulus, Portax, Antilope, Tetraceros (Ungulates).
Platacanthomys, Spalacomys, Phlœomys, Pteromys, Acanthion (Rodents).
Garrulax, Timalia, Mixornis, Paradoxornis, Enicurus, Salpornis, Dendrophila, Sylviparus, Cissa, Urocissa, Dendrocitta, &c. (Passeres).
Chrysocolaptes, Megalæma, Phœnicophaës, Carpococcyx, Nyctiornis, Harpactes, Buceros, Aceros, Rhinoplax, &c. (Picarians).
Pavo, Polyplectron, Euplocamus, Galloperdix (Gallinaceæ).
Hierax, Ketupa, Photodilus (Accipitres).
Hydrophasianus (Rallidæ).

Among the most characteristic animals of this region

stands in the first place the Orang, of which there may or may not be more than a single species. The Anthropoid apes are also represented by the agile family of the Gibbons (*Siamanga* and *Hylobates*). The two genera of Apes, *Macacus* and *Cynopithecus*, might really for all practical purposes have been included among the list of peculiar genera, for they only just get outside the region. Among carnivorous animals the Tiger is one of the most noticeable, though it is not strictly confined to the region, getting north into even the colder parts of the Palæarctic region. The remarkable lemur *Tarsius*, which is generally made the type and only member of a special family of the Lemurs, only just ranges beyond the Oriental region, while the "Slow Loris" and an ally represent the more normal lemurs. The Ungulates are many and characteristic. In addition to the peculiar genera mentioned in the above list there is of course the Indian elephant and the Malayan Tapir; three out of the five existing species of rhinoceros are also natives of this region. The others, as has been already mentioned, are Ethiopian; the porcupine *Atherura* is a genus which is common to this region and to the Ethiopian. So too the *Manis* or Scaly anteater. The flying squirrels, *Pteromys*, get as far north as Japan, but there are some who would place at least the southern portion of this empire in the Oriental rather than in the Palæarctic region. Of birds the family Timeliidæ, the "Babbling thrushes," are very nearly absolutely confined to this region; in Mr Wallace's list 21 out of a total of 27 genera, which he allows to the family, are exclusively Oriental. Some of the most magnificent species of the

pheasant tribe are entirely or mainly restricted to this region and are among the most characteristic of the bird inhabitants. The Cuckoos are well developed, and are represented by 18 genera, of which 2 are peculiar to the region; but here, as in so many cases, the limits of the genera are somewhat uncertain. The Bee-eater *Nyctiornis* is an oriental genus, and oriental only. The parrots are abundant, but there is only a single peculiar genus, *Psittinus*. The rest are mainly of Australian types, but the genus *Palæornis* is in addition African. The remarkable owl *Photodilus* has perhaps a near ally in *Heliodilus* of Madagascar, both of these genera, especially the latter, are again allied to *Strix* and form with it a special subfamily of the Owls. Another highly characteristic genus of birds is the Surgeon bird, *Hydrophasianus*, which has an ally in the genus *Parra* in the New World. The Ralline birds are however not abundant or represented by many peculiar types in the Oriental region.

The Oriental region has also four sub-regions, (I) *Indian*, (II) *Ceylonese*, (III) *Indo-Chinese*, (IV) *Malayan*.

I. *Indian* sub-region. This sub-region comprises the entire peninsula of Hindostan. It does not abound in peculiar forms, but there are a few which are confined to it. The genus *Tæniogale* among the Viverridæ is in this position; the majority of the oriental Antelopes have here their head-quarters.

II. The *Ceylonese* sub-region includes besides the island of Ceylon a large part of southern India. It is a little richer in peculiar types, but is still not very peculiar. The lemur *Loris* is found here; the rodent genus *Plata-*

canthomys is another peculiar type. Several species of "Holy ape" (*Semnopithecus*) are limited to this sub-region. As to the birds Mr Holdsworth allowed in 1872, 325 species, of which 37 are peculiar to Ceylon. This number is raised by Mr Wallace to 80 for the whole sub-region. There is only one genus that is peculiar, viz. *Elaphrornis* and a sub-genus *Sturnornis*.

III. The *Indo-Chinese* sub-region includes the Himalayas as well as Siam and tropical China. Among peculiar genera of Mammals are the Viverrines *Urva* and *Arctonyx*, and the remarkable carnivore *Ælurus*[1]. There are a number of peculiar birds of the passerine and picarian groups; these include the genera *Liothrix, Urocissa, Aceros* (a hornbill), and a number of others; the Gallinaceous *Ceriornis* (the Tragopan) is another genus nearly limited to the sub-region.

IV. The *Malayan* sub-region, as might be inferred from the fact that it is almost entirely made up of islands, has a number of peculiar forms. The Anthropoid apes of the east are most abundant here, and the Orang is found nowhere else: the lemur *Tarsius* is very nearly confined to this sub-region, not occurring in any of the other sub-regions but just passing the boundary of the Australian region. The insectivore *Gymnura*, the curious mountain living carnivore *Mydaus*, the Indian Tapir are among other mammals that are confined to this sub-region. If we regard the island of Celebes[2], that "fragment of miocene Asia," as a part of this region—a position to

[1] This is also palæarctic.

[2] Mr Sclater does in his most recently expressed opinion, *Ibis*, Oct. 1891.

which Mr Wallace does not commit himself—it is a tower of strength in the way of peculiar forms. There are here the Babirussa, the Bull-antelope (*Anoa*) and the ape genus or sub-genus *Cynopithecus*. Among birds this sub-region has as peculiar to it the genus *Timelia* among the "Babbling thrushes," *Eupetes*, a curious form which Mr Forbes placed in the Timeliidæ, and quite a number of other Passerine genera. The Australian *Megapodius* gets into this sub-region, and there is the cuckoo *Carpococcyx*.

V. The Neotropical region.

This region has obvious boundaries for the greater part of its extent, since it consists of the continent of South America. It also includes the West Indies and the greater part of Central America.

(i) Families peculiar to the Neotropical region.

Cebidæ, Hapalidæ (Quadrumana).

Chinchillidæ, Caviidæ (Rodents).

Bradypodidæ, Dasypodidæ, Myrmecophagidæ (Edentates).

Cærebidæ, Oxyrhamphidæ, Pipridæ, Cotingidæ, Phytotomidæ, Dendrocolaptidæ, Formicariidæ, Pteroptochidæ (Passeres).

Rhymphastidæ, Bucconidæ, Galbulidæ, Todidæ, Momotidæ, Steatornithidæ (Picarians).

Cracidæ, Tinamidæ (Gallinaceæ).

Opisthocomidæ ("Hoatzin").

Thinocoridæ, Cariamidæ, Aramidæ, Psophiidæ, Eurypygidæ, Palamedeidæ ("Grallæ").

(ii) Genera peculiar to the region.

Pteronotus, Chilonycteris, Noctilio (Bats).
Solenodon (Insectivore).
Icticyon, Galictis, Nasua, Cercoleptes (Carnivora).
Dicotyles, Lama (Ungulates).
Neotomys, Cercolabes, Chœtomys (Rodents).
Chironectes, Hyracodon (Marsupials).
Mimocychla, Donacobius, Cyanocorax, Basileuterus, Sycalis, Diuca, &c. &c. (Passeres).
Picumnus, Chloronerpes, Guira, Neomorphus, Panyptila, &c. &c. (Picariæ).
Ara, Caica, Chrysotis, Pionus, &c. (Psittaci).
Columbula, Zenaida, Starnœnas, &c. (Columbæ).
Odontophorus, Dendrortyx, Eupsychortyx (Gallinaceæ).
Sarcorhamphus, Spiziastur, Morphnus, &c. (Accipitres).
Heliornis, Oreophilus, Pluvianellus, &c. (Rails).
Tigrisoma, Cancroma (Ardeidæ).
Micropterus, Merganetta (Anatidæ).
Rhea (Struthiones).

Besides the peculiar families enumerated above the Nearctic region shares with the present the exclusive possession of the Humming-birds (Trochilidæ), Tanagers, Mniotilitidæ, Vireonidæ, Tyrannidæ, Conuridæ, of all of which the bulk of the species are South American. The American vultures, which have been aptly termed by Mr Seebohm Mimogypes, are chiefly neotropical, but also range into the northern hemisphere. Of characteristic

forms not by any means either as to the family or the genus to which they belong, which are confined to this region, extending sometimes for a greater or less distance into the Nearctic, are the Tapirs, which are represented by several species, some of which were separated by the late Mr Alston as a distinct genus *Elasmognathus*: the Jaguar and the Puma among the Carnivora, the former being confined to the region: the Opossums of the genus *Didelphys* are found here and in the southern parts of the Nearctic: the Skunk may be mentioned in the same category as the last: *Bassaris* is a carnivorous animal whose affinities, now known to be with the bear tribe, were at one time unrecognised; it also extends into the warmer parts of North America. The number of peculiar genera belonging to the region is very large. Four of the peculiar Gralline families contain but a single genus apiece and very few species between them; they are all of them birds whose position in the system is much disputed, owing no doubt to their being the impoverished relics of groups of birds at one time more abundant. *Palamedea* and *Chauna* are believed to be a relic of an ancestral tribe of anatiform birds; *Cariama* is said by some to present resemblances to the Secretary bird of Africa and to have therefore some relations to the birds of prey. *Psophia* and *Aramus* are more distinctly rails, while *Eurypyga* again is a bird which is allied to the New Caledonian *Rhinochetus*, and to the Madagascar *Mesites*, and possibly represents the sole remaining American type of a nearly extinct order of birds once universally distributed. Of *Opisthocomus* the same kind

of remarks can in all probability be safely made. It seems to be an outlier of the Gallinaceous tribe, which is itself represented in this region by two other ancient families (see p. 28), the Tinamidæ and the Cracidæ, of which of course the Tinamidæ are the most ancient, inasmuch as they alone of all Carinate birds resemble the Ostrich tribe in the absence of any fusion between the pubes and the ischia. The Oil-bird (*Steatornis*) cannot perhaps lay claim to any great antiquity but it is a very remarkable type of Caprimulgine bird. The Trogons and Barbets are also found in the Ethiopian and Oriental regions. The scarlet Ibis, and the Boatbill *Cancroma*—a Night Heron with an enlarged beak, approaching that of the African *Balæniceps*—are other instances of peculiar South-American birds.

The Neotropical region is divisible into four sub-regions; these are (I) *Chilian*, (II) *Brazilian*, (III) *Mexican*, (IV) *West-Indian*.

I. The *Chilian* sub-region. This includes the whole of Patagonia and the greater part of Chili; the Andes divide it to the north from the Brazilian sub-region. It is well marked by several groups of animals, which give it a perfectly distinctive character. In the first place we have the rodent family of the Chinchillidæ; the Llama, Huanaco, Alpaca and Vicuña belonging to the genus *Lama*, are as characteristic; two genera of Armadillos, *Tolypeutes* and *Chlamydophorus*, are restricted in their range to this region, and it has other peculiar rodents in addition to the family mentioned. Among birds the family Thinocoridæ with the two genera *Thinocoris* and *Attagis*, which

the late Prof. Garrod showed to be most nearly related to the "Courser" of the old world, is one of the most typical of the sub-region. The Tinamou genus *Calodromas*, with cæca unique in their complicated branching, is also confined to the sub-region. *Rhea* is equally limited to this part of the world, and there are numerous other genera of birds belonging to many families, which exist only in the Chilian sub-region. Among earthworms it contains all or nearly all of the genera *Acanthodrilus* and *Microscolex*; this group of animals offering one of the best reasons for its separation.

II. The *Brazilian* sub-region. This sub-region includes all the forest region of South America and is practically coextensive with the political division of the continent known as Brazil. It reaches up to the sea on the north and across the Andes on the west. The monkeys, *Lagothrix*, *Brachyurus* and *Pithecia*, are limited to this region, which indeed contains nearly all of the arboreal animals of South America. The Tapirs of the genus *Tapirus* are found here only. The Great Anteater (*Myrmecophaga*), the Sloth *Bradypus* and a few Armadillos are confined to the sub-region. Among birds it has the isolated genera *Psophia* and *Eurypyga*, besides innumerable genera belonging to the Cotingidæ and other families.

III. The *Mexican* sub-region. This sub-region is in some respects intermediate between the rest of the Neotropical and the Nearctic regions. It is not so rich in peculiar types of South American animals as are either of the sub-regions already described. There are however not a few types entirely restricted to tropical Mexico. Among

the most important of these is the mountain Tapir *Elasmognathus*; the *Bassaris*, a raccoon-like animal formerly and wrongly assigned to the Viverridæ, is Nearctic as well as central American. The only other genus of Mammalia which is really confined to the sub-region besides the Tapir is a genus of mice, *Myxomys*. As with the Mammalia so with the birds this sub-region is the common meeting ground of the Nearctic and Neotropical fauna, with a distinct bent towards the latter. Mr Wallace states that there are in all 37 genera of land birds confined to it, all of which are of common Nearctic or Neotropical families.

IV. The *West-Indian* sub-region. This sub-region consists of the islands of the West Indies, and bears a somewhat analogous relation to the continent of South America that the island of Madagascar does to that of Africa. As far as concerns Mammals it is largely marked by negative characters; there are no Edentates, monkeys or Carnivora; but the two older (?) groups of mammals, Rodents and Insectivora, are represented by peculiar types. The latter is represented by the genus *Solenodon*, which belongs to the family Centetidæ, elsewhere only found in Madagascar. The Rodent *Capromys* is the most peculiar representative of its order. The birds are also remarkable; the genus *Todus*, which the late Mr Forbes elevated to a group equivalent to the rest of the Picarian birds, is found here and here only. It is widely spread in the islands and has peculiar forms in many of them. The other birds are not so remarkable; they are characteristically neotropical, belonging to such families as Trochilidæ

(Humming birds), Cotingidæ (Chatterers), Cœrebidæ (Sugar birds).

VI. The Australian region.

The Australian region consists, as its name denotes, of the Australian island-continent; it also embraces the island of New Zealand to the east and various small scattered islands in the neighbourhood of this. The islands of the Pacific lying to the north and to the east of Australia also are referable to the same region, as are the great islands of New Guinea, and probably Celebes. The chain of East Indies beginning with Java is partly Oriental and partly Australian; the division between the two often spoken of as "Wallace's line" lies between the islands of Bali and Lombok.

One order, the Monotremata, is peculiar to this region.

Families peculiar to the Australian region.

Dasyuridæ, Myrmecobiidæ, Peramelidæ, Macropodidæ, Phalangistidæ, Phascolomyidæ (Marsupials).

Paradiseidæ, Meliphagidæ, Drepanididæ, Menuridæ, Atrichiidæ (Passeres).

Platycercidæ, Trichoglossidæ, Nestoridæ, Stringopidæ (Parrots).

Didunculidæ (Pigeons).

Rhinochetidæ (Grallæ).

Casuariidæ, Apterygiidæ (Struthiones).

Genera peculiar to the region.

Hypoderma, Notopteris, Mystacina (Bats).

Babyrussa (Pigs).

Anoa (Bovidæ).

Pseudomys, Hapalotis, Hydromys, Acanthomys, Echiothrix (Rodents).

Malurus, Calamanthus, Orthonyx, Artamides, Pachycephala, &c. (Passeres).

Scythrops, Rhamphococcyx (Cuckoos).

Dacelo, Tanysiptera, Podargus, Aegotheles, &c. (Picarians).

Calopsitta, Microglossus, Eos, Eclectus, Trichoglossus, &c. (Parrots).

Turacœna, Calœnas, Otidiphaps, Phaps, Geophaps, &c. (Pigeons).

Talegallus, Megacephalon, Lipoa (Megapodes).

Urospiza, Uroaëtus, Harpa, Hieracidea, &c. (Accipitres).

Ocydromus, Tribonyx, Habroptila, Pareudiastes (Rallidæ).

Thinornis, Pedionomus, Anarhynchus, Erythrogonys (Charadriidæ).

Malacorhynchus, Hymenolœmus, Biziura, Cereopsis (Anatidæ)[1].

The family of the Megapodes is as nearly as possible confined to this region, a single species getting as far as the Andamans in the Oriental region; so too the Cacatuidæ which extend beyond it only to the Philippines. Of course the most impressive character of the region is the possession of nearly all the Marsupials; with the exception of a single family, the Didelphidæ, found in North,

[1] The above list contains the peculiar Celebes genera. The relations of this island are extremely doubtful.

Central and South America, there are no Marsupials found outside of Australia and the Australian region. As this region consists so largely of islands it might be expected that the peculiar forms have often an extremely limited range within it; that is the case, and I have dealt elsewhere with the fauna of New Zealand, which is an important part of the Australian region, so important indeed that it has been proposed to separate it off as an equivalent region. Among the characteristic animals of Australia that do not belong to genera or families limited to the region is the wild dog, the Dingo; it has been doubted whether this is really an indigenous animal at all.

It is often suggested, or perhaps left to be inferred, that the Avifauna of this region is inferior in its distinctiveness to the Mammalian; no doubt the absolutely unrivalled peculiarity of that fauna tends to obscure by contrast the real and numerous peculiarities of the bird fauna; but a glance at the above list will show that Australia and its adjacent islands in reality abounds with peculiar types of birds. It is specially noteworthy on account of the great abundance and variety of the Parrots, being comparable to—indeed really excelling in this respect—South America. Highly characteristic also of the region are the Pigeons. These rather defenceless birds, which have no beak or claw to speak of, and which construct rude and easily accessible nests exposed to view in the most open manner, possibly owe their abundance to the absence of a great variety of Carnivorous Mammalia. They are also to a considerable extent marked

with green, a protective colour in the forests which they inhabit. Mr Wallace, to whom the above suggestions in explanation of the great prevalence of Pigeons are due, estimates that "three-fourths of the genera have representatives in the Australian region, while two-fifths of the whole are confined to it."

The Australian region is not quite so destitute of Mammals not belonging to the orders Monotremata and Marsupialia as is sometimes apt to be inferred. Apart from the peculiar genera of Rodents and the few other peculiar forms enumerated in the above table, a Macaque and a *Cynopithecus* get into the region where it touches the Oriental; the remarkable Oriental Lemur the *Tarsius* also enters the region; Viverridæ and shrews are not unknown, though few and rare; the genus *Sus* extends as far into the region as New Guinea. On the whole this is perhaps the most isolated in its affinities of all the regions. The boundary between it and the Oriental is sharply marked; I have dealt elsewhere (see below) with such resemblances as it affords to other parts of the world and the Neotropical region.

The Australian has four well marked sub-regions, viz., (I) *Austro-Malayan*, (II) *Polynesian*, (III) *Australian*, and (IV) *Novo-Zealanian*.

I. The *Papuan* or *Austro-Malayan* sub-region includes not only New Guinea and all the islands lying to the west of it as far as the commencement of the Oriental region, but the extreme north of the continent of Australia. Being entirely, or nearly entirely, made up of islands it has a large number of peculiar forms. The

Marsupials get to thin out here considerably; but there are peculiar genera; in New Guinea itself we have *Dorcopsis*; the Tree Kangaroo *Dendrolagus* is confined to New Guinea and North Queensland; a genus of Phalangers *Distœchurus* is also peculiar, and there are several species characteristic of these islands; the recently discovered Echidna, *Proechidna bruijnii*, is peculiar to New Guinea. Among birds the most characteristic are the Birds of Paradise belonging to the genera *Paradisea*, *Manucodia*; *Seleucides* and many others. The cockatoo *Microglossus* is a peculiar genus and the Cassowaries have here their headquarters.

II. *Polynesian.* This sub-region is largely dealt with below; it is characterised rather by the absence of forms which ought, so to speak, to be there than by the presence of peculiar forms.

III. The *Australian* sub-region is of course the headquarters of the Marsupials and Monotremes, of which latter group the Platypus is restricted to the sub-region. Among Marsupials the Wombats, Thylacine and Koala are confined to it. Another remarkable type of Marsupial entirely confined to this sub-region is the small insect-eating *Myrmecobius*; the lately discovered "Marsupial mole" is another type which marks out this from the other sub-regions. This sub-region has according to Mr Wallace a larger proportion of peculiar birds than any other sub-region of any region. Nineteen-twentieths of the birds are confined to it. The Emeu and the Cereopsis goose are among the most characteristic forms.

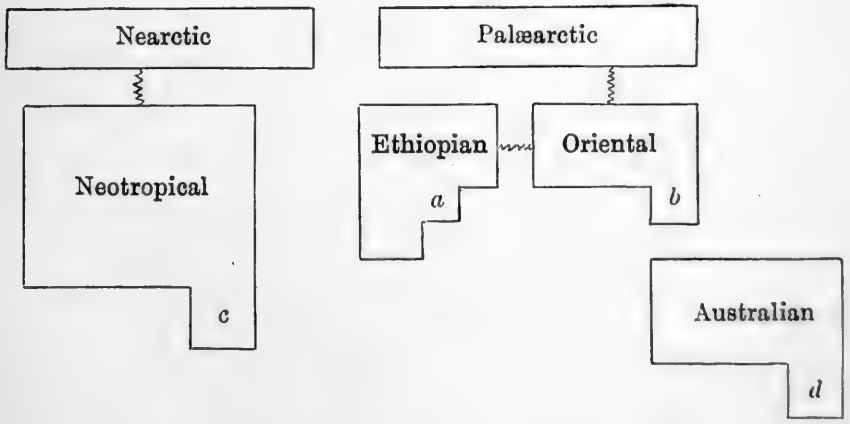
IV. The *Novo-Zealanian* sub-region comprising New Zealand and some of the adjacent islands is described in detail below.

Some graphic Methods of presenting the facts of Distribution.

In order to get a clear idea of the facts of Zoogeography and to compare one series of facts with another it is requisite to present them in a graphic fashion. The usual method is to indicate the different Distributional regions upon a map by the help of varied colour. The colour might even be made to some extent appropriate; the Neotropical region—Dendrogæa as Mr Sclater terms it—preeminently a region of forests and inhabited by so many arboreal types, might be conveniently coloured green; those who accept the Holarctic realm of Prof. Newton might suitably leave it white in order to suggest the characteristic Arctic forms. Prof. Camerano has recently attempted to show that there is a distinct relation between colour and geographical range. He thinks that yellow is the prevailing colour in Africa, grey in Asia and so forth. This method of colouring the primary regions may commend itself to some. A difficulty is offered by the transitional tracts which combine the characters of the two regions between which they lie. These transitional areas are perhaps more marked between the Palæarctic and the Ethiopian on the one hand and between the Palæarctic and Oriental on the other. Prof. Möbius[1] colours these transitional areas with a paler hue of the

[1] Die Tiergebiete der Erde &c. *Archiv f. Naturg.* 1891, p. 277.

tint applied to the region which they most resemble. Dr Heilprin prefers to shade the transitional areas. This method however is too voluminous and expensive to be used in illustration of the geographical range of different species, genera and families. The number of maps required is reduced by a plan adopted by Dr Grevé[1] in a series of papers upon the distribution of the different groups of Carnivora. The areas of certain species that do not overlap are coloured with different tints; where there is an overlapping the boundaries are indicated by differently coloured lines made up of dots or strokes or crosses &c., &c. The complexity of the result thus produced seems however to counterbalance the economy of space. There is no doubt that maps convey a more rapid and accurate impression than tables; and Mr J. A. Allen has eliminated the element of expense by suggesting diagrammatic maps which can be constructed of lines and dashes in ordinary use by printers. The following scheme

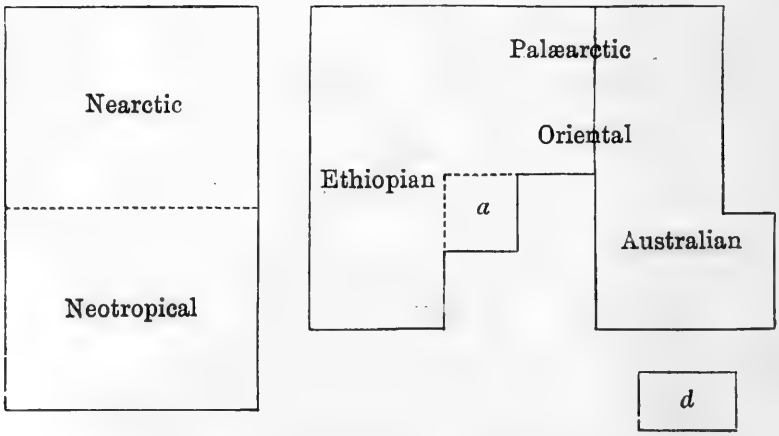


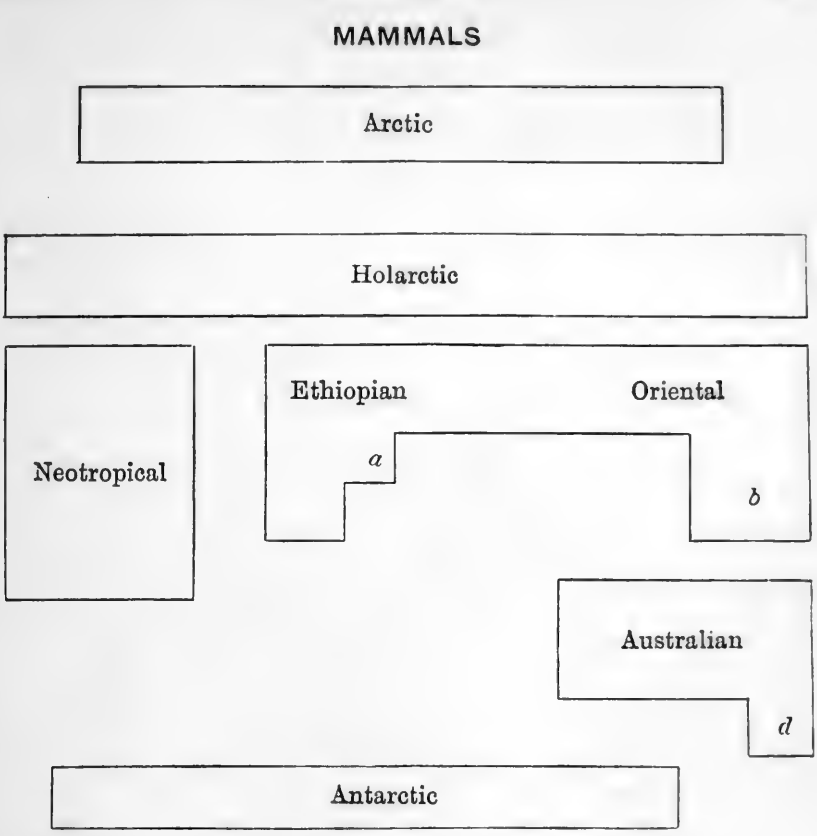
[1] *Zoologische Jahrb. Abt. f. Syst.* Bd. VI. 1892.

slightly altered from the original, indicates the regions of Sclater and Wallace with the *principal* sub-regions, i.e. (*a*) Madagascar, (*b*) Malaya, (*c*) Patagonia, (*d*) New Zealand.

The wavy lines connecting certain of the regions show that they are related. This method (which I have already utilised) is useful for indicating the range of species, genera or families, the names of which can be written in the spaces; but it is more particularly advantageous for a broad survey of the divisions of the earth's surface which a study of different groups necessitates and which may be compared. The following are Trouessart's schemes of herpetological and mammalian regions.

REPTILES





Mr Mitchell has recently[1] devised a still further simplification which again can be printed from ordinary type lines. The regions may be thus indicated.

Nearctic	Palæarctic	
Neotropical	Ethiopian	Oriental
		Australian

The scheme may be made more complete by the

[1] *P.Z.S.* 1890, p. 607.

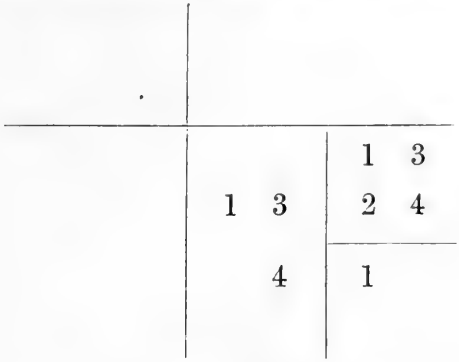
addition of the sub-regions. As Mr Mitchell points out the four sub-regions of each region except in the case of the Nearctic lie in a general way two to the north and two to the south. The sub-regions may be indicated by the following numbers.

Palæarctic region.		*Ethiopian region.*	
N. European	1	W. African	1
Mediterranean	2	S. African	2
Siberian	3	E. African	3
Manchurian	4	Madagascar	4
Oriental region.		*Australian region.*	
Hindostan	1	Austro-Malay	1
Ceylon	2	Australia	2
Indo-China	3	Polynesia	3
Indo-Malay	4	New Zealand	4
Nearctic region.		*Neotropical region.*	
Canada	1	Mexico	1
California	2	Chili	2
Rockies	3	Antilles	3
E. States	4	Brazil	4

The complete scheme therefore will be as follows with the sub-regions shown.

1 2 3 4	1 2	3 4
1 3	1 3	1 3 2 4
2 4	2 4	1 3 2 4

The range of any particular form is given by leaving out all but the sub-regions where it occurs, putting these in their proper place. Thus the range of the existing Lemurs would be expressed in the following way.



It might be advantageous to mark in heavy type those sub-regions which are especially inhabited by the animal in question, and various other modifications are of course possible and will suggest themselves. The great advantage of Mr Mitchell's scheme is that it can be so easily used for the purposes of blackboard demonstration in lectures.

CHAPTER III.

THE CAUSES WHICH INFLUENCE THE DISTRIBUTION OF ANIMALS.

Distribution not dependent upon temperature.

It was at one time held that distribution depended upon temperature; that therefore the world could be divided into zones corresponding to the belts of varying temperature.

That the range of animals is to a large degree dependent upon temperature is an undoubted fact; and to a certain extent that fact does permit of the zonal arrangement of the earth. Only however as concerns the arctic regions; here we have occasionally the same species ranging right round the pole as we have in the case of the marine mammalia and the birds of the south pole. Some even go so far as to unite for the same reason the Palæarctic and Nearctic regions. On *a priori* grounds too there would seem to be something to be said for a series of circumpolar regions; as the earth cooled life would be able to advance from the poles towards the equator, and the whole matter has recently been resuscitated in the polar theory of the origin of faunas (see below).

Distribution of Crustacean Arcturus as illustrative of connection between range and temperature.

It is chiefly marine organisms which show a close interdependence of temperature and distribution. The Isopod genus *Arcturus* and the nearly related *Astacilla* prevail chiefly in the antarctic hemisphere; it is only recently however that they have been obtained from that part of the world. Until the voyages of the German ship "Gazelle" and the English vessel "Challenger" the two genera were only known from the northern hemisphere. Four or five species of *Astacilla* occur on the coasts of Great Britain, N. America and Northern Europe; while the large *Arcturus baffini* is the only representative of its genus from the north, which is an inhabitant of shallow seas. It is in the antarctic region of the globe that *Arcturus* is so prevalent. Two species named *Arcturus coppingeri* and *A. americanus* occur in the shallow water off the coasts of Patagonia; three species of *Arcturus*, viz. *A. furcatus*, *A. studeri*, *A. stebbingi*, are met with on the shores of Kerguelen, besides a peculiar genus still referable to the same family and containing one species *Arcturides cornutus*. A single *Astacilla*, *A. marionensis* lives, as its specific name implies, on the shores of Marion Island, not so far from Kerguelen; finally there is a peculiar form with eyes on long but immobile stalks, *Arcturus oculatus*, on the shores of South Australia. In addition to these inhabitants of shallow water there are a number of species which are only found in deep water and one (*Arcturus furcatus*) which lives in both

shallow and deep water—a very rare exception so far as this group is concerned. The purely deep sea forms with their habitats are the following:—

A. glacialis, Antarctic.
A. spinosus, Antarctic.
A. anna, Antarctic.
A. brunneus, Antarctic.
A. myops, Antarctic.
A. cornutus, Indian Archipelago.
A. spinifrons, Fiji.
A. purpureus, West Indies.
A. abyssicola, Society Islands and Cape York.
A. tuberosus, Arctic.
A. hystrix, Arctic.

The facts at our disposal about the distribution of this family appear to indicate that the genus *Arcturus* is typically a deep sea genus; there are twelve deep sea species as against seven shallow water forms, one being common to both coasts and sea of great depth. The shallow water forms are with one exception exclusively antarctic in range; while in the closely allied genus *Astacilla* the converse is the case, there being but one antarctic species. The facts look very much as if range here were more a question of temperature than anything else; the intervening hotter parts of the oceans are without *Arcturi*; but the southern forms have been able to reach the northern hemisphere or vice versa by taking a long dive and coming up again above the equator. The deep sea in fact is a cool pathway along which Crustaceans

unable to withstand the higher temperature of the surface waters in the tropics can pass in safety.

This view however may be too elaborate; besides it should apply also to the Serolidæ which are considered below[1]; another suggestion may arise from the habits of these Crustaceans; the Serolidæ live at the bottom and swim and crawl on the sand; the Arcturidæ on the other hand are stated to cling with their hinder thoracic limbs to any available object; in this way they might easily happen to select some floating piece of wood which would ultimately take them on a voyage to the more northern from the more southern regions.

An analogous series of facts with perhaps an analogous explanation is offered by the flora of New Zealand. There are many resemblances in the flora of New Zealand to that of Europe. Mr Wallace says that "one-third of the entire number of New Zealand genera (115) are found also in Europe, and even fifty-eight species are identical in these remote parts of the world." No doubt it is easier for many plants than for many animals to cross wide tracts of ocean, but Mr Wallace is of opinion that mountain ranges offer a convenient mode of transit which has been probably made use of. The difficulties of a change of temperature would be in this way overcome; as a matter of fact European plants are known from intermediately lying mountain tracts such as the Himalayas.

[1] In the Chapter dealing with the Antarctic continent.

The country inhabited by an animal is not necessarily the only one in which it can flourish.

The view that animals are suited to the countries which they inhabit and to no others, that in fact their distribution is a matter of temperature, is proved to be quite untenable by the phenomena of colonisation. Sir Charles Lyell[1] refers to the case of the Ligurian bee, *Apis mellifica*, which is a native of Europe. It was however introduced by the early settlers into America and has since that time prospered exceedingly on its own account, apart altogether from the protection afforded by man to his own hives. It inhabits the forests of the interior and builds its combs in hollow trees.

The most striking instance however of successful invasion of a new country by foreign colonists is offered by the sparrow. This bird is now as ubiquitous in most parts of the United States as it is in this country. To such an extent has it proved capable of adapting itself to a new soil and somewhat different climate that measures concerted for its destruction by the United States Government have proved quite incapable of producing any great effect upon its numbers; and yet it is only a few years since it was artificially introduced.

Perhaps the most striking example among plants of the capacity which an introduced organism sometimes possesses of suiting itself to new circumstances is the common canal and pond weed of this country, the *Anacharis*,

[1] *Principles of Geology.*

which was introduced some years since as a rare and interesting botanical specimen.

The rabbits in Australia are another example, whose abundance in a country which might appear from the nature of its fauna to be unsuitable to the higher Mammalia, has so far baffled the attempts of science to lessen their numbers. Within the last few years also a species of *Zosterops* has naturalised itself in New Zealand, this being a case of colonisation not helped or caused by man. The Bee-fly, *Volucella*, has also of late taken up its abode in the same country and in other parts of the world.

In fact plenty of examples might be cited from various groups of the animal kingdom to show that there is by no means always a close and inviolable connection between a given animal and the habitat in which it happens to flourish.

Similarities in the faunas of distant countries.

Dr Seitz has lately complained that a perusal of such books as Mr Wallace's work upon distribution give an erroneous impression of the characters of different countries. He *read* that South America has an infinite number of Cotingidæ and Pipridæ, both of which families of birds are confined to it; but during his visit to that continent he only occasionally *heard* the Cotingidæ, the Bell-bird *Chasmorhynchus* to wit. On the other hand he was struck by the resemblance of tropical Africa to tropical America in the large beetles called by the specific names of "Hercules" and "Goliath." The brightly coloured

flying moths of the tropics of the old and the new worlds, the Agaristidæ and Castniidæ, the toucans of America and the hornbills of the East also contribute to giving them a similarity. So too the apes and monkeys; while the newts of the colder regions distinguish them from the tropics. The humming-birds of America have a superficial likeness to the sunbirds of the old world; the tapir occurs in tropical America and recurs in tropical Asia. Plenty of other such resemblances might be cited.

But a closer examination of the facts dispels the ideas of a similarity of the fauna to which they at first give rise. The humming-birds are not nearly related to the sunbirds; nor are the toucans the nearest allies of the hornbills; ornithologists think that the latter come next to the hoopoes. The apparent similarity in fact is due to a variety of causes. The deserts of America are tenanted by sandy-coloured reptiles just as are the deserts of Asia and Africa; but in all cases it is believed that the similar plan of coloration is not due to any affinity but to their similar needs. The African lizard assimilates in colour to the sand in and upon which it lives just as does its American representative. Perhaps, as has been suggested by a competent observer of the birds and beasts of India[1], the huge beak of the hornbill has been produced in order to assist it in wrenching off from the stem the often tough fruits upon which it feeds; the toucan may have got its almost equally large bill by reason of the same need. Forest country is inhabited by animals that are adapted to life among trees, whence superficial simi-

[1] *A Naturalist on the Prowl*, by "Eha."

larities. It is a matter for the greatest wonder why the old world monkeys have *not* got prehensile tails.

On the other hand the similarity of the faunas of tropical countries even when widely separated have sometimes another explanation. The tapirs of America and India are unquestionably allied. They are purely tropical animals and yet separated by a stretch of land which is not tropical. But in earlier periods of the earth's history we know that Europe was favoured with a higher temperature than at present; we also find the bones of tapirs in Europe at that period; hence the inference that the tapir has been isolated in its present habitats by the gradual decrease of heat in the northern hemisphere.

These few examples again show how needful it is for the student of Zoogeography to have a thorough acquaintance with the structure of animals; he must be able to distinguish between merely adaptative resemblances and real structural similarities.

Problems of Distribution and Evolution.

It is not necessary now to argue against the doctrine of special creation; evolution in some form or other is almost universally accepted; and the facts of distribution, as Darwin himself showed in great detail, are among the most convincing proofs of the untenability of any such belief as special creation. We have for instance remote islands, such as the Azores, which are quite capable of supporting mammalian life, as has been abundantly proved by the flourishing condition of purposely or accidentally

introduced mammalia; and yet these islands are totally without any indigenous mammalian population. Many of the forest regions of Africa and Asia enjoy a climate and temperature like that of the forests of South America, and yet we do not find them tenanted by an identical fauna. A locality which is in every way entirely suitable to the life of a particular animal or plant is by no means necessarily inhabited by that particular organism. This of course is not an argument that is necessarily fatal to the doctrine of creation. But it is at least more intelligible on the theory of evolution. As the late Mr Romanes pointed out[1] we can better understand that the 400 or so species of humming-birds are limited to the warmer parts of America because they came into existence in that continent, and are too feeble in organisation to traverse the intervening seas which separate them from equally suitable countries and localities. There is no explanation except that all these 400 were ultimately derived from some American parent stock; otherwise why should the 400 if betokening so many distinct acts of creation have been *all* of them placed in the same region of the world? Moreover we are met with the fact that tropical regions of the old world with abundant flowers are tenanted by birds which in some degree resemble the humming-birds and lead the same sort of life. These again are limited to those regions and are not found in America. On the doctrine of special creation it is hard to understand why there should not have been some admixture.

On the other hand if we accept the theory of descent

[1] *Darwin, before and after.* Vol. I., The Darwinian Theory.

with modification we are in a better position to grapple with the problems offered by the phenomena of the distribution of animals. Indeed if we hold to the opposite theory there are no problems for discussion.

But though it is absolutely necessary to believe in some theory of descent and modification in order to explain the facts of distribution, this theory itself presents some difficulties which will be briefly indicated. It is usually held that a given species can only come into existence once; that the same modification can only appear once and never again. Consequently if we meet with the same species in two separate localities, there must have been some time or other communication of some kind between them; either the animal in question has been able to traverse the intervening barrier or the barrier at one time did not exist. If the opposite view be maintained, and there are some evolutionists who have maintained it, many of the problems connected with distribution will at once disappear. Probably a middle course is here as in so many cases the safer one to follow. The degree of complication of the changes is in all likelihood a safe guide to follow. It is for example inconceivable, as Prof. Lankester has pointed out, that animals which agree in the possession of that characteristic and complicated organ peculiar to the Mollusca and known as the odontophore should not be all of them genetically related. But on the other hand it is easily conceivable that two birds might independently lose a certain muscle; the fact therefore that they were both without this particular muscle would not be an infallible

guide to their relationship. A species of bird or reptile finding its way to an oceanic island might become darker in colour. After an interval the parent stock might send a colony to another oceanic island where the same modification might well occur, thus exactly reproducing the first variety; this view is supported by Dr Heilprin in his text-book of geographical distribution, who controverts Darwin's suggestion that the same variety cannot be produced twice, owing to the fact that the parent form which gave rise to the variety will be supplanted by its improved offspring, by reminding the reader of the tenacity of form possessed by certain animals, notably by some of the Brachiopods, which have persisted unchanged for many geological periods. Geology also seems to show that forms do reappear after an interval of total absence; but this may be merely another instance of the lamentable "imperfection of the geological record." Dr Heilprin thinks that the tapir which occurs in the Oriental region and again in the Neotropical may be really the offspring of two distinct lines from separate tapiroid ancestors; and that therefore this discontinuity of range does not argue an extinct parent form, which sent off offshoots from one continent to the other.

Other geological facts have to be considered which will be deferred until the next chapter.

Means of Dispersion of Animals.

Animals can extend their range either by active or passive migration. Both kinds of migration are hindered by barriers of various kinds.

A wide expanse of sea is an effectual barrier to the mammalia and reptilia but not altogether to birds, especially if there be islands which shorten the stretches of ocean to be traversed. Even a comparatively small tract of ocean, in some cases a narrow strait, opposes itself as an insuperable barrier to some forms of life. The Amphibia, for example, cannot suffer the contact of sea water, which is also fatal to their eggs. Earthworms are also killed by sea water. The narrowest strait is therefore as efficient a check to the migrations of these animals as is the widest ocean. High mountain ranges are also hindrances sometimes quite effectual to the extension of range of purely terrestrial animals; partly perhaps on account of temperature but probably more on account of the physical obstacle. A great expanse of desert is often as effective a barrier as a tract of sea. The desert of Sahara separates two faunas that are widely different. Changes in climate are also to some extent hindrances, though not to so great a degree as other barriers. Many animals can suffer with impunity an arctic or a tropical climate; the tiger is often regarded as a purely tropical creature, but as is well known it extends its range to Amurland, in northern China. At the Zoological Society's Gardens the polar bears do not show any great mortality; a specimen once lived there in perfect health for 37 years. Travellers have described monkeys leaping among the snow-clad branches of pine trees upon the Himalayas. Minute organisms have special facilities for passive migration. M. de Guerne[1] investigated the mud adherent to

[1] *Comptes Rendus, Soc. Biol.* 1888.

the feet of wild ducks and found it to contain after cultivation numerous small creatures such as Nematoda, Rotifers, eggs of Cladocera, statoblasts of *Plumatella* &c. Not only are the eggs of most of these creatures extremely patient of desiccation, but the animals themselves would readily survive a short journey. A series of journeys would scatter them far and wide over the globe. Such small aquatic organisms are known to be widely dispersed.

We find that the facts of distribution are quite in accord with these principles. Birds and winged creatures generally, such as bats, are on the whole the most widely distributed orders of animals. Amphibia and earthworms rarely or never occur on both sides of a stretch of sea unless there be good evidence to show that a land connection once existed. Oceanic islands which have been formed *de novo* in mid ocean and are not detached portions of pre-existing continents are almost invariably free from such animals as are incapable of traversing the sea. If sufficiently distant from any continent oceanic islands are generally without mammals, reptiles and amphibia, but have both birds and insects and certain other invertebrates which are transported to them by involuntary migration.

Influence of geological terrain upon faunas.

Not only the existence of forests or deserts or open pampas are influential in favouring or checking the advance of animals to fresh localities; it is even held that

the geological structure of the locality has a great influence in the matter. Prof. Edward Forbes held that the snails were decidedly influenced by such causes in their range. Limestone is as might be supposed the most favourable rock for their full development; but according to him a sandy soil is better than a clayey or slaty substratum. Certain apparent exceptions to this general statement are explained by the greater influence of climate; thus the Shetland Islands abound in limestone and yet there is a paucity of shells; on the other hand the island of Guernsey is populated by vast numbers of specimens of a particular species of snail; this is not due to the unfavourable granite soil but rather to the favourable climate, which is a stronger influence than the soil. Dr Gadow has recently put forward again the importance of the geological terrain in affecting the distribution of organisms. It is much more important thinks Dr Gadow than temperature or altitude. His studies upon the subject were made in Portugal, and communicated to the meeting of the British Association at Bath in the year 1888. They relate principally to reptiles and amphibians; Dr Gadow found reasons for coming to the conclusion that for both these groups of animals the red sandstone was by far the most favourable soil. There is of course in these two cases no pretence that the soil has a direct effect comparable to the limy soil which is stated to be so advantageous to land Mollusca.

Dispersal of Oligochæta.

The *involuntary migration* of animals is mainly confined to the invertebrates and smaller vertebrates. Some of the former possess special facilities for being carried about from place to place, and it is invariably the case that these species or genera are the most widely distributed. We will commence with a few examples taken from the terrestrial and fresh-water Annelids. Earthworms as already mentioned are not easily moved from place to place except by their own exertions; there is here but little assisted emigration. Rivers it is true could, and doubtless do, convey them for considerable distances, as many if not all are capable of surviving a prolonged immersion in fresh water. M. Perrier kept an earthworm for some weeks in a vessel of water, and I have made a similar though not so prolonged an experiment myself. This however would not be of much use as a distributing agent unless they were thus enabled to traverse a desert otherwise impassable. It is possible that in this way a peculiar genus of earthworms, *Siphonogaster*, distinguished by a pair of long appendages of problematical use, has been able to pass from tropical Africa to Egypt, the Nile serving as the path. It is difficult however to see how earthworms could be conveyed across the sea[1]. Floating trunks have been observed far

[1] In the case of this as in so many other groups oceanic islands require more study. Earthworms do occur in oceanic islands, but it seems probable that such widely distributed forms as *Eudrilus eugeniæ* (St Helena) and *Pontoscolex arenicola* (Fernando de Noronha) have been accidentally imported.

out at sea and they often harbour even large mammals, which may thus reach a comparatively distant spot; but unless the water remained absolutely calm during the long period necessary for the drifting by currents so that no splashing occurred the worms would probably be killed. Icebergs on the other hand, which often rise high out of the water, might conceivably be efficient vehicles for the transference of these animals. Prof. Leidy found a small worm frozen in a block of ice which recovered; the worm was a member of the family Enchytræidæ, but it is possible that a small earthworm with a thick body wall might also survive temporary freezing. The most active agents in the transference of small animals from country to country are however birds; but in this case they could be of but little use. The only way in which a migration of this kind could be effected would be in the cocoon; earthworms invariably deposit their eggs in chitinous cocoons from which the young do not emerge until nearly adult. But these are often deposited deepish in the ground, or at the roots of grass, whence they would not be very likely to be detached by, and to stick to, the feet of birds. The case however is different with the aquatic Oligochæta. These worms are in the first place smaller than the majority of earthworms, with smaller cocoons, which could be more readily transported; in the second place they are deposited often at the margins of pools, where Limicolæ, ducks, and other birds are in the habit of dabbling. The possibilities of successful migration by these means is increased by the fact that whereas in earthworms it is the rule for one or at most a limited number of individuals to

emerge from a single cocoon, the lower worms often emerge in great quantities from a single cocoon; a single cocoon therefore conveyed to a new locality may be the means of founding a perfectly flourishing colony. The little genus *Æolosoma*, distinguished by the brilliantly coloured oil globules with which the skin is ornamented, has, so far as regards one species at any rate, the power of temporarily encysting itself[1], it has thus a double chance of carriage to a distant locality at the hands or rather at the feet of birds. We find that these facts are in accordance with the actual distribution of the animals concerned. Earthworms as a rule are not found in countries unless there is a reasonable probability of their having reached them by their own efforts in traversing the soil, while the aquatic Oligochæta are often very widely distributed. I have given a few instances of this above. It has been also pointed out that many of the aquatic Oligochæta possess other means of dispersal by birds in addition to the cocoons. The setæ are often such as would readily adhere to any rough surface, owing to their hooked and bifid tips and their considerable size in proportion to that of the body.

Dispersal of land and fresh-water Mollusca.

This subject has been so recently and fully treated by Mr Kew[2] that it is only necessary to make a few extracts from his book. The extension of their range on the part

[1] Cf. *Ann. and Mag. Nat. Hist.* Jan. 1892, p. 12.

[2] *The Dispersal of Shells.* Int. Sci. Series, London, 1893.

of fresh-water Mollusca can be studied in its most simple aspect by a consideration of the faunas of artificial ponds and of "dew ponds." The latter are, it should be explained, artificial ponds dug and lined with concrete or chalk mud for the convenience of cattle; they are left to be filled by rain, dew, and the condensation of mist. At first devoid of inhabitants such ponds gradually become stocked, thus proving a capacity for active or passive migration on the part of the Mollusca. Careful and successive observations have proved in a few cases the actual time in which a given pond may become populous. An isolated pond near Leeds investigated by Mr Nelson during the years 1860–63 yielded two bivalves, *Sphærium lacustre* and *Pisidium pusillum*, and two Gastropods, *Planorbis nautilus* and *Lymnæa peregra*. About 1873 an additional species, *Planorbis corneus*, was discovered; and finally ten years later the Molluscan fauna was increased by six other species. Now this particular pond was in no communication even in seasons of flood with any other pond or stream; hence its inhabitants must have arrived by some other conveyance than running water. To be able to travel at all, and we shall enquire immediately into the means of dispersal, implies considerable tenacity of life, principally in withstanding the fatal effect of a too thorough desiccation. That this tenacity of life need not by any manner of means be underestimated in dealing with the problem under review, is shown by the fact that an Australian *Unio* "having already survived in a dry drawer for 231 days, packed up (after being tested in water) and forwarded to England, reached Southampton in a living

state 498 days after its capture." This may serve as a sample from a rich store of instances.

Some aquatic Mollusca leave the water and travel over the fields. This is the case for instance with *Lymnæa truncatula*. Those that are not able in this way to travel from pond to pond have to trust to vehicles which may be animate or inanimate. Whirlwinds have been proved to take up and deposit safely at a distance shoals of little fish; and not only fish but Mollusca—a thundercloud at Paderborn in Germany rained down crowds of the fresh-water bivalve *Anodonta anatina*. More effective in extending the range of such Mollusca are birds and insects. Canon Tristram on one occasion shot a mallard in the Sahara to the feet of which were attached "the eggs of some Mollusc—probably *Succinea*." Mr Darwin proved by suspending a duck's feet in an aquarium that the newly hatched young of univalves *will* adhere, and *might* therefore be carried long distances. But on the other hand there is little positive evidence that such a means of transit is made use of in nature. Mr Kew enquired with negative results from a large number of our leading ornithologists whether shells had actually been found adherent to the feathers or legs of birds. As a mere matter of probability everyone is agreed that this method of transit is feasible; suggestions as to how it may take place are unfortunately considerably in excess of records of the actual event. Insects however have often been taken with bivalve shells actually adhering to them; "five individuals at least," says Mr Kew, "of the water scorpion (*Nepa*), a large flying bug, have been caught with shells

attached." The great water beetle *Dytiscus* has also been proved to aid in the dispersal of fresh-water Mollusca, while the small *Notonecta*, the "water boatman," belongs to the same category. These insects are powerful fliers and could certainly get from pond to pond even when weighted with a small bivalve. It is bivalves that they have been proved to convey, not univalves. Birds, newts and toads have also been shown to act as the means of dispersal of Lamellibranchs. The fact that these can and do snap at and hold tight to any object that is thrust between the two valves of the shell ensures their dispersal in this way.

The above facts enable us to understand the peopling of isolated ponds. The distances to be traversed are so small, that the means of dispersal appear to be quite adequate. We now come to the more difficult question of crossing arms of the sea or, it may be, wide tracts of ocean. We must consider also the terrestrial as well as the aquatic species. That both classes of Mollusca do cross even the widest seas is shown by their occurrence in oceanic islands; that this occurs but rarely is shown by the peculiarities of oceanic island Mollusca as compared with those of the nearest mainland, whence they have been presumably colonised. It is noteworthy however that those who know most about the group invoke a former land connection where possible. Thus the Rev. A. H. Cooke in considering the rich fauna of land Mollusca of the Philippine Islands[1], so varied upon the different

[1] *P.Z.S.* 1892, p. 447.

islands, discusses the problems offered entirely from the point of view of former land connection.

Such land Mollusca as are operculate can of course close their shells and so endure with impunity events that would be fatal to others; even the temporary operculum formed by *Helix* is effective in this way. It is important too to notice that fresh-water Mollusca can in some cases endure brackish water, but it is stated by both Darwin and Wallace that adults and ova are immediately destroyed by salt water. This is of course fatal to the theory that floating timber and brushwood can convey fresh-water Mollusca in safety from shore to shore. Ice on the other hand may well be carrier; *Anodonta* and *Succinea* and *Paludina* have been frozen and have survived after liberation. With regard to land Molluscs their tenacity of life has become almost proverbial through the famous case of the *Helix desertorum* in the British Museum. More important is the record that out of 100 land shells immersed in the sea in a box pierced with holes for a fortnight 27 recovered; but of these 11 (out of a total of 12) were the operculate *Cyclostoma*. *Helix* however may sometimes survive a similar treatment.

In this way it is possible, or, according to Prof. Semper[1], likely that ocean currents propelling tree trunks or even "floating islands" such as are known in tropical seas may have effected the dispersal of land shells. But in such cases it must be often necessary that the Molluscs in question had secreted themselves in the crevices of the bark of trees, a habit which has been apparently assigned

[1] *Animal Life*. Int. Sci. Series.

to them without too much reason. Animal agencies for the dispersal of both land and fresh water shells for long distances across the sea are practically limited to birds; and as has been already mentioned this method of transport must be rare as it has been so seldom observed. The dispersal of slugs is of course harder to understand than that of snails, as they have no protective shell. And yet they are found in such remote islands as New Caledonia, New Zealand, the Auckland Islands and some of the Mascarene Islands. Madeira and the Azores have *Arion*, which Mr Cockerell says[1] "has some appearance of being native," though he makes the significant additional remark that "none of the species are peculiar[2]." The slug *Testacella* makes a temporary cocoon, as do the land planarians and some earthworms, in which no doubt it can survive drought. But this will not sufficiently account for dispersal over the sea; and sea water is fatal to slugs and their eggs. The eggs however are sometimes deposited in hollow trunks of trees, where even the animals themselves occasionally hide. The various methods of migration used by other Molluscs may *possibly* be effective in the case of slugs; but at present there is here more than anywhere a lamentable want of actual fact.

Dispersal of Amphibia.

The migrations of the larger aquatic animals are more difficult; and yet they have not unfrequently a wide

[1] *Geographical Distribution of Slugs.* *P.Z.S.* 1891, p. 214.
[2] *Cf.* p. 152.

range, which means power of dispersal. The edible frog, *Rana esculenta,* is a case in point. This species extends from Great Britain, where however it is supposed to have been introduced, in the West to Corea and Japan in the East and to Algeria in the South. Its range in fact is over the entire Palæarctic region; but individuals from Siam agree with Japanese specimens, so that the frog is Oriental as well as Palæarctic in habitat. In a paper upon the distribution of this frog Mr Boulenger[1] quotes 14 synonyms, generic as well as specific, thus illustrating the difficulties introduced into the study of geographical distribution by imperfect acquaintance with zoological fact. Intermediate forms however prove that there is but one species, divisible into four varieties. It is a question whether certain of these varieties which occur in the same country and do not interbreed are not rather of specific than varietal value; but in any case they must be derived from the same stock, and the eastern variety does not overlap any of the western. These facts seem to argue powers of extended migration hampered by infrequent opportunity. A river system appears to be, at least as a rule, inhabited by an identical fauna throughout, though its course may be, as is that of the Nile, from tropical to temperate regions. But river systems are isolated from each other by intervening mountains; and moreover the rapid streams at the source are not suitable for Amphibian life; hence a species which inhabited one river system would not in the ordinary course of events get within a measurable distance of the tributaries of

[1] *P.Z.S.* 1891, p. 374.

another river system. We can only understand the mingling of the faunas of two river systems by wide-spreading floods or by alterations in mountain ranges. Mountain ranges are necessarily modern, geologically speaking, owing to the potency of the effects of subaerial denudation. Different relations existed in river systems before their upheaval; and it is probably to facts of this kind and *possibly* also to whirlwinds that we must trust in reflecting upon the migrations of the Amphibia, which cannot be much carried about by birds, as they are absent from oceanic islands[1], even so close to the mainland as is Fernando Noronha.

Dispersal of Reptiles.

It will be pointed out later that as a rule the only terrestrial vertebrates of purely oceanic islands, if there are any at all, are Reptiles. This necessarily argues that Reptiles possess some power of crossing the sea which is denied to other vertebrates. There are a certain number of facts which favour this view. While there are comparatively few mammals which voluntarily take to the sea, there are not a few reptiles which either live almost habitually in sea water without any corresponding modification of structure, or which occasionally are met with in salt water.

[1] There is however *Bufo dialophus* of the Sandwich Islands; it may be that the *strings* of eggs produced by the toad are more portable by birds than the *masses* of eggs of the frog.

Coupled with this series of facts, which will be dealt with immediately, there is the tenacity of life of reptiles to be constantly borne in mind. The most familiar example of a Lizard which is almost entirely marine is the remarkable iguanoid *Amblyrhynchus* of the Galapagos. Not only does this lizard take long swims out to sea but it can evidently only be drowned with difficulty. Darwin made the experiment of sinking one to the bottom for several hours, at the conclusion of which it appeared to be uninjured. It is even a question whether the animals may not possibly be able to respire oxygen dissolved in sea water; at any rate it seems certain that some other reptiles, e.g. certain tortoises, can. The pharynx of a few species, for instance the water tortoise *Aspidonectes*, is provided with filamentary appendages, apparently attached to the remains of the gill arches, which are full of blood vessels and which enable the creature to breathe; at any rate this tortoise has been kept under water for the space of 10 hours. It is held that these vascular tufts are the homologues of the gills of the Amphibia, and it is quite conceivable that this capacity for breathing oxygen dissolved in water may have been inherited by other reptiles besides the tortoises.

Apart altogether from theories there are other reptiles besides the *Amblyrhynchus* which can swim with impunity in sea water and which do so on occasions.

The crocodiles of the present epoch are entirely fresh water in habit; but the majority of the extinct families were on the contrary marine. From the ancient *Belodon* downwards we meet with the remains of the crocodiles in

marine strata, which in all probability indicates that they were at least frequently in the habit of swimming out to sea. It is not of course positive proof, for it might be urged that we have to do merely with the remains of crocodiles which had been washed down the rivers after death. The interesting point in connection with these habits of the more ancient crocodiles is that many living crocodiles will take to the sea sometimes; a crocodile has been met with at a very long distance from land—within the last year or two a crocodile has been recorded at the Cocos Islands, which must therefore have swum for a considerable distance.

Not only are there purely marine snakes, like the poisonous *Pelamys*, but serpents which are habitually terrestrial will make an occasional trip to sea. It is stated the snake *Tropidonotus tessellatus* (allied to our common Grass snake) which lives upon the shores of Dalmatia will enter the sea. Even the cobra (*Naia tripudians*) has been captured entangled in the anchor chain of a ship[1]. Fresh water tortoises are by no means always impatient of salt water. And finally as many lizards and probably all snakes can swim in fresh water it is quite a reasonable supposition that in some cases they could survive a sea voyage.

With these examples before us it is clearly incorrect to say that lizards and serpents are incapable of passing ocean barriers, which indeed their presence on oceanic islands shows conclusively that they can do. Mr Wallace while admitting that lizards possess some means of

[1] Cf. Simroth, *Die Entstehung der Landthiere.*

dispersal across the sea thinks that this migration is effected involuntarily and in the egg state. As to involuntary migration on the part of reptiles Mr Wallace quotes the case of a boa constrictor which floated on a cedar to the island of St Vincent, two hundred miles away from its home, where it killed a sheep before it was itself put an end to.

Evidence of capacity for Migration on the part of a given animal.

As Prof. Semper has acutely pointed out[1] the facilities for migration possessed by an animal can be to a certain extent measured by the amount of modification gone through by obviously migrated individuals. Naturally no clearly defined scale can be drawn up; but if an animal, say a Mollusc, can very readily cross the sea to an oceanic island it will be likely that its descendants upon the island will hardly, if at all, differ from the parent stock upon the main land. The reason of course is that migration being easy will be constant and frequent, thus preventing the acquisition of new characters through isolation; the perpetual interbreeding with newly arrived individuals of the parent race will securely keep the progeny in the original mould. Of course other causes must also come into play, but this fact cannot be without significance.

It has been already pointed out that Reptiles are rare

[1] *Animal Life*, Int. Sci. Series.

on oceanic islands; indeed they are more often entirely absent than present even in small numbers; hence it must be inferred that they have peculiar difficulties in crossing a considerable expanse of ocean. When they are met with upon oceanic islands, as for example in the Galapagos, they have undergone considerable modification, thus emphasising from another point of view the difficulties of their transference. On the other hand birds are of all animals the most liberally endowed with the capacity of crossing long stretches of ocean; correlated with this the birds of oceanic islands are not always greatly modified as compared with their nearest allies upon the mainland; this is particularly well shown in such birds as are in the habit of taking long flights; the Waders for instance of oceanic islands are but rarely of different species from those of the adjacent continents. On the other hand the finches and such like "small birds," frequently arboreal, depending entirely or largely upon vegetable food, and not in the least marine in their proclivities are commonly much specialised upon oceanic islands; often indeed to such a degree that their affinities are hard to interpret, as is particularly well shown in the case of some of the Sandwich Islands' birds (for which see below).

Influence of human interference upon Migration.

In considering the facts and problems of distribution it is very important to eliminate the changes in faunas

due to the interference of man. Such islands as St Helena have had their fauna and flora radically changed by these means.

But there are other cases in which man has probably had an influence which are not quite so obvious as that just cited. Many small land Mollusca are readily carried by ships laden with timber or other material upon which such animals are found; and the same kind of argument applies to numerous other cases. When therefore we find an identical species upon the two sides of a wide ocean or other barrier hardly to be crossed by the animal in question, we must not at once assume that this is evidence of past land connection, or of unsuspected facilities for crossing the barrier; it may be merely a question of transport by ships. A consideration of the distribution of certain genera of earthworms will serve to illustrate the kind of argument and tests which may be applied to sift these cases.

The continent of Europe, and, so far as it is known, northern Asia and the whole of North America is chiefly tenanted by members of the genera *Allurus*, *Allolobophora* and *Lumbricus*. There are but few other genera than these met with in the regions named. But these same genera also occur in every other part of the world. They are abundant for example in South America and in New Zealand. A gathering of earthworms from tropical regions is in fact, so far as my own experience goes, rarely without Lumbricidæ. This might be urged as an argument for the antiquity of this particular family; but as a matter of fact the structural relations of this family to others seems

rather to indicate that it is modern. Indeed the world-wide distribution of the three genera is really in all probability due to the interference of man and not to their own unaided efforts. The reasons for this are twofold. In the first place it is important to show that accidental transference is possible. This is shown by the fact that Wardian cases received at the Royal Gardens Kew frequently contain earthworms which have been included accidentally.

In plenty of other ways could specimens be conveyed in this way from one country to another. Now were the occurrence of the same genera in so many and so distantly separated parts of the world a fact due to natural causes alone, we should expect to find some differentiation of species. But this is precisely what we do not find. Without a single exception[1] the Lumbricidæ from extra-European regions are identical with those of Europe; there is not even a variety known which is characteristic of a foreign continent. This is an argument of great force; if this dispersal were of old standing, as it must have been were it brought about by purely natural causes, time would have elapsed to allow of some modification in various directions. The second argument is derived from a consideration of the actual range of the presumably imported species in the country of their adoption. Dr Michaelsen has pointed out that in South America, where Lumbricidæ are very abundant, they are most abundant in cultivated ground near to the coast, nearest to the point

[1] Unless *Allolobophora Japonica*. But of course Japan belongs to the Palæarctic region.

of disembarcation; the further we recede from the coast the rarer do the European Lumbricidæ become; in the interior of South America they are not to be seen. Prof. Spencer met with exactly the same state of affairs in Australia; the gardens in the towns abound in Lumbricidæ to the almost entire exclusion of the truly indigenous forms; to find these the cities must be left behind. The coincidence is too great to be passed over. This leads to the inference that in the case of these particular genera the forms met with outside the Palæarctic region—perhaps even including North America—are due to carriage on the part of man. Every case of a supposed wide distribution of a species should in the same way be submitted to careful criticism before acceptation as a fact of distribution. Mr Macpherson's record[1] of an African lizard in Cumberland and Dr Gray's statement of a young crocodile hidden beneath a haystack need no special examination to deny their claims to indigeneity; but there are plenty of cases like that of the earthworms just referred to.

On a former page we have dealt with discontinuous distribution as a phenomena explicable in various ways.

An excellent instance of the discontinuous distribution of a species due to the influence of man is afforded by the common bear (*Ursus arctos*) of Europe. And here we can, which we could not in the last case, fill up the gaps for ourselves with certainty and not merely with reasonable probability. In a carefully coloured map illustrating the distribution of the bear-like Carnivora Dr Grevé[2]

[1] *The Natural History of Lakeland.*

[2] *Zool. Jahrbücher,* Vol. VI. *Abt. f. Syst.*

tints nearly the whole of the Palæarctic region with the colour which he uses to express the range of this Carnivora. He also indicates the tract of country from which this bear has died out within the historic period. At the present time there are several isolated patches to the west and south of the country continuously occupied by the animal, where it is still to be met with; such as the Pyrenees and a portion of Switzerland. These isolated patches are in most cases connected with the main area by regions from which the animal has recently retired. Another map illustrates precisely the same kind of distribution exhibited by the lynx. This animal has a range almost co-extensive with *Ursus arctos*, but it does not get into Japan, which the bear does. It persists as two outliers in Western Europe almost exactly corresponding to those of the bear. But a tract on the east coast of Italy no longer inhabited by the lynx is still the home of the bear. Cultivation and civilisation are no doubt the cause of these gaps; but it is curious that they should have been more effective in the case of the smaller lynx than the larger bear.

The existing Distribution of land and sea considered in relation to Zoological Geography.

In considering the phenomena of distribution at the present day, it is important to bear in mind that the existing distribution of land and sea has on the whole remained the same for very long periods, according to some for as long a time as we have any cognizance of.

There are, it is true, those who would evolve a continent to account for the range of a genus of beetles; but on the whole the evidence is against any such radical views of past changes in the positions of oceans and continents. The superstition of Atlantis connecting Africa and America has perhaps not quite died away; and Mr H. O. Forbes would relegate the tropical island of Madagascar, not to mention the colder and more southern regions, to the icy clasp of the Antarctic continent.

Evidence in favour of Permanence of Oceans.

The evidence in favour of the permanence of oceanic area as such has been recently summed up by Mr Blanford[1]. The arguments are fourfold.

I. It has been ascertained that the density of the earth's crust below the deep oceans is greater than that elsewhere. This leads to the inference that this has been so always, because denudation, if the ocean bottom had been ever dry land, would have removed this inequality. The detritus washed away by the action of rivers, rain, and such causes would have tended to equalise the density of the land everywhere. Mr Blanford however points out in criticism of this suggestion that the observations, due to Archdeacon Pratt, were made only in the Indian Ocean, and may perhaps not hold universally. The argument therefore is not of that weight which may be fairly attached to some other considerations.

[1] *Presidential Address to Geological Society*, 1890.

II. It seems to be well ascertained that no oceanic islands are formed of stratified rocks belonging to early geological periods. They are in the main either of recent volcanic or coral formation. Sir Archibald Geikie in reviewing the Abbé Renard's petrological work upon the rocks of the island of St Paul in the Atlantic in *Nature* some years back entitled his review, "A search for a lost continent with a microscope." But no amount of research either with or without a microscope has ever revealed the slightest traces of a pre-existing continent in the oceanic islands of any of the great oceans. On the other hand it has been found that certain islands, once regarded as purely oceanic, are in reality not so. This is the case for example with New Caledonia, which contains both palæozoic and mesozoic rocks, though it is isolated by water exceeding 1000 fathoms in depth. But these few instances do not invalidate the general conclusion. Yet two possible criticisms must be borne in mind; in the first place we are not as yet in possession of all the requisite knowledge about all the islands in question; in the second place we can imagine a subsidence of a large continental tract which would leave above the surface of the water no trace of its continental origin. If Africa, as Mr Blanford points out, were to be submerged 2000 fathoms below the sea only a few elevations would remain; these are Mt Kilimanjaro, the Camaroons, and a few other peaks; these mountains it must be remembered are purely volcanic in structure and would give no clue to the fate which had overtaken the surrounding land.

III. The third argument is of equal force, or perhaps of greater force, than the last. If the great ocean depths have not always been permanent we should expect to meet with, among the stratified rocks, evidence of deep-sea deposits. Here again defective knowledge offers a way out of the difficulty to those who choose to believe in a thorough change from time to time of the existing relations between continental areas and the great oceans; the fact that no continental deposits present any likeness to deep-sea "oozes" and "clays" seems to prevent the holding of such a theory; but the matter requires to be more thoroughly disproved. An exploration of certain geologically little known tracts might reveal evidence in favour of the view which is at present not forthcoming. It was at one time held that there is a great likeness between the chalk of the Mesozoic epoch and the globigerina ooze now in course of deposition in certain tracts of the ocean. Superficially this resemblance is not a little striking; but a closer comparison dissipates the theory. It is true that in the deep sea—in regions where the globigerina ooze is found—certain animals exist which are identical with or very closely allied to animals characteristic of the chalk. The Echinoids with flexible tests, numerous Cidarids, and the species of the Globigerinæ themselves bear out this statement. A careful analysis however of the chemical composition of the ooze and a comparison of the results thus obtained show divergences which are of importance. The percentage of carbonate of lime in chalk is from 94—98 $^{\circ}/_{\circ}$, while

in ooze from a depth of many fathoms in mid-Atlantic it is only 43—79 °/₀. Chalk has a very small quantity of silica, alumina and insoluble *débris*, while in ooze there is 10—43 °/₀ of these substances.

IV. Dr John Murray found that the ooze from shallow water resembles chalk much more nearly than that from depths over 1000 fathoms. Prof. Agassiz has described a shore deposit largely derived from the *débris* of coral rocks which bears a very close resemblance to chalk; and it is possible that the chalk of Europe was to some extent at any rate formed from the denudation of the coral reefs which were so abundant during the oolite period. The most striking instance which appears so far to support the contrary proposition is the Radiolarian earth of the Barbadoes, and perhaps of some of the other West Indian islands. This overlies unquestioned sandstones of tertiary origin; hence it follows that, since the beginning of the tertiary epoch, the land immediately surrounding those islands and the islands themselves must have been depressed to a depth of at least 1000 fathoms.

Evidence against the view that existing Oceans have not largely changed their areas.

There is another series of facts which have a bearing upon the problems at issue, and which indicate, though obscurely perhaps, a possibility that far back in time there may have been a relative disposition radically different from that now prevailing.

That this may have been so is suggested by two considerations deduced from two classes of facts. In the first place the former wider range of organisms than now is well known. This has been held to imply a former predominance of more uniform conditions of temperature and climate, but it may also perhaps be looked upon as evidence of another kind, which we shall now enter into. I quote from Prof. Heilprin's manual the fact that out of 13 Silurian and 24 Devonian Brachiopods found in the deposits of China 10 of the former and 16 of the latter occur in European formations, a proportion which is not only very striking, but almost inexplicable on the hypothesis that the conditions of marine life in the several regions were then precisely as now.

Another example may be taken from the Graptolites. This is a particularly useful example, for it enables us to make use of the dilemma. It has been suggested that the Graptolites flourished in deep water and that the rocks which contained them are therefore true deep-sea deposits. If this is admitted, then the question is settled at once without any necessity to proceed further. But if not, we have to account for the striking fact that out of the 24 species of Graptolites from Australia no less than 18 are species belonging to Canada and the United States.

Now we may contrast with the conditions that obtained during the Palæozoic period those which obtain at the present day. And the contrast is most thorough. Prof. Heilprin remarks that out of "the 400 or more species of molluscs inhabiting the Japanese waters it

appears that not more than 20 are found on the west coast of North America." The proportion, in fact, instead of being three-fourths is one-twentieth. It will be remembered also, in estimating the significance of these facts, that the coasts of Japan enjoy a climate and temperature that is not widely different from that which is enjoyed by the coasts of the part of America brought into comparison.

We may take as another example the Isopod Crustaceans of the antarctic region which have been investigated by the "Challenger," "Gazelle," and recently by the German Polar expedition, the results of all these expeditions having been carefully reported upon by Dr Pfeffer. He enumerates 55 marine species of which only five have at all an extensive range, and two of these, which are stated to inhabit at once the shores of Patagonia and of Rio Janeiro, are queried. As to a more northward extension there are no species which show any signs of it. The genera enumerated are in all 27; and out of these 11 are limited to the southern ocean in the antarctic area.

So much then for the first series of facts, which is that the wide past distribution of marine animals contrasts with the present limited distribution of the same, even along areas which have very similar climatal conditions.

Many geologists, including Mr Mellard Reade[1], have pointed out the extreme similarity between the contemporaneous or supposed contemporaneous rocks in different parts of the world. When we "consider the rocks," says the last-mentioned observer, "constituting the

[1] *Natural Science*, 1894.

Carboniferous formation, the persistence of characteristics over large areas of the earth's surface is most striking. The repetition of coals, sandstones and shales in the Carboniferous rocks of the North American continent and in that of Great Britain seems almost to point to a common origin." And this is by no means the only example that could be adduced of the closest lithological analogies between contemporaneous rocks in widely separated localities.

These two series of facts almost seem to lead at once to the conclusion that we have here evidence that in, say the Carboniferous period, there was a tract of ocean continuous from east to west of not great depth, which would point to adjacent land and set aside the theory that the deep oceans of to-day have always been practically the same.

But there are some criticisms to consider first. It has been objected to the question of contemporaneity, let alone the continuity, in a given formation that it is impossible strictly speaking, since organisms take time to migrate. A given species comes into existence let us suppose in the Australian district; it has to get to the European seas where it may be also found; the time that elapses while this journey is made is longer or shorter according to the distance and to the variety and difficulty of the obstacles. "For anything that Geology or Paleontology is able to show to the contrary," wrote Prof. Huxley, "a Devonian fauna and flora in the British Islands may have been contemporaneous with Silurian life in North America and with a Carboniferous fauna and flora in Africa."

In this case it would necessarily follow, on account of the disparity of age, that there need be no similarity in conditions between the different parts of the world during the same geological period. Prof. Nicholson[1], accepting this criticism, observes, "Most of the facts bearing upon this question may be elicited by a consideration of such a widely extended and well-known formation as the Mountain Limestone or Sub-Carboniferous Limestone. This formation occurs in localities as remote from one another as Europe, Central Asia, North America, South America and Australia; and it is characterised by an assemblage of well-marked fossils, amongst which Brachiopods belonging to the genus *Productus* may be specially singled out. Now if we believe that the Carboniferous Limestone in all the widely distant localities was strictly contemporaneous, we should be compelled to admit the existence of an ocean embracing all these points, and in spite of its enormous extent so uniform in temperature and depth and the other conditions of marine life, that beings either the same or very nearly the same inhabited it from end to end." These two statements are ingeniously met by Prof. Heilprin. They imply, he says, that every animal has migrated in exactly the same way and direction. And it is hardly conceivable, in fact impossible, that this can have been everywhere the case. "Given the possible equivalence in age, as is argued, of the Silurian fauna of North America with the Devonian of the British Isles, and the Carboniferous of Africa or any similar arrangement, why has it never happened that when migration,

[1] *Manual of Palæontology.*

necessitated by alterations in the physical condition of the environs, commenced, a fauna with an earlier facies has been imposed upon a later one, as the Devonian of Britain upon the Carboniferous of Africa, or the American Silurian upon the British Devonian?" The migration of one animal might have been in one direction and the migration of another in the reverse direction.

Besides the migration of animals can hardly be supposed always or often to occupy a space of time that could be fairly compared to a geological period. Especially is this the case with marine creatures whose powers of dispersal are so much greater than those of terrestrial animals. The Indo-Pacific fauna for example is widely spread at the present day; and formations now being laid down at the extremities of this vast area are not only synchronous but will entomb the remains of largely similar organisms, often of identical species.

These general considerations lead to the discussion of the following particular examples of a possibly greater extension of land in past times through what is now deep sea.

Evidence in favour of a formerly more extensive Antarctic Continent.

Faunal conditions in the southern hemisphere have recently been applied again to the question of a former northward extension of the antarctic continent. The evidence has been brought together by Mr H. O. Forbes[1].

[1] *Proc. Roy. Geog. Soc.* 1894.

The continent at present is entirely ice-bound, and though of great size, about twice as large as Europe, does not bulk largely upon most maps; this is due to the small extent of coast line which has been explored. At present the antarctic continent is probably almost entirely without a terrestrial fauna by reason of course of its rigorous climate.

Mr Forbes boldly draws imaginary land tracts connecting this region with the adjacent continents of Africa, America and Australia. There is certainly some evidence in favour of such a connection having once existed. There are however numerous facts which appear to negative such an idea. The negation however is possibly more apparent than real. It has been pointed out that the ocean which separates the south polar continent from any other land is of great depth, and all those arguments for the permanence of the great oceans apply in this case as in the others dealt with on a previous page. But it must be admitted here as in so many cases that our knowledge of ocean soundings is far from complete; Mr Blanford points out[1] that south of Africa there are no soundings and that therefore we are at liberty in the meantime to regard as possible the existence of a bank uniting the two continents of no greater depth than the Mozambique channel. It is however rather New Zealand and Patagonia which are allied in their fauna than either of them with the southern parts of Africa; resemblances between tropical Africa and tropical America have been dealt with on another page (p. 112). These likenesses in a few cases

[1] Presidential address to Geol. Soc. 1890.

amount to positive identity of species; and moreover of species whose identity is exceedingly remarkable in relation to the problem offered for solution.

That the Penguins should extend throughout the whole antarctic area from New Zealand to Patagonia is not so remarkable a fact; there is no need of evolving a continent for the convenience of these almost marine birds, or even to explain the wide range of the purely antarctic *Chionis*. Nor do the arguments, such as they are, which are to be derived from a study of the range of the living "struthious" birds appear to have overwhelming force; both Penguins and struthious birds are in all probability the remnants of ancient types; and their relegation to the southernmost half of the globe is as much in accord with the polar origin of life dealt with elsewhere as with a former extensive antarctic continent. Besides the struthious birds are not now regarded as belonging to one family; they seem really to form an assemblage of the remains of more than one family. The distribution of the struthious birds both living and extinct may be brought forward as evidence of the former northward extension of the antarctic continent. Recent discoveries in the Argentine have an important bearing upon the matter; the evidence takes us back to the middle and even to the beginning of the tertiary period; this however is nothing to be surprised at; the connection between the existing land masses and the antarctic continent, if it ever existed at all, must have been very ancient, as the stretch of ocean now dividing them is so wide. As is unfortunately the rule with extinct species known by

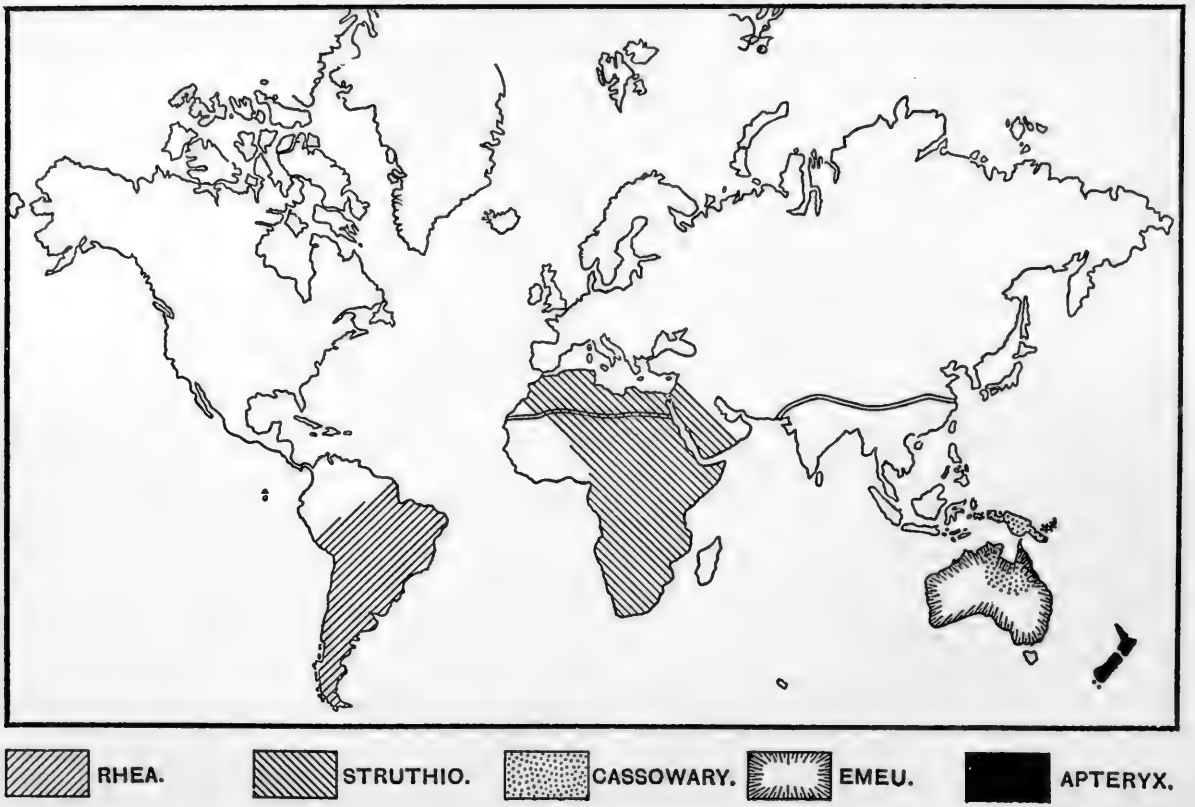
remains which are in various degrees fragmentary, the actual number of the genera and species is doubtful; but it seems now to be well established that there were in the more southern regions of the American continent at least three genera of gigantic flightless birds comprising seven or eight species. To these genera the names of *Brontornis*, *Phororhacus* and *Opisthodactylus* have been applied. Some of these birds were actually the largest known forms of Ratites. It appears from certain roughnesses on the bones of the skull that some species bore upon the head a casque like that of the Cassowaries; though in some respects, thinks Mr Lydekker, the resemblances are with the living and South American *Psophia* and *Cariama*[1]. They approximate however to the Dinornithidæ in a number of characters which together are of some importance; thus there is with them as in the Dinornithidæ a bony bridge over the extensor groove of the tibia, and the general proportions of the tibia and tarso-metatarsus are like those of the same bones in the Dinornithidæ. But the significance of the facts from the point of view of Zoogeography is somewhat blurred if we rightly refer to the Ratites, or Platycoracoideæ, as Fürbringer calls them, the European genera *Gastornis* and *Dasornis* and the American *Diatryma*. Fürbringer however queries the inclusion of the two last in the group, and does not allow *Gastornis* there at all. *Dasornis* is only known by an imperfect cranium, and *Diatryma* by an incomplete tarso-metatarsus, so that this evidence is not at present

[1] See a paper by Lydekker in *Ibis* for 1893.

necessarily fatal to the evidence offered by the undoubtedly struthious Argentine birds.

As with the Sea-lions, also practically confined to the southern hemisphere, the explanation of the range of the Penguins is possibly rather one of temperature. The Sea-lions are strong swimmers, and have been met with far from land; indeed the "Sea-serpent" is possibly partly compounded of a large sea-lion. Currents too would assist in the dispersal of these animals without any recourse to a continuous coast-line to aid in migration. M. Milne Edwards, whose name is particularly to be associated with the idea of an antarctic region, has pointed out that marine currents flow from the polar region in all directions northward; with the aid of these currents, reinforced by floating ice, which is known to reach land abutting upon the southern ocean, we can understand the peopling of Kerguelen and other regions with the birds and mammals referred to. Mr Wallace while naturally admitting the resemblances between various tracts of land in the southern hemisphere is disposed to rely upon floating masses of ice to account for the facts. It is difficult to apply this solution of a puzzling problem to the case of the terrestrial Annelida of the antarctic area. It is a curious fact that Mr Forbes with the material before him did not use the strongest argument that could be used in favour of his views; since those papers were written the evidence has moreover increased. The earthworm fauna of New Zealand is perhaps as well known as is that of any extra-European region. That our knowledge is approaching completion is shown by the fact that collec-

DISTRIBUTION OF STRUTHIOUS BIRDS.



To face p. 168.

tions from that part of the world do not so frequently as formerly contain new species. This fauna consists principally of species of the genus *Acanthodrilus*. There are three genera of the same family peculiar to New Zealand, viz. *Octochætus*, *Plagiochæta* and *Deinodrilus*. All these worms form a very well-marked family which is characterised by the fact that the male sperm ducts open on to the XVIIIth segment of the body, and that on to the two segments in front of and behind this open a pair of coiled tubular glands accompanied by a bundle of modified "penial" setæ. The bulk of the species of Acanthodrilidæ belong to the genus *Acanthodrilus* itself. Besides this genus there are three species of quite a different genus, *Microscolex*. This genus is referable to another family allied however to the Acanthodrilidæ. There is here only one pair of tubular glands which open in common with or or very close to the sperm ducts upon segment XVII. The penial setæ also exist. The remaining *Oligochæta terricolæ* of New Zealand, apart from introduced *Lumbricidæ*, are a few species of *Perichæta*, or rather a closely allied genus which I have named *Diporochæta*. In the more southern parts of the South American continent precisely the same families are met with; and not only that, but the same genera. Dr Michaelsen of Hamburg has recently made a voyage to that part of the world, and has brought back with him a very large collection of earthworms; these belong, with the exception of introduced *Lumbricidæ* and a single *Perichæta*, exclusively to the genera *Microscolex*, *Acanthodrilus* and *Kerria* (a near ally of *Acanthodrilus*). So far as we know at present not a single species

from America is identical with any New Zealand form; but they are all closely related. This however does not exhaust the antarctic region. During the voyage of the "Challenger" and the transit of Venus expedition a few earthworms were collected at Kerguelen and at Marion Island. These amounted to only a single species, which is common to both islands, and is a member of the genus *Acanthodrilus*. The same genus also occurs in South Africa; but Africa so far as concerns the family *Acanthodrilidæ* chiefly abounds in the genus *Benhamia*, which differs in a few small though constant points from *Acanthodrilus*. The genus *Benhamia* in the opinion of Dr Michaelsen, is really limited to Africa. Species have been described from America, the West Indies, and from India and Malaya; but it is possible, as Dr Michaelsen thinks, that they have been imported by man. The family *Acanthodrilidæ* indeed is almost exclusively antarctic, and in any case by far the majority of its species and genera are limited to the antarctic area. *Microscolex* passes into North America, has been met with in Europe and the Azores and Canaries, and also occurs in Australia. But with the exception of America all the species found outside the antarctic area are identical with species living within it[1]; this suggests importation from abroad. This series of facts is a very remarkable one, and deserves more consideration than has been devoted to it in forming any theory about a possible former antarctic continent of greater dimensions than the present shrunken land mass. The facts seem also to point to a more recent communication

[1] Excepting *M. poultoni* from Teneriffe and *M. algeriensis* from Algeria.

between Patagonia and New Zealand than between either of these countries and the Cape of Good Hope. These however are by no means the only facts which seem to point to some ready method of transit between these different regions for purely terrestrial or fresh-water animals. Many writers have with justice emphasised the extremely significant fact that the fresh-water fish *Galaxias attenuatus* occurs in Tasmania, New Zealand, the Falkland Islands and the southern extremity of the South American continent. This is perhaps the only case of a *species* of fish with so wide a range in the antarctic hemisphere; but the two families of Salmonoid fishes *Galaxiidæ* and *Hoplochitonidæ* are restricted to the same countries with the addition of southern Australia. A species of *Galaxias* has recently been described from India; but Mr Blanford states that the determination is doubtful. Now a fresh-water fish, even more if possible than the purely terrestrial *Oligochæta*, needs a continuity of free land surface for its migrations[1]. And the fishes of these two families form a considerable proportion of the entire fish fauna of the countries where they occur. It is well known, of course, that the ova of many fish, particularly of Salmonoids, can be safely transferred in ice and will hatch out at the other end; rivers in New Zealand have been stocked in this very way. So that there is no antecedent improbability in the iceberg theory of the migration of these fishes. But in this case it is

[1] The possibility however must be borne in mind that they have been independently evolved from marine ancestors. This can hardly perhaps apply to *Galaxias attenuatus*, to the same species.

remarkable that oceanic islands which happen to be within the districts visited by icebergs have not also been stocked with fish. This criticism it will be seen cuts both ways. We cannot apply it to continents, if we are forbidden to consider it in connection with oceanic islands. It has already been pointed out in connection with the same subject of oceanic islands that they are invariably destitute of frogs or of amphibians of any kind. These creatures are quite powerless to migrate across the sea. Now a family of frogs, the *Cystignathidæ*, are common to South Australia and to South America. I do not think it prudent to lay any particular stress upon the likeness in the Coleopterous fauna of the antarctic parts of the world; for beetles or their larvæ can with comparative ease be carried about by that convenient *deus ex machina*, the floating log; more remarkable is the negative fact that the land shells do not support the idea of a former extended antarctic continent. Precisely the same facilities are enjoyed by the terrestrial mollusca for dispersal as by insects. It is however difficult to extract anything of value out of this fact either in favour of or against the view that the antarctic current had formerly a greater extent to the northward. It is perhaps to be correlated with the fact that there is only a single land shell in Kerguelen, which would seem to be some indication that in this quarter of the globe some hindrance exists to the migration of these animals. The matter must remain unexplained for the present.

The distribution of the Isopod genus *Serolis* may be cited as further evidence in the same direction; by some

it is made the type of a distinct family of that group, and it is in many respects peculiar; the outward form recalls that of the extinct Trilobites—"An protypon Entomolothi?" asks Fabricius, and attempts to reinstate the genus in the neighbourhood of those long defunct Arthropods have lately been made. Apart from this spurious claim to interest, *Serolis* has a genuine attractiveness by reason of its remarkable geographical range. It may be explained in the first place that *Serolis*—or the Serolidæ, if the family be approved of—differs from all other Isopods in the facts that (1) the first two segments of the thorax are more or less completely united with the cephalic shield, (2) that the last three segments of the abdomen are fused with the telson, (3) the wide depressed body with usually elongated epimera. This assemblage of characteristics divides the Crustaceans in question from others.

There are in all twenty-six species of the genus, of which perhaps some (those queried) are a little doubtful. They are thus distributed:

(1) Off Pernambuco (675 fathoms), *Serolis gracilis*[1].

(2) Off Pernambuco (410 fathoms), *Serolis antarctica*. The same species also found in 1375 and 1600 fathoms near Crozets.

(3) Off Rio Janeiro in 600 and 2040 fathoms, *Serolis neœra*.

(4) Off antarctic continent, near New Zealand in 410—1975 fathoms, *Serolis bromleyana*.

[1] For a full account of this genus see Beddard, *Report Zool. Chall. Exp.* Vol. XI., and Pfeffer, *Jahrb. Hamb. wiss. Anstalt*. 1888.

(5) *Serolis paradoxa*, Patagonia, Falkland Islands, New Zealand (?), Senegal (?)
(6) ? *Serolis trilobitoides*, South Shetlands, Patagonia.
(7) *Serolis gaudichaudi*, Chili.
(8) *Serolis planus*, Patagonia.
(9) *Serolis convexa*, Patagonia.
(10) *Serolis schythei*, Patagonia, New Zealand (?).
(11) *Serolis septemcarinata*, Marion and Prince Edward Islands, Kerguelen, S. Georgia.
(12) *Serolis latifrons*, Kerguelen, Crozets, Auckland Island.
(13) *Serolis cornuta*, Crozets, Kerguelen.
(14) ? *Serolis serrei*, Patagonia.
(15) ? *Serolis acutangula*, ? locality.
(16) *Serolis pagenstecheri*, S. Georgia.
(17) *Serolis polita*, S. Georgia.
(18) *Serolis carinata*, California.
(19) *Serolis tuberculata*, Bass' Strait.
(20) *Serolis australiensis*, Australia.
(21) *Serolis elongata*, Australia.
(22) *Serolis pallida*, Australia.
(23) *Serolis longicaudata*, Australia.
(24) *Serolis minuta*, Australia.

It will be noted that four are deep sea forms; and we postpone consideration of these; for it is well known that the deep sea fauna must be studied by itself. The remaining forms are absolutely confined to the antarctic region and to the south coast of Australia, with the doubtful exception of *Serolis paradoxa* and *S. carinata*.

They are most prevalent on the coasts of Patagonia. A few, but very few, species range widely through the antarctic region; thus *S. septemcarinata* extends from S. Georgia to Kerguelen. The Australian species, with the exception of *Serolis minuta*, form a well-marked assemblage to which perhaps a different generic name ought to have been given; these species differ from the typical species of the genus in the fact that the dorsal part of the sixth thoracic segment is absolute in the middle line; there are also other smaller particulars in which these Australian species diverge from the normal structure of the genus.

Here we have a family of curiously restricted range; it is exclusively antarctic, not getting so far north as the equator. It may be surmised that the genus came into being in the antarctic region; whence conditions of temperature did not allow it to migrate. But a difficulty is presented by the wide range within this area of species which being addicted to shallow water would find some hindrances in crossing the thousands of miles of deep water which part Patagonia from the Crozets. Possibly this difficulty is removed by the supposition that in former times the antarctic continent extended further north than it does now, thus enabling the species to wander far without altering greatly the surrounding conditions. The marked differences which distinguish the Australian species from their more southern allies are so far a proof of the more remote period at which a migration to the shores of Australia was possible. A cold current, which sweeps up the western shores of South America, may

have carried with it the single species *S. carinata*, which extends to so northerly a situation.

"Lemuria."

By some naturalists, Madagascar is believed to be the remnant of a great continent extending across the Indian Ocean, and has been referred to as Lemuria. Some of the islands lying to the north of Madagascar will be in this event other scraps of the same continent. Among these islands the Seychelles at least offer other evidence of being the last fragment of a vanished continental expanse: they are a group of about thirty islets lying 700 miles to the north of Madagascar. Though oceanic in most of their characters they are composed of "granitoid or gneissoid" rocks, thus arguing original continental conditions. In spite of this fact in their geological structure they do not possess a single indigenous mammalian inhabitant. This fact, it may be incidentally pointed out, is of importance; it shows that the true remains of continents may be without mammals and that the absence of mammalia is not always to be relied on as an infallible sign of an oceanic island. Their small size may have caused the decay of the original mammalian fauna, an argument that can of course be applied to the doubtful case of the Galapagos archipelago (see below). There are however four Amphibia, a more infallible sign of a former continental connection. These are a frog, *Rana mascarina*, which is widely distributed in this region of the world, a peculiar Tree frog and two Cæcilians, that group of

tailless and underground Amphibia particularly characteristic of Ceylon. Mr Blanford instances the Seychelles as the only thoroughly authenticated case of an oceanic island composed of granitoid rocks. This however only takes us necessarily as far as a possible former connection with Madagascar, which Mr Wallace admits, though premising that if this and the other island groups in the neighbourhood were ever connected with each other and with Madagascar "it was probably at a very remote period." There now remain the characters of the fauna of the Mascarene region for consideration. So far as concerns the Mammals and Birds the evidence is not so strong, or rather it need hardly be considered as any indication of a former connection with India.

The mammals, as has been already pointed out, are either African or altogether peculiar, chiefly the latter. It is true that there are Oriental birds in Madagascar, but these are, as Mr Wallace acutely points out, "slightly modified forms of existing Indian genera or...species hardly distinguishable from those of India." This argument, triumphantly adduced by Dr Hartlaub as evidence of the former "Lemuria," really points precisely the other way. Apart altogether from the ready means of migration possessed by birds—birds offer most unreliable evidence in proving a matter of this kind—we should expect on the hypothesis of a former land connection with India *not* to find such close resemblances; what is wanted to prove the theory of those who believe in "Lemuria," and use birds to support their theory, is to discover Mascarene birds which though presenting certain likenesses to those

of India should be widely different as to species and genera, showing a great divergence which would have naturally occurred in the time during which India and Madagascar have been, on any hypothesis, divided.

If however we turn to other groups of the animal kingdom, the rejection of the hypothesis of a former connection between India and Madagascar does not appear to be so reasonable. For example, the Amphibia are not to be passed over; there are according to Mr Blanford, 16 species of the genus of frogs *Rhacophorus*, all the other species being Oriental. The genus *Calophrynus* has three species, of which two are Oriental and one Mascarene. The family Discophidæ comprises seven genera and thirteen species in Madagascar; the only other member of the family is Burmese. Among fresh-water fishes Mr Blanford calls attention to a remarkable instance of an intermediate form being a native of Madagascar. It is a peculiar genus, named *Paretroplopus*, belonging to the family Chromididæ and intermediate between the African genus *Hemichromis* and the Oriental genus *Etroplus*. This family of fishes is especially characteristic of Africa, and is also found in South America. It is rarer in the Oriental region. The facts that Mr Blanford has laid stress upon seem to indicate, as he remarks, that there have been in this family of fishes two lines of migration from Africa to India. One by way of the Nile into Palestine, where the family occurs; the other through Madagascar, leaving behind evidence of its passage in the shape of the genus referred to which has so to speak not quite attained to the Asiatic character. The importance

of the evidence offered by spiders is emphasized by M. Simon's removal of Madagascar from the Ethiopian and its transference to the Oriental region[1].

The land and fresh water Mollusca are a doubtful group with which to have many dealings of the present kind; they are not so reliable as many, owing to the fact of their possessing a shell which has made them the objects of collectors who often do no more than refer to the "animal" as if it was a casual and unimportant inhabitant of the shell. But their evidence, so far as it can be read, is not without bearings upon the problem that we are now engaged in. A large proportion of the land Mollusca are peculiar; and there is, as in the West Indies, a great development of the Cyclostomatidæ. In this latter family a genus *Cyclotopsis* is limited to the Mascarene islands and to the Indian peninsula. In the Seychelles we have *Cyathopoma* and *Leptopoma*, which are also Oriental genera, and *Helicina*, which is almost world-wide but *not* African. The two families to which these belong, Cyclophoridæ and Helicinidæ, "must apparently," says Mr Blanford, "have reached the Seychelles from the eastward, for not one of them is found in Africa."

Mr Blanford deals with the obvious suggestion that the presence of these animals may be recent and due to floating trees or the like. The currents however indicate that the transference of such small creatures would be from the Seychelles to India and not in the reverse direction. Another possible method of colonisation by the help of winds is not to be considered; for it appears

[1] Trouessart, *La Géographie Zoologique*, p. 210.

that great wind storms, prevalent in this part of the world, do not cross the equator, which they would certainly have to do in order to convey animals or their eggs from India to the Seychelles. The earthworms of Madagascar are unfortunately not at all well known. But what we do know supports the facts brought together and emphasized by Mr Blanford. There is in the island at least one peculiar genus. This has been termed by Dr Michaelsen *Kynotus*, and it contains three or four species. The only other earthworms known from Madagascar are Perrier's *Acanthodrilus verticillatus* and *Perichæta madagascariensis* and *P. indica*. The former worm is only very doubtfully an *Acanthodrilus*; I bring forward reasons in my forthcoming Monograph of the Oligochæta for referring it to the already mentioned genus *Kynotus*, with one of the already described species of which it may be identical. *Perichæta madagascariensis* is closely allied to, if not identical with *Megascolex armatus*, a common Indian form. *Perichæta indica* is not far from being a cosmopolite. Now the genus *Kynotus* belongs to the family Geoscolicidæ, which is distributed through tropical South America and the West Indies, tropical Africa, and certain parts of Malaya; it just gets into Europe. But the old world forms can be separated from those of the new world to so marked an extent that it is permissible to divide the family into two subfamilies. The spermathecæ in the old world forms if present at all, and they are occasionally absent altogether, are very numerous and minute, while those of the American genera are the usual paired structures which are so characteristic of the Oligochæta.

The bulk of the old world genera of Geoscolicidæ are Oriental; and it may be fairly said that *Kynotus* is at least as nearly allied to them as it is to the African genera. Another possibly important piece of evidence to be derived from this group of animals is the existence in the Seychelles of a species, which I have dissected and cannot distinguish from the Oriental *Megascolex armatus*, already referred to. But this worm, if truly indigenous, indicates obviously a migration from India. In the Mauritius and in Rodriguez are species of the characteristically Oriental genus *Perichæta*, which are not unfortunately thoroughly well known anatomically, but in one instance, *Perichæta robusta* from Mauritius, are probably distinct species. I have described *Perichæta mauritiana* from the same island, which is certainly not identical with any known and adequately described species. There are thus some facts to be drawn from this group of animals not unfavourable to "Lemuria."

But the most striking evidence perhaps is geological and palæontological. This evidence I again abstract from Mr Blanford's address to the Geological Society. It comprises evidence derived from several distinct periods of the Palæozoic and Mesozoic epochs, and is therefore not by any means so "fragmentary" as has been alleged. It is pointed out that in carboniferous times there was a great resemblance between the plant faunas of Australia, India and South Africa. With this correspondence was a great difference from the flora of Europe. Supposing this flora to have been transported across the sea, there would of course be no use in invoking the presence of what Prof.

Suess terms "Gondwana land" instead of Lemuria. But if so, why are there no European plants in the same strata in India, &c.? For such plants do occur in the carboniferous strata of certain parts of Africa and Brazil. Nor do we find this kind of evidence only in carboniferous times. In the formation known as Cenomanian we have similar evidence, though in this case derived from marine organisms and thus serving to check the data derived from plants. At Nerbudda, in Western India, eight species of fossil Echinoderms have been found, of which six are also known from European rocks. But in South India 26 species have been found, of which only four, and two of these are doubtful, occur in European strata. The inference obviously is that the Nerbudda fossils are the remains of animals which lived in a sea continuous with the sea of the same period in Europe, and that the Trichinopoly beds are the bottom of a sea which was separated from the northern sea by a land barrier. The Trichinopoly fauna recurs in Natal.

Further evidence of the same kind comes to hand from a study of the Jurassic fauna of the world. Lastly, the fossil *Belemnites* of Madagascar are not identical with those of the beds of a corresponding age in Uitenhage, a fact which may at first sight appear to be hardly worth bringing forward in support of the present hypothesis. But the interesting fact about these fossils is that they belong to forms which are typical dwellers in warm seas, while the single Uitenhage Belemnite is as distinctively a cold-water form, thus tending to prove the existence of a belt of land shutting off a cold south sea from a warmer equatorial sea.

CHAPTER IV.

THE FAUNA OF ISLANDS.

THE principles dealt with in the preceding Chapter are also admirably illustrated by the fauna of islands, of which some account will now be given.

The Fauna of the British Isles.

The islands of Great Britain and Ireland are situated upon a bank which comes so near the surface that the sea is nowhere more than comparatively a few fathoms deep. From the neighbouring coast of France England is separated by barely thirty miles. There can be no doubt in fact that the separation is, geologically speaking, very recent, probably within the period of human occupation. We should expect therefore to find the very closest similarity in the fauna of England of the adjacent parts of the Continent; this is precisely what we do find, the differences being chiefly in the poverty of the British fauna as compared with that of the Continent.

As Mr Wallace has pointed out, this poverty is probably to be accounted for by the recent glaciation of

these islands, which destroyed a large proportion of the inhabitants, unable to escape to more southern and warmer latitudes or, if they did, cut off from returning by the severance of the land. Poor though the fauna is, there are still a few species which are really peculiar to these islands, and are not found, or at least have not as yet been found, anywhere upon the Continent. As however many of these supposed peculiar species are obscure and small insects, it is quite within the bounds of possibility that they remain to be discovered later upon the Continent. Among the Vertebrata the peculiar species are mainly fishes; there are however three species of birds, or at least forms that are reputed to be species, found nowhere outside of the British isles; the only one of these however which is without any question at all a distinct form is the grouse *Lagopus scoticus*. The Cole-tit *Parus britannicus* is held by some naturalists to be distinct from the *Parus ater* of the Continent; and in the same way the British form of the Long-tailed tit, called *Parus rosea*, is distinguished from its ally in Europe. The St Kilda wren is possibly also to be added to the list of peculiar species.

Mr Wallace enumerates no less than 15 different kinds of fresh-water fishes which he states, on the authority of Dr Günther, to be well-marked species. They are entirely Salmonoids and nearly all of them are lake fish; they include the familiar Gillaroo trout, the Loch Leven trout, the Gwyniad, the Vendace and the Pollan. Considering that in many cases these fishes are extremely restricted in their range within the islands, it is not surprising that

they do not range beyond. The Welsh Charr for instance, *Salmo perisii*, is limited to the Llanberris lakes. Out of these fifteen fish no less than six are confined to Ireland. The specialisation of these fish is comparable to that of the Cassowaries and the Ibexes dealt with on another page; they live in isolated areas whose living inhabitants can never intermingle except by the rarest circumstances, such as a whirlwind taking up the young fry and depositing them still alive in an adjacent lake; at any rate the very fact that they are of different species shows that intercommunication is not frequent.

The list of peculiar insects is a much longer one; but some entomologists hold that it is a list which is only at present imposing upon paper; that in fact the insects really await discovery upon the Continent. Mr Wallace however is of opinion that the list of peculiar British insects is in the main to be depended upon; he points out that all islands show an equal if not larger proportion of peculiar insects than of any other class of animals. Besides, the climate of this country is different from that of any part of the Continent, a further reason for the validity of the argument that there are really peculiar species restricted to these islands. Of butterflies there are only two species which are exclusively British; and both of these are very limited in their range within these islands; indeed one has become in the last few years absolutely extinct. This is the "Large Copper," *Polyommatus dispar*. Its extinction has been no doubt caused by the draining of the fens where it was formerly abundant. The other butterfly is a variety of one of the common

"Blues" known to entomologists as *Lycæna agestis*; the variety being termed *L. artaxerxes*; it occurs upon Arthur's Seat and upon some of the other Scottish hills.

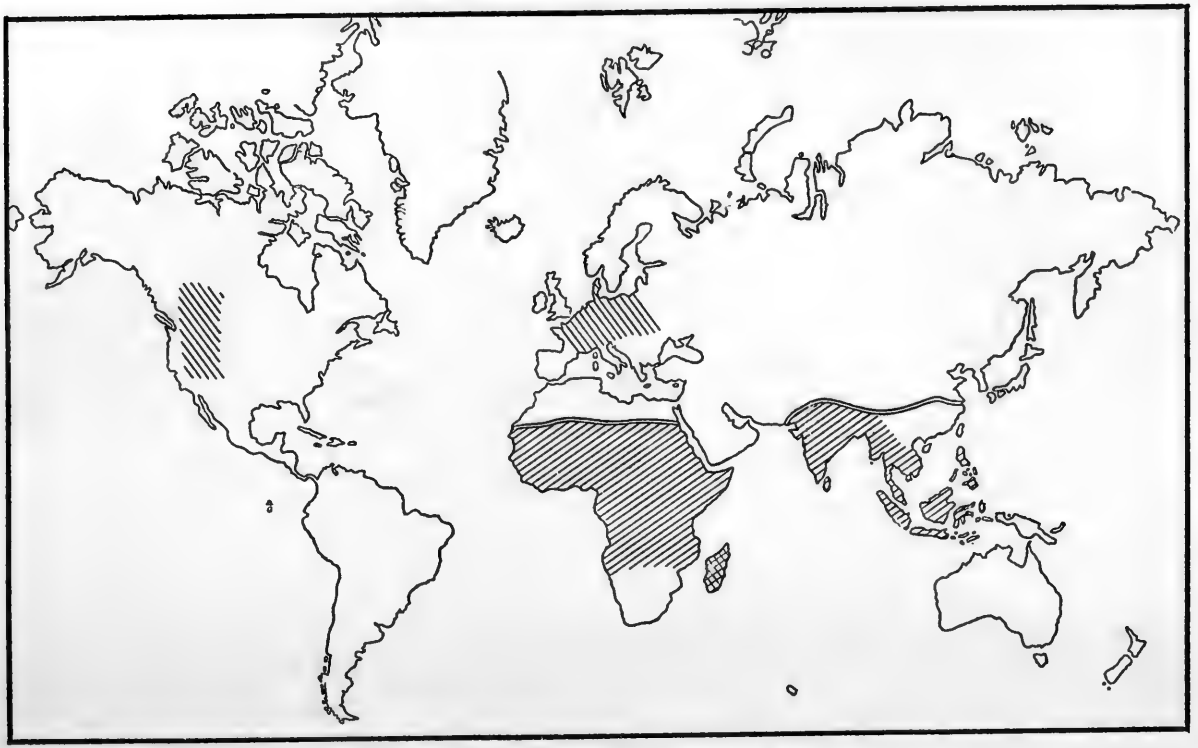
No less than 87 moths are given in Mr Wallace's list as peculiar to Great Britain. Of these of course the larger portion are "Microlepidoptera," and frequently minute forms, which might be easily overlooked were they really to occur also on the Continent. Though there are these 87 moths they do not all of them rank as species. However 61 are considered to merit specific distinction. This number is, according to the late Mr Stainton, to be further reduced to 50 undoubtedly distinct species since some of the reputed species are rather local forms than definable species. Of the beetles Mr Wallace's list shows 72 species and varieties confined to the British islands; the list of insects concludes with the mention of three Trichoptera, all apparently good species, which are not found out of the British isles.

The land and fresh water Mollusca present us with a few peculiar forms; a black slug spotted with yellow, *Geomalacus maculosus*, was discovered on the shores of lake Carogh in Kerry in the year 1842, and has not been met with elsewhere since that year. A small pond snail, *Lymnæa involuta*, is confined to a small Alpine lake near Killarney; finally there are two small shells which are ranked as species, one a bivalve, the other an univalve, besides 79 varieties.

The Rev H. Friend reports[1] the presence of a species of *Lumbricus* (*L. papillosus*) in Ireland, which has not yet

[1] *Irish Naturalist*, Feb. 1894.

DISTRIBUTION OF LEMURS.



RECENT FORMS.

EXTINCT FORMS.

To face p. 187.

been found elsewhere, and Mr Benham's[1] peculiar new genus *Sparganophilus*, found in the Thames, is so far as we know limited to that river. There are one or two other examples of Oligochæta which have not been met with outside of the British islands.

There are thus a fair number of animals which are confined to the British islands; but there are no marked generic (except the worm *Sparganophilus*) or family types; nor is the proportion of peculiar forms large as compared with that of the animals which are also found upon the continent of Europe. But this is perfectly in harmony with the geological history of these islands, which teaches us that the severance from the continent of Europe is, geologically speaking, an event of yesterday.

The Fauna of Madagascar.

Madagascar is a large island about twice the length of England, and as broad nearly all through as the widest part of England. It is situated about 250 miles from Africa. It is largely forest covered; but there are also in the central granite plateau moors. The fauna is both rich and peculiar. Among the Mammals the most characteristic forms are the Lemurs. Of this group of mammals there are no less than nine genera, viz. *Indris*, *Propithecus*, *Avahis*, *Hapalemur*, *Lepilemur*, *Lemur*, *Cheirogaleus*, *Microcebus*, and *Chiromys*, absolutely confined to the island. These genera contain all belonging to the subfamilies Chiromyidæ, Lemurinæ, and Propi-

[1] *Quart. Journ. Micr. Sci.* Vol. xxxiv.

thecinæ; the remaining Lemurs consist also of three subfamilies, which however include but few genera and species, and are distributed in Africa and in the Oriental region. Doubtless, as Mr Lydekker has pointed out in the "Royal Natural History," the excessive allowance of Lemurs is partly to be attributed to the entire absence of large and powerful carnivorous animals. Carnivora are not at all abundant. But they include two highly peculiar forms. Firstly, *Cryptoprocta*, a Viverrine believed by some to have relations with the extinct Creodonta but which is at any rate to be referred to a separate subfamily of the Ailuroidea, and *Eupleres*, which is also an isolated form and has some affinities to the Insectivora. This latter group includes five genera of a peculiar family, the Centetidæ, found nowhere else in the world except in certain islands of the West Indies[1]; the Rodents, an universally distributed family of mammals, all belong to the Myomorpha (the rat tribe); but they are all peculiar genera of that group, viz. *Nesomys*, *Hallomys*, *Hypogeomys* and *Brachytarsomys*. The ungulates are exceedingly poorly represented; there is only a *Potamochœrus* (*P. edwardsi*), and quite recently a *Hippopotamus* has been dug up from marshes where its bones were commingled with those of other living and recently extinct forms. Mr Blanford[2] reckons that out of the twenty-four genera of mammals of Madagascar only two, *Potamochœrus* and the shrew *Crocidura*, exist in Africa.

[1] Mr Dobson however (*Ann. and Mag. Nat. Hist.* Sept. 1884) denies that the W. Indian *Solenodon* is a member of this family.

[2] Presidential address to Geol. Soc. 1890.

The birds are not so strikingly peculiar as are the mammals; still there are not a few genera and species which are restricted to Madagascar. Among these is the remarkable *Mesites*, which is believed to be allied to the Sunbittern of tropical America and to the Kagu of New Caledonia, and is possibly to be regarded as a relic of a primitive group of rail-like birds once dominant in all parts of the world. *Leptosoma* is also a peculiar bird, whose affinities are far from clear. The late Mr W. A. Forbes[1] thought from his investigations into its structure that it might be regarded as the type of a distinct family near to the Rollers (Coraciidæ). The Cuckoo genus *Coua* is also peculiar to the island, as are also the Vasa parrot, *Coracopsis*, and a few more types. On the whole the avian fauna is not so remarkable as the mammalian; but in both cases the fauna of Madagascar stands out as noteworthy by the absence of animals which might be expected to occur just as much as by reason of the peculiar types which do occur. There is an entire absence of the characteristic African Elephants, Rhinoceroses, Anthropoid Apes, Lions, Hyænas, &c. and among birds, of Hornbills, Plantaineaters, and Colies.

The reptiles are almost as peculiar as the mammals. The chief feature of the island is the presence of the American genera *Philodryas* and *Heterodon* among snakes, a fact which is remarkably paralleled by the Centetidæ among the Insectivora. There is an exactly analogous case among lizards; for two genera, *Hoplurus*, *Chalarodon*,

[1] *P. Z. S.* 1880.

are Iguanoids—a family otherwise restricted to America. The Chamæleons are very abundant in Madagascar, more so than in any other part of the world, though they are by no means limited to the island. As with mammals and birds the reptiles which are remarkable for their absence are as numerous as those which are noteworthy for their presence. The most striking example is perhaps the large group of Monitor Lizards, which abound not only in Africa but in many parts of the old world, to which division of the globe they are confined. Some further facts about the zoology of Madagascar will be found on page 176 *et seq.*, *apropos* of its relations to India.

The Fauna of Fernando Noronha.

The island of Fernando Noronha lies at a distance of 194 miles N.-E. from Cape San Roque on the coast of Brazil. It consists now of an archipelago of small islands; but the original discoverer, Amerigo Vespucci, speaks of it as one island; it seems probable therefore that the splitting up into an archipelago has occurred within the last 400 years. The recent formation of an archipelago is also rendered probable by the fact that the individual islets have not their peculiar inhabitants, but that—in the words of Mr Ridley[1], whose report upon its zoology has furnished me with the material for the present section—"almost all the species noted occur on all the islands suitable for their existence." This is entirely different to the older oceanic archipelagos, such as the Sandwich

[1] *Trans. Linn. Soc.* 1886.

Islands (see below). The fauna is poor. No indigenous mammal is to be found, with the possible exception of a mysterious rat belonging to a tribe which Vespucci describes as "Mures quam maximi." This description seems inapplicable to the black rat, which is now found in company with the common mouse. The cat also is said to have become feral, but there is not the slightest ground for believing in a truly indigenous cat. There appear to be only three land birds, of which two are peculiar; the peculiar species are *Vireo gracilirostris* and *Elainea ridleyana*, both very nearly related to American forms. The third bird is a dove, *Zenaida maculata*, "merely a small race of the ordinary *Z. maculata* of the South American continent." It is not, however, peculiar even as a small race, to the islands; for precisely the same variation occurs in Brazil.

Only three reptiles exist in Fernando Noronha. These are an *Amphisbæna* (*A. ridleyi*) peculiar, a skink (*Mabuia punctata*) from Demerara, and a common Gecko. The peculiar species has its nearest ally in the West Indies, *not* on the mainland of South America.

The fresh-water Mollusca consist of a species of *Planorbis* peculiar to the islands. The land Mollusca are seven in number; of these four are peculiar, but only as species, not as genera. A peculiar Centipede is described by Mr Pocock under the name of *Geophilus ridleyi*, whose nearest ally occurs at San Francisco. There is also a peculiar Millipede, *Spirobolus noronhensis*. Two species already known were also met with. Among the Insects are two peculiar genera, and a considerable number of

peculiar species. In all 75 species of Insecta were identified, and out of these 27 were peculiar species, including the two genera above referred to. The fresh waters of the islands contained, besides the *Planorbis* mentioned, an Ostracod and a *Gammarus*, both believed to be peculiar. There was a total lack of fresh-water fish and of fresh-water as well as terrestrial Amphibia.

One earthworm is known from Fernando Noronha, identified by Mr Benham with the widely ranging but especially Neotropical *Pontoscolex corethrurus*.

The most salient features therefore in the fauna of these islands are the total want of mammals of an indigenous character, of fresh-water fish, and of Amphibians, the rarity of reptiles, and finally the large number, speaking relatively to the total of course, of indigenous forms peculiar to the island. Of these however but few are of new generic types; but this statement as in the case of the fauna of Kerguelen, to be dealt with presently, must be tempered by reflection as to the different ideas which different naturalists have of the value of a genus. As to the affinities of the fauna it is noteworthy that the West Indies enters largely into the matter; there is not, as might be assumed at first, an absolute likeness with the nearest coasts of South America. But the winged fauna, Mr Ridley points out, whether they are endemic or have a wider distribution, have a South American facies which is quite unmistakable.

The Fauna of Kerguelen.

The island of Kerguelen is situated in the southern ocean in lat. 50, about half way between Australia and the Cape of Good Hope. It is a large island of irregularly indented form measuring in greatest diameter some 80 miles. The island is moreover situated on a plateau which extends for a distance of more than 150 miles.

The island is entirely built up of volcanic rocks; it is chiefly formed of basalt; but trachyte and phonolite enter also into its composition.

Our information as to the fauna of Kerguelen is apparently fairly complete. It was investigated by an English expedition some years ago, the results of whose discoveries were published by the Royal Society in 1875. Later the "Challenger" stayed for some time at various parts of the coast, and the German ship "Gazelle" during its voyage in the years 1874—76 touched at the island and collected a quantity of material.

In spite of the large size of the island, there is no indigenous mammal; the only mammal indeed which occurs there, apart of course from marine forms, is the ubiquitous *Mus musculus*. As the island is visited by whale fishermen it is easy to understand how the common mouse may have been introduced in ships. The only land bird is the duck, *Querquedula eatoni*, a species peculiar to this island and to the not very remote Crozets; the bird lives in marshes. Of the marine birds *Sterna virgata* is also peculiar to Kerguelen and to the Crozets.

Only a single species of land shell has been so far discovered; this is *Patula hookeri*, a species closely allied to *Helix dianæ* of S. Helena, to *H. quadrata* of Juan Fernandez and to *H. tessellata*.

Among insects there are on the other hand several peculiar forms. The beetles are in every case without the second pair of wings; they comprise *Ectemnorhinus viridis* and a few other species of that genus, *Phytosus atriceps* and *Cannonopsis*. A moth with rudimentary wings has been recorded, as well as the peculiar genus (peculiar to the island) *Embryonopsis halticella*. The Diptera do not show the same rudimentary character of the wings that is met with among the Coleoptera; there are however six peculiar genera with a species apiece and an introduced form.

The spiders of the island are represented by two peculiar genera, *Myro* and *Pœcilophycis*, of which the latter is so aberrant that the Rev. O. Pickard-Cambridge has felt it necessary to form an entirely new family for its reception. Among the fresh-water invertebrates, which are not very numerous, there are no peculiar genera; but all the species are, so far as we know at present, peculiar; these comprise species of the two Crustacean groups Cladocera and Copepoda, and an Enchytræid (unidentified). One terrestrial Annelid has been found and described by Lankester as an *Acanthodrilus*[1] (*A. kerguelenensis*); this is a species peculiar to the island, unless the *Acanthodrilus* of the Crozets be the same; but the

[1] *Phil. Trans.* Vol. 168, Extra Volume.

genus is widely spread in the antarctic region of the globe[1].

There are five striking points about the fauna of Kerguelen which may be emphasised. In the first place of course, the poverty of the fauna. Secondly, the immense number (relatively speaking) of peculiar genera; thirdly, the fact that there is only one terrestrial species (excluding birds) which is not peculiar to the island; and fourthly, that the fresh-water species are not so peculiar as the purely terrestrial. The fact that the Coleoptera are without the second pair of wings—the pair which are used for flying in the normal Coleoptera—and that there is a moth with rudimentary wings, completes the more remarkable facts which characterise the indigenous inhabitants of Kerguelen.

The Fauna of the Galapagos.

The Galapagos are a group of sixteen islands, five larger and eleven small islands—situated to the west of the South American continent, about 600 miles from the coast of Ecuador. They have been explored more than once with a view to their fauna. The most recent account of them is from the pen of Dr Baur[2], who made a careful study of the entire fauna.

As is the case with Kerguelen, the rocks of which the Galapagos are built up are entirely volcanic; they consist of basaltic rocks, masses of scoriæ, and lavas; but there

[1] See p. 60.

[2] *American Naturalist*, 1892.

are also, on Charles Island, remains of older volcanic formations, which recur in one or two of the smaller islands. All the islands of the archipelago are placed within the 1000 fathom line. They were first discovered in the sixteenth century.

Mammalian life is not entirely wanting, but it is scarce, in these islands. At present we are only acquainted with two species; one of these is a mouse belonging to the American genus *Hesperomys*, which may or may not be indigenous. The other mammal is a bat; but our knowledge is here not accurate; for the bat has been only seen and not collected.

There are on the other hand a good many reptiles. The most famous are of course the huge tortoises, which have given their name to the archipelago; there is no doubt that these bulky creatures, which sometimes reach a weight of 700 pounds, are truly indigenous; for they were seen by the Spaniards who discovered the islands. The peculiar thing about these tortoises is that different islands are characterised by different species. There are in all six species of these Chelonians, but the exact locality of one or two is not known.

Tortoises however are not the only reptiles which live in or round these islands. Four genera of Lizards exist there; these are *Tropidurus*, *Conolophus*, *Amblyrhynchus*, and the Gecko *Phyllodactylus*.

Of the genus *Tropidurus* there are altogether eight species on the islands, each island as in the case of the tortoises having its own peculiar form. *Amblyrhynchus* is a marine genus feeding on seaweeds; it is like the last a

member of the Iguanidæ, a family of lizards just not absolutely confined to the New World. Dr Baur thinks that when the species of *Amblyrhynchus* come to be examined critically, differences will be found like those between the tortoises of the different islands. There are three geckos on the islands, all belonging to the genus *Phyllodactylus*, already mentioned. These are *P. galapagoensis*, *P. leei*, and *P. tuberculosus*; the last lizard is the only species found on the islands which is not peculiar to them. In addition to these lizards there are two snakes; they are both very closely allied to South American forms.

The land birds, according to Mr Salvin's paper upon the subject[1], are in all 31 species. Of these only one, the Rice bird, is not peculiar to the islands. As Mr Wallace has pointed out there is every possible transition between this case and birds which are so different from any found upon the adjacent mainland that they are not merely of different genera, but of very dubious affinities. The birds belong altogether to fourteen genera, of which four are peculiar to the Galapagos; these peculiar genera are *Certhidea*, one of the Sugar birds (Cœrebidæ), *Geospiza*, *Cactornis* and *Camarhynchus*, all of them Fringillidæ. The birds that are merely of different species are all allied to South American or West Indian forms, or of course to forms which like *Strix flammea* (the common Barn Owl) are of universal range.

As with the reptiles certain of the peculiar birds are confined to a single island; the same genus has one

[1] *Trans. Zool. Soc.* 1875.

species in one island and one in another. Thus *Mimus parvulus* is only met with in Albemarle Island and *Mimus trifasciatus* only in Charles Island.

The insects of these islands are not very numerous. Mr Wallace following Mr Waterhouse allows about 35 species of Beetles, belonging to 29 genera. The species are as a rule peculiar and so are the genera in some cases. But as they are "mostly small and obscure insects," it is difficult to be positive upon either of these points.

The Orthoptera of the Galapagos are equally interesting. Considering that nine different expeditions have been made to these islands, from which insects of this group have been brought back to Europe or America, and reported upon, it may be fairly assumed that our knowledge of the fauna is not too incomplete to permit of conclusions. There are in all 20 species, of which Dr Scudder, the latest writer on the subject[1], leaves with justice five out of consideration, as they are world-wide forms and probably not endemic. The remaining 15 include five distinct generic types; but the whole assemblage presents, according to Dr Scudder, a South and Central American facies. Another matter worthy of mention is the very great prevalence of apterous or sub-apterous species. The 20 species are in many cases confined to one of the islands of the Galapagian archipelago. This is so with no less than eleven of them. A few are found in two or three of the islands; one species —*Schistocerca melanocerca*—is unique for its wide dis-

[1] *Bull. Mus. Comp. Zool. Harvard*, 1894.

tribution in the archipelago; it occurs in no less than eight islands. The specimens were submitted to a rigid scrutiny to discover whether they could be referred to distinct races, but the most that can be said apparently is that "there is a distinct tendency toward the formation of races." On the other hand another species of the same genus—*S. literosa*—which occurs in three islands, can be separated into as many races.

The Fauna of New Zealand.

The fauna of New Zealand has been so abundantly investigated through the labours of Capt. Hutton and others, that it is one of the best known quarters of the globe.

It will be well to preface our account of this fauna by a brief sketch of the physical features of the island and the surrounding ocean. The name New Zealand is applied to two principal islands which are together "about as large as the kingdom of Italy." Their climate is mild and equable, while the vegetation is luxuriant and there are no deserts such as occur in Australia. The two islands lie upon an extensive plateau, where the water is not more than 1000 fathoms deep; a prolongation of this submarine plateau runs out and joins New Caledonia to the north, whence it is continued on to the Australian continent; another spur runs out so as to embrace Lord Howe Island; elsewhere a depth of over 2000 fathoms divides New Zealand from Australia. Its distance from Australia is about 1200 miles. The geological structure

of the islands shows deposits of ancient sedimentary rocks, besides jurassic, cretaceous, and tertiary strata; it is thus evidently a continental island, though it exhibits much volcanic material of ancient as well as of more modern date.

The fauna of New Zealand is highly remarkable; though the island is of the continental type there are hardly any mammals, no *large* mammals at all; only two bats and a rat—the latter being almost certainly an importation—are known to exist in New Zealand. Rumours of a larger and, conjecturally, a carnivorous mammal have been from time to time floated; but the domestic cat may be responsible for the footprints, assigned to a new and isolated type of New Zealand mammal. The bats however are not of universally distributed species; one of them is an Australian form, *Scotophilus tuberculatus*; the other is a peculiar genus, *Mystacina tuberculata*. The birds are very characteristic; the most salient type is of course the but recently extinct *Dinornis* and its allies; there were until well within the historic period a large number of species of Dinornithidæ. The existence or at any rate the abundance of these often huge birds is ascribed to the absence of mammals—of carnivorous mammals that is to say. The curious genus *Apteryx* is found in New Zealand and nowhere else; of this genus there are about four species. It is regarded by Fürbringer as allied to the Rails, but to be a low stock of the Ralline birds, a little more modified however than the Cassowaries, Emus and the rest of the so-called Struthious birds; the *Apteryges* are placed by the same author in close proximity to the

Dinornithidæ. It is not only these archaic forms of birds which are peculiar to New Zealand. Nor are they the only flightless birds that inhabit this country. The parrot, *Stringops*, an undoubtedly ancient form of parrot, is a very characteristic inhabitant; so too are the rails, *Ocydromus* and *Notornis*; all these birds, though with wings better developed than those of the Apteryx, or Dinornis, are practically without the power of flight. The "Parson-bird," *Prosthemadera*, is another peculiar form. Mr W. A. Forbes has described[1] as peculiar Mesomyodian genera of Passerine birds, the genera *Xenicus* and *Acanthisitta*. He regards them as worthy of inclusion in a separate family, to which the name *Xenicidæ* is applied; the only other family of Mesomyodian Passeres that enters the Australian region is that of the Pittidæ. The Xenicidæ are also allied to the Tyrannidæ and to the Cotingidæ of the New World. Another remarkable Passerine of New Zealand is *Heteralocha*, which, like the equally restricted *Callœas* and *Creadion*, is referable to the family Sturnidæ. Among reptiles the isolated *Hatteria* is the most remarkable; the Amphibia are represented by a single frog, *Liopelma hochstetteri* allied to European forms belonging in fact to the Palæarctic family Discoglossidæ. It is curious that there are no scorpions in New Zealand[2], since that family exists in Australia. The earthworms of this part of the world are mainly Acanthodrilidæ, including three genera confined to

[1] *P. Z. S.* 1882.

[2] Pocock. *On the Geographical Distribution of Scorpions.* Natural Science, 1894.

New Zealand. The characteristic Australian types are either absent or but feebly represented. The South American genus *Microscolex* is represented by six distinct species.

In Mr Lydekker's recently issued "Catalogue of the Fossil Birds" in the British Museum is an exhaustive list of the extinct flightless or wingless birds of New Zealand, which were wonderfully numerous; they may be fairly considered as part of the existing fauna of the island, since they have been in existence there up to the historic period, or disappeared from the island at a period only just antecedent to it. A new genus, *Pseudapteryx*, with but a single species, represents a bird hardly different from *Apteryx* and of about the size of the comparatively small *Apteryx oweni*. Of *Dinornis* itself no less than four species are allowed, many of those formerly referred to the genus being now better placed in closely related but different genera. These are *Megalapteryx*, *Anomalopteryx*, *Emeus*, *Pachyornis*, with at any rate 17 species between them. Another very remarkable and characteristic inhabitant of New Zealand is the large goose, *Cnemiornis*, which is regarded as a near relative of the Australian *Cereopsis*; it was a bird with apparently no powers of flight, for the keel of the sternum, as in the Struthious birds, is aborted. The bird was considerably larger than the existing *Cereopsis*. There is one certainly known species of the genus, *Cnemiornis calcitrans*, and one doubtful one, to which Mr Lydekker does not give a name. A large rail, *Aptornis*, is another inhabitant of New Zealand whose remains, belonging to two species, are found associated

with those of the *Dinornis*. Though these great birds must have led a comparatively unharassed life in New Zealand before the advent of the Maories, who are probably chiefly responsible for their disappearance, there were in the islands at the same time great birds of prey, which might have proved able to destroy the largest of Dinornithidæ. These were birds now referred to the genus *Harpagornis*, half again as large as the Golden Eagle. They are believed to be most nearly allied to the genus *Aquila*, but by some are placed rather in the neighbourhood of the Kites or Falcons. As all the last mentioned birds come very near to each other, the affinities of the *Harpagornis* may be considered to be well known.

Fauna of the Sandwich Islands.

Our information about this group of islands is growing rapidly. The second edition of Mr Wallace's *Island Life* contains a great deal more information than the first edition; and since that book was published a Committee appointed to take steps for the exploration of the islands have reported briefly to the British Association[1]. The islands in question are a group of largish islands, 2,350 miles from the coast of America and purely volcanic in structure. They have of course no indigenous mammals; there is a reptile or two; but the birds are the most remarkable and interesting. Dr Sharp states that out of 78 birds found in the islands 57 are peculiar. Seven or eight of the twelve or fourteen peculiar genera

[1] *Rep. Brit. Assoc.*, 1893, p. 783.

belong to a family Drepanididæ, which is absolutely confined to these islands and which may have, thinks Mr Wallace, affinities on the one hand to the Oriental Dicœidæ and on the other to the characteristic American family of Vireonidæ, or Greenlet. The Passerine birds of the islands are the most interesting, for two reasons; firstly they comprise nearly all the peculiar genera of the islands, and secondly they show a remarkable specialisation among the islands. The genus *Loxops*, for example, of the Drepanididæ has a different species in each of the islands Hawai, Molokai and Mani[1]. This specialisation into peculiar genera, and species with so restricted a range, is of course correlated with the immense distance to be traversed and the feeble flight of these birds when compared with that of say the ducks and geese. There are however peculiar genera among the non-Passerine birds, as the little flightless Rail *Pennula ecaudata*. Among other peculiar birds are the Sandwich Island goose, *Bernicla sandvicensis*, and a peculiar Buzzard, *Buteo solitarius*. Of land and fresh-water Mollusca Dr Sharp states that there are 475 species, *all* of them peculiar. Out of 1000 insects 700 are peculiar; but Dr Sharp thinks that the numbers are very much less than the total will ultimately prove.

General Observations upon the Fauna of Islands.

We have now dealt at some length with the fauna of six islands or groups of islands. A consideration of the

[1] Wilson, *Aves Hawaiensis*, and Rothschild, *The Avifauna of Laysan.*

facts brought forward will at once serve to divide these islands into at least two groups, which are again capable of subdivision.

Continental Islands.

In the first category are Great Britain and Madagascar, which have a copious indigenous fauna of mammalia and amphibia; to the second category belong the other islands, which have either no mammalia at all or they are extremely few, at most one or two species identical with those found upon the adjacent mainland, and which are absolutely destitute of amphibia of any kind.

These distributional facts go hand in hand with Geological structure. Great Britain and Madagascar are detached portions of continents, which have been separated from the mainland for varying periods. The remaining islands, with the possible exception of the Galapagos, which will be considered later, are not such fragments but have arisen *de novo* in the ocean by volcanic agency. They have never had any connection with any continent. The relation between the geological structure and the nature of the inhabitants is a real one; the mammalia, as has been already observed, are not capable of extended migration over the sea on their own account; it could only be but rarely that a mammal could reach a distant and oceanic island; and it would be necessary in many cases that two individuals at least should emigrate within a reasonable time of each other. The immense tract of ocean which separates Kerguelen from the nearest continent has proved an

impassable barrier to mammalian life; for the common mouse, which, as has been said, occurs there, could easily be, and doubtless has been, conveyed there by man's agency. With the Amphibia the difficulties are even greater; for in their case there is not only the difficulty of transport, but the serious additional difficulty that sea-water is fatal to them. It might be urged that as some of these purely oceanic islands are of large dimensions and have probably been larger, mammalian life might have come into existence upon them independently. This assumption however would be entirely contrary to our ideas of evolution; indeed it is not necessary to argue from any *a priori* point of view, for we are confronted with the fact that some oceanic islands at any rate—*e.g.* S. Helena—are not incapable of supporting mammalian life, for imported animals do well, and yet they are totally without an indigenous fauna of the kind. On the other hand, there is no doubt at all that both Great Britain and Madagascar are severed portions of continents, which were amply stocked with mammalian life when they were finally cut adrift.

Although there is this general similarity between the two islands just mentioned, it is clear that there are also differences, and considerable differences too. The mammalian fauna of Great Britain, and for the matter of that the fauna in general, is poor in peculiar forms, restricted to the archipelago and not found living in the continent of Europe; there are a good many peculiar species, it is true, but very few in comparison to the fauna as a whole.

On the other hand, Madagascar abounds in peculiar forms, even of family rank, and certainly in numerous cases of generic rank. This difference again is correlated with physical conditions. Britain is separated from France by scarcely 30 miles of sea, which is so shallow that, as is stated, the dome of S. Paul's Cathedral in London, if submerged anywhere in that sea, would stand for the most part clear above the waves. On the other hand Madagascar lies 250 miles from the African coast, from which it is separated by an ocean varying in depth from 1,000 to 1,500 fathoms. The inference is that the separation between Britain and Europe is of much later date than that between Madagascar and Africa. More time would in all probability elapse between the scooping out of the deep channel which divides Madagascar from Africa, than of the narrow and shallow Straits of Dover.

Oceanic Islands.

The four oceanic islands again possess faunas which are not absolutely the same in character. Fernando Noronha and Kerguelen contrast with the Galapagos and the Sandwich Islands by reason of the poverty of their fauna. They differ from each other also. Kerguelen has a poor fauna, hardly if at all richer than that which populates Fernando Noronha, but the number of peculiar types is larger and more marked; more marked because the types are to a considerable extent of peculiar genera. This would tend to prove that Kerguelen is older as an island than is Fernando Noronha; more time has elapsed since it was

originally populated, and during that time the descendants of the original migrants have had time to pursue an independent line of development. That Kerguelen is an island of some antiquity is shown by the submerged bank which surrounds it, which would have demanded time for its submergence, and by the occurrence of stratified, though originally volcanically produced, rocks. We now come to the remarkable case of the Galapagos. Reptiles are often not totally wanting in islands of purely oceanic type; there seems to be some method, at present mysterious, in which reptiles have the advantage over mammals in traversing the sea. So that the actual presence of lizards and snakes, though they are rather numerous, is not an absolute bar to regarding the Galapagos as of purely oceanic origin. The great tortoises seem to be a huge difficulty; there is no way of slipping out of the problem by bringing in the help of settlers; besides, in another island, Aldabra, there are also huge tortoises. This island belongs to the Comoro group lying at some distance from Madagascar but connected with it by a shallow of about 1,000 fathoms in depth. There is much the same relation between Aldabra and Madagascar that there is between the Galapagos and the South American continent. But in neither case could these huge tortoises, sometimes weighing 700 pounds, have swum across a wide and deep ocean. And the fact that the first visitors to the Galapagos mention them shows that they have not been introduced by man.

Dr Baur thinks that these tortoises are of themselves almost sufficient to prove the former connection of the

Galapagos with the mainland. A further argument in the same direction is offered by the fact that the fauna of the mountain peaks of the Galapagos at a height of 900 feet are like that of the mainland at 9000 feet. Given a great depression this would be accounted for. That view of the matter clears up in a satisfactory way the difficulty of the tortoises; it would be inferred from this way of looking at the problem that the huge Chelonians of the Galapagos like those of Aldabra had been able to hold their own by isolation and consequent freedom from competition or persecution. Mr Wallace however is of opinion that this assumption is unnecessary. "Considering the well-known tenacity of life of these animals," he remarks, "and the large number of allied forms which have aquatic or subaquatic habits, it is not a very extravagant supposition that some ancestral form carried out to sea by a flood was once or twice safely drifted as far as the Galapagos, and thus originated the races which now inhabit them." The almost total disappearance of mammals requires explanation on the hypothesis that the Galapagos are a disjointed piece of South America.

The study of the distribution of animals thus throws an important light upon geological problems, and tends to support the belief that animal life has come into being upon large continental tracts and that it is liable to variation when isolation is brought to bear. A careful comparison of island fauna moreover enables some estimate, chiefly of course comparative, to be made concerning the age of the island in question.

Anomalous islands.

New Zealand is spoken of by Mr Wallace with justice as an "anomalous" island. Though continental it has many of the characters of an oceanic island which has never had any connection with a continent. It contrasts in the most marked way with Madagascar. Unless the mysterious carnivore already referred to really turns out to be what has been suggested, a kind of otter, New Zealand possesses no indigenous mammals except the flying bats, which are largely uninfluenced by the ordinary barriers to mammalian dispersal. The "Maori rat" may be slightly different from the *Mus rattus*; but the difference, if present, is not considerable. On the other hand there is one frog, and frogs are absent from truly oceanic islands. Most remarkable are the birds of New Zealand and the unique *Hatteria*, the representative of an otherwise extinct group of Saurians. The fact that the majority of the birds are flightless is due perhaps to the absence of destructive mammalia; this flightlessness applies not only to the *Apteryx* and the Dinornithidæ, but in a lesser degree to the but recently extinct *Cnemiornis* and to the Rails. The islands are perhaps too large to permit of a comparison between this incapacity for flight on the part of the birds of New Zealand and the defective wings of the Coleoptera of oceanic islands generally. Before considering the bearings of these facts upon former land connections, if any, between New Zealand and the most adjacent regions, it is convenient to refer to an ingenious suggestion on the

part of Captain Hutton as explanatory of the Moas of New Zealand. These recently vanished birds are represented by a large number of different species which are now placed in more than one genus. The area upon which they lived is small, and accordingly the number of species is rather remarkable. In the Australian region there are nearly as many Cassowaries as there are Moas. Now these Cassowaries are spread over a considerable number of islands; they are not limited to the continent of Australia but occur also in Ceram, New Britain, New Ireland, &c. On these various islands and continent are different species. This suggests that isolation and the absence of opportunity for retaining the type by crossing with the parent stock was responsible for the great variety of Cassowaries. If New Zealand had been at one time a mass of not very distantly separated islands, each inhabited by its own particular species of Moa, a state of affairs very like that now existing among the islands lying to the north of Australia would result; this is precisely what Mr Hutton in effect suggests. Mr Wallace regards the suggestion as a reasonable one, and it is impossible to follow a better opinion. If there has been this oscillation of New Zealand, whereby a continent (comparatively speaking) has been broken up into an archipelago, and reconstructed into a continent again, it may be that we have a clue to the existence of the large, clumsy, and flightless birds such as the *Cnemiornis* and the *Notornis*. Their case might well be analogous to that of the Galapagan and Aldabran tortoises; or perhaps also to that of the flightless beetles of

the Azores. At the same time if the tract of land, now known as New Zealand, were a mass of smallish islands during the time that mammalian life came into existence upon the Australian continent, the small superficies of the individual islands might hinder the successful immigration of the primitive mammalia; to get a successful footing would be in every way more likely upon a larger than upon a smaller land surface. The chances of landing too would obviously be greater in proportion to the extent of coast line. Had New Zealand been as Madagascar undoubtedly was, a broken-off fragment of a formerly more extensive Australian continent, there would surely be some traces of at least marsupial life. On the other hand it might be well urged in reply to this that the connection of the two countries may have antedated the advent of marsupials. A separation may have occurred while Australia was only populated by the lower vertebrates. Or with equal probability it might be pointed out that Australia was joined with New Zealand when it was itself divided into two halves, of which the western had only just received its stock of marsupials. This latter is Mr Wallace's view. There is no doubt that the fauna of New Zealand is one of the greatest puzzles that distribution has to offer.

Some peculiarities of island animals.

Having already dealt with peculiarities of island faunas as regards the classes of animals which inhabit them, the absence of some kinds of animals and the presence of

others, there remains another series of facts of which a brief epitome may be useful. It has been already pointed out incidentally that many islands, whether oceanic or not, are, or were until well within the historic period, inhabited by birds not only of large size but also without the power of flight, either owing to the partial abortion of the wing muscles and bones or simply by use, like the Weka rail of New Zealand. This is quite a common characteristic of the birds of islands. The Dinornis of New Zealand, the Dodo of Mauritius, the "Solitaire" of Rodriguez, are instances to the point. It seems highly probable that this large size coupled with an incapacity for flight was correlated with the absence or at least the rarity of fierce enemies; mammalia are, if not absent, small in those islands where these large and flightless birds exist or existed. It is to be observed that even among the Struthious birds, all of which are flightless, the majority of the species are inhabitants of islands. This majority is mainly formed it is true by the genera of Dinornithidæ; but a large number of Cassowaries are exclusively island forms.

Birds are not the only animals which grow to a large size upon islands. On a former page attention was called to the huge tortoises of the Galapagos. These tortoises are not altered apparently in any other respect; they do not for instance show any structural feature which could be said to be analogous to the flightlessness of so many of the ornithic inhabitants of islands. But the tortoises of the islands are actually the largest of the whole tribe; their unwieldy bulk, likely to be disadvantageous where

the struggle for existence was keener, is in all probability to be referred to the same causes as the defenceless state of the Dodo and other island birds.

The island of Mauritius was also inhabited quite recently by gigantic tortoises which are now without exception extinct. Dr Gadow in a recent communication upon the subject[1] distinguishes no less than six "forms" of these. He uses the word "form" because it seems improbable that they have the full value of species; and yet names are given to them without any such prefix as "*forma*" or "*var.*" It is at least not usual for species of the same genus—and all these giants belong to *Testudo*, just like those of the Galapagos—to herd together in a limited tract. Now five out of these six forms have deposited their bones in one marsh; so much confused were they, owing no doubt partly to the fault of those who fished them out, that in some cases the bones seem to have entirely lost their mutual relations. Waiving the question of species it is clear that great variability reigned among these large and unpersecuted inhabitants of the Mauritius—their freedom from enemies being also perhaps indicated by the thinness of the shells. It is incorrect to make the general statement that great size is characteristic of island tortoises only, because the giant *Colossochelys* of India and some other forms flourished under continental conditions. But among living or but recently extinct tortoises large size seems to have been only attainable on these favoured because restricted spots,

[1] *Trans. Zool. Soc.* Vol. XIII.

where natural selection imposed no check upon unwieldy bulk.

Dr Dobson has pointed out the curious circumstance that bats are not nearly so numerous in oceanic islands as birds. From many considerations they ought to be; their nocturnal habits and the general nature of their insect food are characters which would favour successful colonisation. The reason apparently for their comparative scarcity in islands which must have been stocked with them from the nearest mainland is correlated with the comparative rarity of flying objects. On another page I direct attention to the fact that the insects of oceanic islands are largely like the birds flightless. Now bats are as a rule thoroughly aerial in their habits; they seek their prey upon the wing. This fact, thinks Dr Dobson, is largely responsible for the poverty of New Zealand in Chiroptera.

Even in the British islands poor though their fauna is there are eight times as many bats as in New Zealand. One of the peculiar New Zealand bats, *Mystacina tuberculata*, "has the claws of the pollex and toes remarkably elongated, very acutely pointed, and provided at the base of each with a small talon projecting from its concave surface near the base; the wings are peculiarly folded so as to occupy the least possible space; and they and the interfemoral membranes are preserved from injury by being encased, when so folded, in a specially thickened part of the wing and interfemoral membrane, analogous to the thickened part of the anterior wings in Hemiptera,

[1] *Ann. Mag. Nat. Hist.* Sept. 1884.

and to the elytra of the Coleoptera; furthermore the plantar surface of the foot including the toes is covered with very soft and very lax integumental tissue deeply wrinkled." These peculiarities of structure, thinks Dr Dobson, must have some relation to the habits of the bat. The probability seems to be that the structure of the feet gives to the animal an unusual power of grasping tightly any rough surface like the bark of a tree, while the wings not being needed when the creature is in such a situation are protected from injury by being carefully stowed away in the fashion described. Dr Dobson is of opinion that this bat instead of hunting its prey on the wing seeks it upon the trunks and branches of trees up and along which the bat crawls. This curious modification of structure therefore is probably an indirect effect of living upon an island where there are but few flying insects. From the same group of animals may be drawn another example of modification of structure having a relation to habitat. In the Bermudas, which are 700 miles from the American coast, are two species of bats; but one only in the Azores, which are closer to the island of Madeira by about 150 miles. The presence of these animals is said to be due to the occasional prevalence of violent storms. It is remarkable that these species have a robuster and more hairy body, which would of course tend to endow them with a greater power of withstanding the violence and coldness of a long-continued gale.

Another highly remarkable association of structure with locality is afforded by the flightless insects of many oceanic islands. Attention has been already directed to

the fact that in the Galapagos and Kerguelen many of the insects are flightless. The same is the case with other oceanic islands. But in other cases the insects have larger wings than their allies upon the mainland. These two facts are both explained in the same way by Mr Darwin. The small size of the islands and the frequent prevalence of gales of wind would tend to blow the insects out to sea, where they would in all probability perish. Those individuals therefore which either had wings uncommonly strong or were incapable of flight altogether would have the best chance of maintaining their footing. The same need has thus produced two effects of the most opposite kind.

Prof. Eimer has remarked upon the fact that "the butterflies of Sardinia are in general smaller and also more darkly coloured than those of the mainland." The same thing exactly is met with in the case of the variety of the small Tortoiseshell butterfly upon the Isle of Man. This island has other insects which are darker in colour than those upon the neighbouring mainland. *Dianthœcia capsophila* is a variety of the more usual *D. carpophaga*; in Ireland the examples of this variety are dark coloured, but those of the Isle of Man are more darkly coloured still. Mr Wallace mentions four other moths which show some such difference from their representatives upon the mainland. The somewhat rare *Cirrhœdia xerampelina* is not much darker than the mainland form but it differs from it in the production of a characteristic yellow line. The late Mr J. Jenner Weir, a well-known entomologist, noted that several of the Geometer moths of the Hebrides

had a tendency towards a greyer coloration than the specimens of the same species on the mainland. This alteration he was disposed to put down to a colour variation of a protective significance in relation to the abundant grey gneiss of the islands; it may however be a phenomenon like the other instances that have been just mentioned. It has been suggested that this prevailing melanism of the insects of islands is an effect of the moist climates of islands. On the other hand Mr Wallace noticed a prevalence of white in the colour patterns of some of the butterflies of the Moluccas and New Guinea, a peculiarity more likely perhaps to be due to a possible action of natural selection than the more usual darker colour. The colour in this case would increase the conspicuousness of the insects; but in an island they would run less risks from insect-eating foes and might therefore develop more freely in certain directions than on the mainland, where enemies are more numerous and competition severer.

Precisely the same class of characters distinguish the birds of the Galapagos islands[1]. The genus *Geospize*, a finch peculiar to the islands and consisting of eight species, is of a dull colour to black, the darker hues being the distinctive mark of age. "In old males," says Mr Salvin, "the plumage is almost uniformly black." Such specific names as "*fuliginosa*" and "*nebulosa*" keep the peculiarities of these insular birds in the mind. *Cactornis*, another genus restricted to the islands, is "olivaceo-

[1] On the Avifauna of the Galapagos Archipelago. *Trans. Zool. Soc.* Vol. IX. 1876, p. 447.

fusca" dorsally, and the species is called by Messrs Sclater and Salvin "*pallida*," which is significant. Mr Salvin thinks that the species may have been founded upon birds not adult. These statements however do not only apply to genera which are peculiar to the islands and occur nowhere else; indeed they would have much less interest and significance if they did. One of the two Owls living in the Galapagos, *Asio galapagensis*, is defined by Mr Salvin as "*Asioni brachyoto* similis, sed minor, coloribus *obscurioribus*" &c. The Night Heron of the Galapagos, whether it is a distinct species or merely a variety of the common *Nycticorax violaceus*, is stated to be darker coloured than that species, and further instances of a like nature might be brought forward from Mr Salvin's monograph upon the birds of these islands. Generally speaking his Latin diagnoses of the species abound with such words as "niger," "nigerrimus," "fuscus," "fuliginosus," &c., and completely bear out what has been already said of the coloration of island forms belonging to this as well as of other groups of the animal kingdom.

CHAPTER V.

SOME THEORETICAL CONSIDERATIONS.

The bearing of the facts of distribution upon the places of origin of different groups.

THERE seems to be little doubt that life first originated in the sea, whence it spread to the fresh waters and so to the land. We are not however concerned in the present volume, which only professes to deal with the distribution of terrestrial and a few fresh-water groups, with this problem.

But it is necessary to see how far the existing and past facts of distribution enable the place of origin of a particular terrestrial group to be indicated with probability. No exhaustive survey of the different groups of the animal kingdom will be attempted; but a few facts and suggested explanations will be put forward as examples.

In some cases, of course, palæontology throws a clear light upon the problem. The horse, for instance, came into being in the new world, whence it migrated into the

old world, becoming for a time extinct in its place of origin; it was subsequently reintroduced, apparently by man. An instance of this kind shows how careful we must be to guard against the assumption that that locality where a given group is most abundant is its place of origin. It is perhaps a stronger argument to use the locality of the more ancient forms of the group as being probably the cradle of the race.

Fürbringer has lately urged the antiquity of the genus *Stringops*, the flightless parrot of New Zealand; this coupled with the presence of abundant parrots in the Australian region—many of them being primitive forms that have preserved the ambiens muscle missing in many, the normal arrangement of the carotids and a completely developed clavicle—argues for that region as being the starting-point of the Parrot tribe. Here we are not helped to any great extent by palæontology.

The different regions into which the world is divided possess, as has been pointed out in some detail, in every case a characteristic fauna. That fauna may be or may not be autochthonous; the American Edentates seem to have arisen where we now find them, since no fossil Edentates are known of the American type save in America. Other countries are peopled by immigrants. There can be no doubt that wherever the groups of animals that inhabit oceanic islands arose it was not in those islands; there is clear evidence that they are the more or less modified descendants of animals that found their way across the sea in some way.

The place of origin of the Marsupials.

The Australian region offers difficulties which have perhaps been passed over too lightly. As is well known the continent of Australia and some of the adjacent islands to the northward are mainly characterised by Marsupials. With the exception of the American Opossums all the Marsupials are crowded into this comparatively limited tract of continent and island. In addition to Marsupials there are of course the ubiquitous bats, the Dingo dog and a few rodents, notably the genus *Hydromys*, with more than one species. The Dingo has been regarded as the feral descendant of a domesticated dog introduced by man. M'Coy has however demonstrated the existence of fossil remains of this Carnivore in the Pliocene deposits of Australia, the remains of a period when there were no human inhabitants of the continent. On the other hand the proof has been strengthened by investigations which approach the matter from another side. Nehring denies that the osteological characters of this dog are those of a feral animal, and affirms that it presents all the features of a truly wild race. The indigenous nature of the rodent inhabitants of Australia have not been called in question. The line which separates the Australian from the contiguous Oriental region passes between the islands of Bali and Lombok and between Borneo and Celebes, the last-mentioned island being in each case within the Australian division. Lyell shows in a sketch map of that part of the world that this line (which has been called "Wallace's line") nearly

coincides with a line marking off the range of the Indo-Malayan and Pacific races of mankind. This remarkable series of facts is usually accounted for in the following way. The greater depth of water between the islands mentioned probably indicates a longer time or separation from each other than in those cases where the dividing seas are shallower. Hence it may be assumed that the dominant race of Mammalia in the earlier periods of the earth's history occupied Australia in common with the rest of the world; at this time the deep separation between the two regions, as we now admit them, took place. Australia and the Australian region generally would be well stored with Marsupials. So too would the Oriental region. But in course of time the wave of migration of higher types of mammals, the placental mammals, evolved gradually from the Marsupial, would extend eastward and improve the remaining Marsupials off the face of the world; the deep straits already referred to might be reasonably held to offer an impediment to their further progress eastward in sufficient numbers at any rate to compete successfully with the mammalian possessors of the soil. As a matter of fact the fringes of the Australian region, the islands of Lombok and Celebes, to wit, have received some few of these later migrants; "a baboon, a wild cat and a squirrel" occur in Celebes; while *Macacus cynomolgus* and one or two other placental mammals reside in Lombok. This appears to be a feasible explanation of the facts. But as already hinted there are difficulties in the way of its immediate acceptance. To begin with, remains of the elephant have been

dug up in Australia and in its furthest corner, viz. Queensland. Furthermore, as the colonists know to their cost, the common rabbit when artificially introduced has proved capable of suiting itself with a marvellous degree of success to the conditions found in Australia. In this latter case no competition has had the least effect; and even when hampered by repressive legislation aided by the experiments of bacteriologists the rabbit has done a good deal more than hold its own. It is clear therefore that there is nothing in the "air" of Australia which is in any way fatal to the constitutions of mammals in general. Then why, if the Marsupials have disappeared elsewhere, have they not also disappeared from Australia? The key to the explanation of this difficulty seems to be the assumption that Australia is the native country of that group. It will be remembered that in Australia alone and in some adjacent territories (New Guinea) are there any representatives of the oldest order of Mammalia, the Monotremata. The two existing genera *Echidna* and *Ornithorhynchus* are unknown save in this part of the world.

It is generally accepted that the Monotremata stand at the base of the mammalian series and that the Marsupials stand between them and the higher mammals; the name Metatheria applied by Mr Huxley to the group is an expression of this opinion. The very fact that Marsupials abound in Australia is so far a proof that they originated there; for they would have died out were they not so suited. Over-population or the migratory instinct caused many forms to leave the Australian region and to spread over Europe and America, in which latter country

alone they have persisted. In fact the Marsupials have had the start in a country eminently suited to them and have only been beaten in the struggle for existence in regions subsequently settled in by them and therefore perhaps less fit for their peculiar organisation. There still remains the puzzle why some races of animals have been able to establish themselves in Australia in spite of the existing mammalian fauna, and why others have not. The case of the rabbit shows that we cannot get out of this difficulty by assuming that as much colonisation as there was room for has as a matter of fact taken place. On this view we should regard the presence of the elephant as an unsuccessful attempt at colonisation. The presence of comparatively speaking numerous placental Mammals on the outskirts of the Australian region renders it impossible to have resort to the hypothesis that colonisation was at such rare intervals that only the Dingo and the other few Australian placental Mammals have had time to establish themselves. The only way out of this difficulty which at present suggests itself is to dwell upon the superior energy of the younger races of the Palæarctic region.

It is generally held that the desert of Sahara was an open sea during the Miocene period; and that this checked the immigration or emigration of many purely terrestrial forms, and that it therefore formed a boundary between the Ethiopian and Palæarctic regions. This boundary is not accepted by everyone certainly; but it is by some. Mr Blanford has pointed out[1] that the geological views which

[1] Presidential address to Geological Society 1890.

argued a sea occupying the region of the Sahara during tertiary times are now believed to have been erroneous. Zittel, says Mr Blanford, has shown that there is no reason to think that any part of the Sahara has been sea since the Cretaceous period. This fits in admirably with the present and past distribution of the Marsupials and in quite a convincing way. There is of course abundant evidence that these mammals were common in Europe during the mesozoic epoch, whether they originated there or not. Now if there was then land connection with the African continent why did they not migrate there as well as to Australia and to America? It is of course possible that they did and that they have since become extinct. Madagascar however has to be considered; many writers have pointed out that Madagascar appears to have preserved some of the more ancient mammalian inhabitants of the Ethiopian continent. In any case it seems certain that many of the newer immigrants into Africa never succeeded in getting as far as Madagascar. There are so many analogies of a kind between Madagascar and Australia that the negative fact that Marsupials do not occur there gets a certain importance. If however the severance between Africa and Europe was of earlier date than is commonly held we have a possible explanation of the entire (?) absence of Marsupials from the former continent. Besides, their absence sheds perhaps an oblique light upon my suggestion that the group originated in Australia. The numbers in Europe may have been small, and there was therefore no pressure such as to lead to migration.

Theory of the Polar origin of Life.

The theory of the polar origin of life[1] is, as regards terrestrial and fresh water vertebrates rather seductive. On this theory it is clear that the further away from the north pole the more archaic will be the types of animals met with; and on the contrary the newer groups will have moved away to a less distance. Among the Mammalia this is strikingly exemplified of course by the Marsupials, once existing in great variety in Europe and North America. They are now absolutely extinct in Europe and but feebly represented in North America. The survivors have been pushed in to the furthest corner of the world—the Australian continent, and some of the islands to the north. The bulk of the American Opossums are confined to the Neotropical, i.e. the more southern regions of the American continent, only a single species occurring in North America. This it is presumed upon the theory under discussion is due to the fresh development of types of life in the polar regions which have forced the older and less vigorous forms of life to emigrate; a continued efflux of waves of life spreading out from the place of origin push further away the races which have the start. Everyone is agreed that the Struthious birds are in all probability an ancient race, or perhaps races, for the unity of the group is now-a-days rather called in question. Here again we meet with no northern types at all; North Africa is the northern limit of the birds, and the vast

[1] See Haacke, *Biol. Centralblatt* VI.

majority are in the most southern parts of the globe; New Zealand itself had quite recently a number of species as great as all the existing forms. The northern types of birds, for instance the sandpipers, crows and hosts of others, embrace no forms that can be regarded with any probability as more ancient than the Ostrich tribe. Among Reptiles the *Hatteria*, allied to the triassic *Hyperodapedon*, has been driven quite to the verge of inhabitable country; it has even got beyond New Zealand to a few small islands off the coast. Turning to another group of animals, the Dipnoid fish exemplify what has been said in a forcible way; the three existing genera *Ceratodus*, *Protopterus* and *Lepidosiren* are confined respectively to Australia, South America, and certain parts of Tropical Africa. The fossil remains of Dipnoi are common in the more ancient strata of this country and of North America. Even invertebrates fall in with the theory to some extent. It seems on all grounds reasonable to conclude that the genus *Lumbricus*, and its immediate allies, are the most modern existing forms; these genera are precisely those which are indigenous to the northern hemisphere only, where they form, with a few exceptions, the only earthworms met with. The more archaic Perichætidæ, Acanthodrilidæ and Cryptodrilidæ are characteristic of the southern hemisphere while the Acanthodrilidæ which are very possibly the oldest existing family of the group are particularly antarctic in their range. The fresh water Crayfishes fall in with the other groups cited; and the facts in their distribution and structure agree entirely with those of

the earthworms. Huxley[1] has divided the family into two families the Potamobiidæ and the Parastacidæ; the former are confined to the northern the latter to the southern hemisphere. Of the Potamobiidæ there are but two genera *Astacus* and *Cambarus*. In both of these the pleurobranchs are greatly reduced, indeed in *Cambarus* they are completely absent. As in *Astacus* there are distinct rudiments of the pleurobranchs belonging to several pairs of appendages, in addition to one pair completely developed; the inference appears to be that the extra pleurobranchs have in the course of time been lost. Now in all the Parastacidæ with the exception of *Astacoides* there are four pairs of fully developed pleurobranchs, thus indicating an earlier type. Furthermore the genera of the southern hemisphere, "in which the apices of the podobranchiæ are not separated into a branchial plume and a well developed lamina, present a less differentiated type of branchial structure than that which obtains in *Astacus* and *Cambarus*." Prof. Huxley himself is inclined to postulate the existence of a marine ancestor of world wide distribution which entered the rivers of the northern and the southern hemisphere and diverged in different ways in each hemisphere; but this leaves unexplained why the antarctic genera should have retained more primitive characters than the Crayfishes of the north.

There is another essential if the polar theory of the origin of life is to be accepted. To establish this theory upon a firm basis it will have to be proved that the faunas of the different countries become more and more

[1] *The Crayfish* in International Sci. Series.

divergent the further they are removed from the hypothetical seat of origin. This can be defended by a series of facts. There has been of late a considerable amount of discussion as to the value of the Palæarctic and Nearctic regions of Mr Sclater. It has been proposed to unite them into one common region to which the name Holarctic has been applied by Prof. Newton. This is accepted by Dr Heilprin in his work upon Geographical Distribution. More recently Mr Wallace has defended the retention of the two separate regions. The present object is not to attempt to decide upon the relative values of these two opinions but to emphasise the fact that there has been a discussion, and to point out that there never has been any question as to the distinctness of two such regions as the Neotropical and the Oriental. An ingenious reconciliation has been suggested by Dr Hart Merriam who would institute a Boreal region cut off from Nearctic, and joined to the Palæarctic leaving the rest of the Nearctic alone as a distinct "Southern" region. This proposal brings into prominence the very close resemblance of the circumpolar fauna; indeed out of the 30 genera of mammals in the Boreal region only 10 are peculiar to America. If we were to adopt a slightly different plan and cut off a boreal region or Arctic region as it has been termed from both Palæarctic and Nearctic the almost complete identity of the circumpolar fauna would be clearly demonstrated. Such animals as the Reindeer, the Glutton, the Elk, the Lemming, the Arctic Fox are circumpolar in range. Between the Palæarctic and the Nearctic, after this large slice has been cut off from both, there is not a little

likeness, though there are also differences. Moving further south the differences increase until the resemblances almost entirely vanish.

It is unnecessary to recapitulate the characters of the faunas of the several regions here, as the matter has been already treated of. Broadly speaking it is unquestionably the fact that the differentiation of the different regions gradually increases as we pass southwards from the north pole. We cannot of course hope to reduce to an exact table the progressive differentiation of the fauna along the lines of migration; some have moved more rapidly, others have lagged behind; while structural changes have proceeded more rapidly in some groups of animals than in others. But a survey of the facts tends to prove the general accuracy of the conclusion that the differentiation of faunas proceeds more rapidly the further we get from the pole.

It is obvious that if life originated at the north pole the conditions of climate must have been more favourable than at present. That this was so there is abundant evidence to prove. The existence of a luxurious and at least subtropical fauna in the arctic regions during the Miocene period is justly termed by Mr Wallace "one of the most startling and important of the scientific discoveries of the last 20 years." In remote Greenland we find abundant and well preserved remains of chestnut, walnut, plum, vines and even magnolias. Further north still in lat. 78° and 79° there was in Spitzbergen an almost equally rich fauna, of which one member the swamp cypress (*Taxodium distichum*) is now a dweller in the southern

United States. Water lilies, pond weeds, and an iris, flourished at the same time in the same place. This however does not indicate by any means the limits of life towards the pole; in Grinnel land distant only $8\frac{1}{4}$ degrees from the pole itself there was a flora composed of poplars, elms, hazels and the swamp cypress again. This warm period preceded the glacial period, which of course put an end to the flora and fauna or else drove it southwards. It is the opinion of many that the glacial period was not an isolated phenomenon but the last in a series of many glacial periods. If this were so and if they recurred with tolerable frequency as is again the opinion of many, all question of a polar origin of life would be out of the range of possibility. This view of the matter has been mainly based upon two series of facts. In the first place it is argued that these glacial periods have been due to the variations in the obliquity of the earth's orbit, which alternates from a more to a less pronounced ellipse. This would bring about in conjunction with the rotation of the earth on its own axis long cold winters and short hot summers as well as the reversed condition. The former would it is thought account for glacial periods. That these have taken place in the recurrent fashion demanded by this astronomical cause is attempted to be proved by the existence of erratic boulders imbedded in the sedimentary rocks belonging to past epochs. Mr Wallace however holds that this cause is not of itself sufficient to cause excessive glaciation; it is necessary also to have continuous land surfaces and high mountains to retain the

snow and ice and to prevent the influx of warm currents from more southern latitudes. The undoubted boulders he regards not as evidence of exceptional glaciation, but as evidence of high mountains with glaciers which carry down these boulders; this is not inconsistent with a warm, even tropical, temperature at their base. It is not until we reach the Permian period that Mr Wallace thinks that a severe glaciation occurred. In the west of England there are beds of ice-borne rocks which must have been carried for a distance of fifty miles and this together with the poverty of the fauna and flora are indications of a glacial period. If however we consider as Prof. Huxley did in 1870 that even the highest group of animals the mammalia probably originated well within the Palæozoic period, since it has taken from the commencement of the Eocene to almost to-day for so small a modification as the reduction of the horse's foot from the five-toed to the one-toed condition, even this remotely distant glacial epoch will be sufficiently near to exclude all possibility of the polar origin of mammalian, let alone all other vertebrate and invertebrate life. We may take it therefore that the polar regions enjoyed a mild or even a warm climate throughout the tertiary and secondary epochs, but it has been pointed out that in Carboniferous and Silurian times the temperature judging from the fauna and flora was of the same kind; this however is of no importance from the present point of view if the Permian glacial period really took place as the evidence seems to assert.

INDEX.

CAMBRIDGE: PRINTED BY J. AND C. F. CLAY, AT THE UNIVERSITY PRESS.

Pitt Press Mathematical Series.

Arithmetic for Schools. By C. SMITH, M.A., Master of Sidney Sussex College, Cambridge. With or without Answers. Second Edition. 3*s.* 6*d.* Or in two Parts. 2*s.* each.

Key to Smith's Arithmetic. By G. HALE, M.A. 7*s.* 6*d.*

Elementary Algebra. By W. W. ROUSE BALL, M.A., Fellow and Tutor of Trinity College, Cambridge. 4*s.* 6*d.*

Euclid's Elements of Geometry. By H. M. TAYLOR, M.A., Fellow and formerly Tutor of Trinity College, Cambridge.

BOOKS I.—VI. 4*s.* BOOKS I.—IV. 3*s.* BOOKS I. and II. 1*s.* 6*d.*
BOOKS III. and IV. 1*s.* 6*d.* BOOKS V. and VI. 1*s.* 6*d.*
BOOKS XI. and XII. [*In the Press.*

Solutions to the Exercises in Taylor's Euclid. BOOKS I.—IV. By W. W. TAYLOR, M.A. 6*s.*

Elements of Statics and Dynamics. By S. L. LONEY, M.A., late Fellow of Sidney Sussex College, Cambridge. 7*s.* 6*d.*

Or in Two Parts.
PART I. ELEMENTS OF STATICS. 4*s.* 6*d.*
PART II. ELEMENTS OF DYNAMICS. 3*s.* 6*d.*

Solutions to the Examples in the Elements of Statics AND DYNAMICS. By the same Author. 7*s.* 6*d.*

Mechanics and Hydrostatics for Beginners. By the same Author. 4*s.* 6*d.*

An Elementary Treatise on Plane Trigonometry. By E. W. HOBSON, Sc.D., Fellow and Tutor of Christ's College, Cambridge, and C. M. JESSOP, M.A., Fellow of Clare College, Cambridge. 4*s.* 6*d.*

London: C. J. CLAY AND SONS,
CAMBRIDGE UNIVERSITY PRESS WAREHOUSE,
AVE MARIA LANE.
Glasgow: 263, ARGYLE STREET.

SOME PUBLICATIONS OF

The Cambridge University Press.

Chemistry, Treatise on the General Principles of, by M. M. PATTISON MUIR, M.A., Fellow and Prælector in Chemistry of Gonville and Caius College. Second Edition. Demy 8vo. 15*s.*

Chemistry, Elementary. By M. M. PATTISON MUIR, M.A., and CHARLES SLATER, M.A., M.B. Crown 8vo. 4*s.* 6*d.*

Chemistry, Practical. A Course of Laboratory Work. By M. M. PATTISON MUIR, M.A., and D. J. CARNEGIE, M.A. 3*s.*

Qualitative Analysis, Notes on, Concise and Explanatory. By H. J. H. FENTON, M.A., F.I.C., Demonstrator of Chemistry in the University of Cambridge. Cr. 4to. *New Edition.* 6*s.*

Catalogue of Type Fossils in the Woodwardian Museum, Cambridge. By H. WOODS, B.A., F.G.S., of St John's College, with Preface by T. M'KENNY HUGHES, Woodwardian Professor of Geology. Demy 8vo. 7*s.* 6*d.*

Fossils and Palæontological Affinities of the Neocomian Deposits of Upware and Brickhill with Plates, being the Sedgwick Prize Essay for the year 1879. By W. KEEPING, M.A., F.G.S. Demy 8vo. 10*s.* 6*d.*

The Jurassic Rocks of Cambridge, being the Sedgwick Prize Essay for the year 1886, by the late T. ROBERTS, M.A. Demy 8vo. 3*s.* 6*d.*

Bala Volcanic Series of Caernarvonshire and Associated Rocks, being the Sedgwick Prize Essay for 1888, by A. HARKER, M.A., F.R.S., Fellow of St John's College. Demy 8vo. 7*s.* 6*d.*

Fossil Plants as Tests of Climate, being the Sedgwick Prize Essay for 1892. By A. C. SEWARD, M.A., St John's College. Demy 8vo. 5*s.*

London: C. J. CLAY AND SONS,
CAMBRIDGE UNIVERSITY PRESS WAREHOUSE,
AVE MARIA LANE.
Glasgow: 263, ARGYLE STREET.

Cambridge Natural Science Manuals.

BIOLOGICAL SERIES.

GENERAL EDITOR, A. E. SHIPLEY, M.A.

Elementary Palæontology—Invertebrate	H. WOODS, M.A., F.G.S.	6*s.*
Elements of Botany	F. DARWIN, M.A., F.R.S.	4*s.* 6*d.*
Practical Physiology of Plants	F. DARWIN, & E. H. ACTON, M.A.	4*s.* 6*d.*
Practical Morbid Anatomy	H. D. ROLLESTON, M.D., F.R.C.P. & A. A. KANTHACK, M.D., M.R.C.P.	6*s.*
Zoogeography	F. E. BEDDARD, M.A., F.R.S.	6*s.*
Flowering-Plants and Ferns	J. C. WILLIS, M.A. In two vols.	10*s.* 6*d.*
The Vertebrate Skeleton	S. H. REYNOLDS, M.A.	12*s.* 6*d.*
Fossil Plants	A. C. SEWARD, M.A., F.G.S. 2 vols. Vol. I.	12*s.*
Outlines of Vertebrate Palæontology ...	A. S. WOODWARD.	14*s.*
The Soluble Ferments and Fermentation	J. REYNOLDS GREEN, Sc.D., F.R.S.	12*s.*
Zoology	E. W. MACBRIDE, M.A. and A. E. SHIPLEY, M.A.	10*s.* 6*d. net.*
Lectures on History of Physiology ...	Sir MICHAEL FOSTER, K.C.B., M.D.	9*s.*
Grasses	H. MARSHALL WARD, Sc.D.	6*s.*

PHYSICAL SERIES.

GENERAL EDITOR, R. T. GLAZEBROOK, M.A., F.R.S.

Heat and Light	R. T. GLAZEBROOK, M.A., F.R.S.	5*s.*
,, ,, in two separate parts	,, ,,	*each* 3*s.*
Mechanics and Hydrostatics	R. T. GLAZEBROOK, M.A., F.R.S.	8*s.* 6*d.*
,, ,, in three separate parts		
Part I. **Dynamics ... ...**	,, ,,	4*s.*
,, II. **Statics ... ...**	,, ,,	3*s.*
,, III. **Hydrostatics ... ...**	,, ,,	3*s.*
Solution and Electrolysis	W. C. D. WHETHAM, M.A. [Second Edition, *in the Press.*	
Electricity and Magnetism	R. T. GLAZEBROOK, M.A., F.R.S. [*In Preparation.*	

GEOLOGICAL SERIES.

Petrology for Students	A. HARKER, M.A., F.G.S.	7*s.* 6*d.*
Handbook to the Geology of Cambs. ...	F. R. C. REED, M.A.	7*s.* 6*d.*
The Principles of Stratigraphical Geology	J. E. MARR, M.A.	6*s.*
Crystallography	Prof. W. J. LEWIS, M.A.	14*s. net.*

Laboratory Note-Books of Elementary Physics	L. R. WILBERFORCE, M.A., and T. C. FITZPATRICK, M.A.	
I. **Mechanics and Hydrostatics.**	II. **Heat and Optics.**	
III. **Electricity and Magnetism.**		*each* 1*s.*

Other volumes are in preparation and will be announced shortly.

BIOLOGICAL SERIES.

Zoology. An Elementary Text-book. By A. E. SHIPLEY, M.A., and E. W. MACBRIDE, M.A. (Cantab.), D.Sc. (Lond.), Professor of Zoology in McGill University, Montreal. Demy 8vo., with numerous Illustrations. 10*s.* 6*d. net.*

The book in the main deals with the normal structure of the adult forms of recent animals. Wherever possible this structure has been exhibited as the outcome of function and habit.

School World. As a thoroughly trustworthy and instructive text-book for serious students, the work can be strongly recommended. Its value is enhanced by the large number of excellent illustrations, many of which are delightfully fresh.

Grasses. A Handbook for use in the Field and Laboratory. By H. MARSHALL WARD, Sc.D., F.R.S., Fellow of Sidney Sussex College, Professor of Botany in the University of Cambridge. Crown 8vo. 6*s.*

The Field. The work is essentially suited to the requirements of those desirous of studying the grasses commonly grown in this country, and it can fairly be said that it furnishes an amount of information seldom obtained in more pretentious volumes.

A Manual and Dictionary of the Flowering Plants and Ferns. Morphology, Natural History and Classification. Alphabetically arranged. By J. C. WILLIS, M.A., Gonville and Caius College. In Two Volumes. Crown 8vo. With Illustrations. 10*s.* 6*d.*

Bookman. One of the most useful books existing for students of botany.

Elements of Botany. By F. DARWIN, M.A., F.R.S. Third Edition. Crown 8vo. With numerous Illustrations. 4*s.* 6*d.*

Journal of Education. A noteworthy addition to our botanical literature.

Practical Physiology of Plants. By F. DARWIN, M.A., F.R.S., Fellow of Christ's College, Cambridge, and Reader in Botany in the University, and E. H. ACTON, M.A., late Fellow and Lecturer of St John's College, Cambridge. With Illustrations. Third Edition. Crown 8vo. 4*s.* 6*d.*

Nature. The authors are much to be congratulated on their work, which fills a serious gap in the botanical literature of this country.

Outlines of Vertebrate Palaeontology for the use of Students of Zoology. By A. S. WOODWARD, Assistant Keeper in the Department of Geology in the British Museum. Demy 8vo. 14*s.*

Athenæum. The author is to be congratulated on having produced a work of exceptional value, dealing with a difficult subject in a thoroughly sound manner.

BIOLOGICAL SERIES.

Lectures on the History of Physiology during the sixteenth, seventeenth and eighteenth centuries. By Sir M. Foster, K.C.B., M.P., M.D., Sec. R.S., Professor of Physiology in the University of Cambridge. Demy 8vo. With Frontispiece. Price 9*s.*

The author has chosen for treatment and developed certain themes connected with the history of physiology, and has woven into the story of ideas the stories of the personal lives of the men who gave birth to those ideas.

Nature. There is no more fascinating chapter in the history of science than that which deals with physiology, but a concise and at the same time compendious account of the early history of the subject has never before been presented to the English reader. Physiologists therefore owe a debt of gratitude to Sir Michael Foster for supplying a want which was widely felt.....no higher praise can be given to the book than to say that it is worthy of the reputation of its author.

The Soluble Ferments and Fermentation. By J. Reynolds Green, Sc.D., F.R.S., Professor of Botany to the Pharmaceutical Society of Great Britain. Demy 8vo. Second Edition. 12*s.*

Nature. It is not necessary to recommend the perusal of the book to all interested in the subject since it is indispensable to them, and we will merely conclude by congratulating the Cambridge University Press on having added to their admirable series of Natural Science Manuals an eminently successful work on so important and difficult a theme, and the author on having written a treatise cleverly conceived, industriously and ably worked out, and on the whole, well written.

PHYSICAL SERIES.

Mechanics and Hydrostatics. An Elementary Text-book, Theoretical and Practical, for Colleges and Schools. By R. T. Glazebrook, M.A., F.R.S., Fellow of Trinity College, Cambridge, Director of the National Physical Laboratory. With Illustrations. Crown 8vo. 8*s.* 6*d.*

Also in separate parts. Part I. **Dynamics.** 4*s.* Part II. **Statics.** 3*s.* Part. III. **Hydrostatics.** 3*s.*

Knowledge. We cordially recommend Mr Glazebrook's volumes to the notice of teachers.

Practical Teacher. We heartily recommend these books to the notice of all science teachers, and especially to the masters of Organised Science Schools, which will soon have to face the question of simple practical work in physics, for which these books will constitute an admirable introduction if not a complete *vade mecum.*

Heat and Light. An Elementary Text-book, Theoretical and Practical, for Colleges and Schools. By R. T. Glazebrook, M.A., F.R.S. Crown 8vo. 5*s.* The two parts are also published separately. **Heat.** 3*s.* **Light.** 3*s.*

Journal of Education. We have no hesitation in recommending this book to the notice of teachers.

Practical Photographer. Mr Glazebrook's text-book on "Light" cannot be too highly recommended.

GEOLOGICAL SERIES.

Handbook to the Geology of Cambridgeshire. For the use of Students. By F. R. Cowper Reed, M.A., F.G.S., Assistant to the Woodwardian Professor of Geology. With Illustrations. Crown 8vo. *7s. 6d.*

Nature. The geology of Cambridgeshire possesses a special interest for many students....There is much in Cambridgeshire geology to arouse interest when once an enthusiasm for the science has been kindled, and there was need of a concise hand-book which should clearly describe and explain the leading facts that have been made known....The present work is a model of what a county geology should be.

The Principles of Stratigraphical Geology. By J. E. Marr, M.A., Fellow of St John's College, Cambridge. Crown 8vo. *6s.*

Nature. The work will prove exceedingly useful to the advanced student; it is full of hints and references, gathered during the author's long experience as a teacher and observer, and which will be valuable to all who seek to interpret the history of our stratified formations.

University Extension Journal. Mr Marr is an old University Extension lecturer, and his book, which is distinguished by the lucidity and thoroughness which characterise all his work, cannot fail to be of service to University Extension students who are making a serious study of Geology.

Crystallography. By W. J. Lewis, M.A., Professor of Mineralogy in the University of Cambridge. Demy 8vo. *14s. net.*

Athenæum. Prof. Lewis has written a valuable work....The present work deserves to be welcomed not only as a greatly needed help to advanced students of mineralogy, but as a sign that the study itself maintains an honoured place in the University Science Course.

Nature. The author and the University Press may be congratulated on the completion of a treatise worthy of the subject and of the University.

Petrology for Students. An Introduction to the Study of Rocks under the Microscope. By A. Harker, M.A., F.G.S., Fellow of St John's College, and Demonstrator in Geology (Petrology) in the University of Cambridge. Crown 8vo. Second Edition, Revised. *7s. 6d.*

Nature. No better introduction to the study of petrology could be desired than is afforded by Mr Harker's volume.

London: C. J. CLAY and SONS,
CAMBRIDGE UNIVERSITY PRESS WAREHOUSE,
AVE MARIA LANE.

AND

H. K. LEWIS, 136, GOWER STREET, W.C.
Medical Publisher and Bookseller.

LIBRARY
SEP 7 - 1993
UNIVERSITY OF TORONTO

QL
101
B43
1895
c.1
Zool

Beddard, Frank E.
A text-book of
Zoogeography

QL 101 B43 1895 c.1.

Author Beddard, Frank E

Title A Text-Book of Z

DATE	NAME OF BORR

DEPARTMENT LIBRARY
ZOOLOGY
University of Toronto

UTL AT DOWNSVIEW
D RANGE BAY SHLF POS ITEM C
39 10 03 02 02 007 1