

climate and vegetation, are nevertheless inhabited by very different kinds of animals. Thus the forests of Equatorial Africa teem with elephants, apes, leopards, guinea-fowls, and touracos; while the similar arboreal regions of South America shew the tapir, the prehensile-tailed monkey, the jaguar, the curassow, and the toucan. Certain parts of Australia are remarkably like certain parts of Africa; but while the latter possess the mighty lion, the graceful zebra, and the tall giraffe, the former can produce nothing larger or more formidable than the kangaroo, the wombat, or the phalanger. Many large and important groups of animals are found restricted in their range in some way that cannot be accounted for merely by climate or soil. Antelopes are found only in Africa and Asia; sloths only in South America; true lemurs are limited to Madagascar; birds-of-paradise to New Guinea. Acknowledging the cogency of this objection to our explanation of the facts, and now at the end of our resources, we should require to look beyond ourselves and our own range of knowledge for an answer.

Responsive to our look of inquiry up starts Mr Alfred Russel Wallace, of *Malay Archipelago* fame, and gives us, in two large and handsome volumes, a most learned and fascinating account of the distribution of animals throughout the world.* The reader need not fear that this work is too scientifically dry for any but the professed naturalist. The last part, it is true, consisting of a systematic sketch of the chief families of land-animals in their geographical relations, may well be left to the professional; but there is abundance of interesting reading in the other three sections of the book. Part first, in particular, treating of the general phenomena of distribution, we recommend every one to peruse. Here we can do little more than indicate the theory of zoological distribution as set forth by Mr Wallace, with a very few cullings from his interesting examples and details.

Those who have studied the subject scientifically have one factor to use in their answer to the question with which we started, not at the disposal of the ordinary observer. They deal with the problem of distribution not only with reference to the present, but with all the light that can be shed upon it from the past. Historical geology gives most valuable aid in determining the probable explanation of the distribution of living creatures. By attention to the various geological strata we can reproduce the physical geography of the earth in the remotest times. Quoting from Geikie's *Manual of Historical Geology*, issued by the publishers of this *Journal*, we find that 'vast changes in the relative position of land and sea there have been; myriads of species of plants and animals have successively appeared, and then vanished for ever; the same climatic conditions have not always persisted in the same latitude, but ever and anon warm conditions of temperature have given place to cold, and *vice versa*.' In particular, palæontology or the science of fossil animals, a branch of historical geology, is most useful, by giving the clearest indications of the former states of distribution.

With due regard to materials both past and

THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

EVERY one whose life has not been wholly spent within city walls must have observed that animal life varies greatly in the districts with which he is familiar. Different species are not found uniformly scattered over the surface of the country, but in different localities with similar features. Every country boy knows 'Postlethwaite Oaks' is the only place for miles round where he has a chance of capturing a Purple Emperor butterfly, or that if he visits 'Harkend Brook' at the proper season the chances are that he finds two or three kingfishers' nests. If we quit our own confined districts and travel into other counties or countries, new kinds of animals appear; and the more extensive the range of our observation the greater the difference in the forms of animated life. If we should be sufficiently curious or interested to ask ourselves 'Why should this be so?' we should probably feel satisfied with the obvious, though somewhat vague answer, that 'differences of climate and vegetation demand animal life in harmony.' In all likelihood we should not go a step farther back and ask ourselves: 'Have these peculiar species existed in these peculiar localities throughout all time?' A modern naturalist, however, could easily shew the insufficiency of this answer. He would point out that various regions of the world, closely resembling each other in both

* *The Geographical Distribution of Animals*. By Alfred Russel Wallace, author of *The Malay Archipelago*, &c. London: Macmillan & Co. 1876.

present, Mr Wallace's answer to the question whether the same species have existed in the same localities throughout all time, is, in the mass, as follows. All the higher forms at least of animal life appear to have had their origin in one and the same region of the globe, and have thence migrated to the other regions, which seem all at one time or another to have been in connection with the original seat of animal life. Different obstacles have determined the migration of one species in one direction and another in another, and the various upheavals and depressions of land-surfaces which have taken place, account to a great extent for the phenomena of zoological distribution. The migrated animals having reached other countries, became gradually modified to suit their new conditions of life, and so fresh varieties were introduced. The greatest dissimilarity to the fauna of the original region will be found in those parts of the world from which it has been separated during the longest period.

To shew that there would be no difficulty in whole continents being thus stocked by immigration, Mr Wallace reminds us of the wonderful power of multiplication among animals. A bird which produces ten pair of young during its life and lives for five years, will increase to one hundred million in forty years. Many fishes and insects are capable of multiplying many thousand-fold each year, so that in a few years they would number billions and trillions. Even large animals which produce only one at a birth may, in less than forty years, increase from a single pair to ten million. These calculations are of course on the supposition of abundant sustenance and absence of enemies.

Some animals seem able to range over whole continents, stopped by almost no physical obstacle. The elephant, for instance, can climb steep mountains, cross deep rivers, and force its way through dense jungle. There would appear, therefore, no limit to its power of migrating overland from any one spot save the necessity of food and a suitable climate. Other groups of animals are much more limited. Apes, lemurs, and many monkeys are strictly adapted to an arboreal life. The camel, giraffe, and zebra, on the other hand, cannot exist in a forest country. We thus begin to see how the animals would migrate from their original region in different directions. A wide desert on one side would favour the emigration of camels and zebras and stop that of monkeys. A tract of marshy ground would prove an effectual barrier to animals adapted to a dry and hilly region; and so on. An arm of the sea would be an insuperable obstacle to most animals, yet many beasts can swim great distances, and are known to have extended their range in this manner. The jaguar, bear, bison, and even the pig, are good swimmers. Sir Charles Lyell tells us of some pigs only six months old that, during the floods in Scotland in 1829, were carried out to sea, swam five miles, and got on shore again. Ice-floes and driftwood would, besides, assist migration over expanses of water. Spix and Martius, for instance, declare that they frequently saw monkeys, tiger-cats, and squirrels carried down the Amazon on pieces of floating vegetation.

It seems at first sight a strange fact that many birds are as strictly limited by barriers as the mammalia. Only birds of very powerful wing

can cross any great width of sea, and even these seldom do so unless compelled by the exigencies of food and climate. Flocks of birds are sometimes swept out to sea by violent storms, and though often destroyed, are sometimes carried to lands hundreds of miles distant. Birds whose habits keep them sheltered by forests are not exposed to such a fate, and therefore are confined more strictly in their own districts. The annual migration of many birds to a more genial climate 'may be looked upon,' says Mr Wallace, 'as an exaggeration of a habit, common to all locomotive animals, of moving about in search of food.' In the tropics, birds move northward with the summer, feeding on young flower-buds, larvæ, and ripening fruits; while the birds in Polar regions are driven southward in winter by hunger, cold, and darkness. Migrations such as that of the nightingale in April, from Africa and Asia northward, probably date from the period when there was continuous land along the route passed over. Geologists can tell us that in comparatively recent times Britain was connected with the continent, and Gibraltar, Sicily, and Malta with Africa. 'The submersion of these two tracts of land (which were perhaps of considerable extent) would be a slow process, and from year to year the change might be hardly perceptible. It is easy to see how the migration that had once taken place over continuous land would be kept up, first over lagoons and marshes, then over a narrow channel, and subsequently over a considerable sea, no one generation of birds ever perceiving any difference in the route.' The sea-passage is, however, dangerous to many birds. Great numbers of quails when migrating are drowned in unfavourable weather, and probably the migration would cease were the sea to become a little wider. Many birds, on the contrary, from the introduction of favourable conditions by man and other causes, have greatly increased their area of migration.

Causes proceeding from animals themselves, affect zoological distribution. A herd of goats introduced into St Helena destroyed a whole flora of forest trees, and with them the insects, the mollusca, and perhaps birds dependent on them. Swine exterminated the dodo in Mauritius. Neither horses nor cattle run wild in Paraguay, (though they are abundant both to the north and south of it), on account of a fly which destroys the new-born young of these animals. Pigeons are thin where monkeys abound. The relation of one form of life to another is well illustrated by Mr Darwin's case of the cats and clover (*Origin of Species*, 6th ed. p. 57). Red clover is fertilised in this country by humble-bees only. Field-mice keep down humble-bees by destroying their combs and nests. Field-mice in their turn are kept down by cats and owls; and so upon these carnivorous animals depends the existence of red clover!

The naturalist, in confronting the question of animal distribution, soon feels his need of 'some system of geographical arrangement which shall serve the double purpose of affording a convenient subdivision of his subject, and at the same time of giving expression to the main results at which he has arrived.' Hence the discussion about 'zoological regions.' For a number of reasons, Mr Wallace thinks that the earth is naturally divided into six great regions, marked

by certain differences of animal life. Of course these regions, which correspond pretty closely to the great geographical divisions of the globe, are not separated from each other by hard-and-fast lines, but by zones of neutral territory, in which some of the species characteristic of each region are intermingled. They were chosen mainly with regard to the mammals, but are found to suit other forms of animal life. Of these six regions an excellent map is given at the beginning of the work, and each has also a separate map to itself. His first region he calls the *Palæarctic* region (that is, northern region of the Old World). It consists of Europe, Asia with the exception of India and the Indo-Chinese peninsula, and Africa north of the Tropic of Cancer. The second or *Ethiopian* region embraces the rest of Africa, Madagascar, and the Mascarene Islands. The third or *Oriental* region is of comparatively small extent, consisting of India, the Indo-Chinese peninsula, and the western Malay Islands. The *Australian* region comprises Australia, New Zealand, the tropical islands of the Pacific, and the Malay Archipelago from Celebes on the west to the Solomon Islands on the east. The *Neotropical* region (tropics of the New World) consists of South America and Central America to the Tropic of Cancer. The sixth and last district, the *Nearctic* (northern region of the New World), is North America and Greenland. Mr Wallace finds the original dwelling-place of the higher forms of animal organism in the *Palæarctic* region. It is to Europe and Asia that he bids us look as the starting-point from which animal migration has been carried on throughout the ages. From geological investigations we find that the present fauna of Europe is almost wholly new. 'For a long succession of ages, various forms of monkeys, hyenas, lions, horses, hipparions, tapirs, rhinoceroses, hippopotami, elephants, mastodons, deer, and antelopes, together with almost all the forms now living, produced a rich and varied fauna such as we now see only in the open country of tropical Africa.' There is no ground for believing that the climate was more favourable to these animals then than now, so that they were true indigenes, whose banishment or extinction is a strange phenomenon, most probably due to the combined action of the glacial period and the subsidence of large tracts of land once connecting Europe with Africa. It is at least interesting to observe here a coincidence which Mr Wallace himself has probably not noticed. In this work we find that an apostle of development and natural selection has come to a conclusion respecting the original seat of animal life in perfect harmony with the Mosaic account of the creation of living creatures in the Asiatic garden of Eden.

Mr Wallace thinks it almost beyond a doubt that each of the other great regions into which he has partitioned the globe was at one time in connection with the *Palæarctic*. For the main stream of migration must have gone overland. Only minor features of distribution are accounted for by the help given by floating vegetation, icebergs, &c. A comparison of the fossils of the Old and New Worlds points to the conclusion that most at least of the different higher kinds of animals inhabited Europe and Asia *before* they inhabited America. Australia, whose connection with the *Palæarctic* region must have been in the remotest ages, should on this theory be found to have the most

special fauna. So eminently in this case do facts support the theory, that it has been proposed to divide the globe into two zoological regions, of which Australia and the adjacent islands should form one! The line of emigration from Europe to Africa was probably always a dry and desert track, suitable to antelopes and felines, but almost impassable by animals adapted to a fertile and well-wooded country. Now the absence of bears and deer from the fauna of tropical Africa has always been a puzzle; but when it is remembered that neither of these animals could make way over a desert region, and if we accept Mr Wallace's theory, the problem is solved. There are districts in tropical Africa which are apparently well suited for either bears or deer; and if the various species of animals were but newly created where now found, the absence from Africa of the two kinds named above, would be unaccountable. Now it is folly to leave a thing as not to be explained when a reasonable cause can be found, and on the hypothesis given above we have a simple and complete explanation of the zoological distribution of Africa.

The manner in which species have been modified after arriving in a new district is often exceedingly interesting. A remarkable feature among the beetles of Madeira is the unusual number of wingless species, many usually having wings in Europe being without them in Madeira. On the other hand, the species in Madeira which have wings often have them larger than the corresponding species in Europe. These two facts were connected by Mr Darwin, who suggested that flying insects were more apt to be carried out to sea and destroyed than those that do not fly; so that the most frequent fliers would be constantly diminishing, while the more sluggish individuals, who could not or would not fly, would remain to perpetuate the race; and so in time would result the entire loss of wings by insects to whom they were *not* a necessity. Those insects to whom flight is a necessity would have to battle with storms, and the strongest winged would survive and in time get stronger, while the weak-winged individuals would become extinct.

The dodo is another highly interesting example of adaptation to new conditions of life. Its remains are found in Madagascar and the Mascarene Islands, which at one time must have been joined to the African continent. While still joined to the mainland the dodo reached that region, and at a period prior to the arrival of the carnivora. When, therefore, the region came to be surrounded by water, the dodo having no enemies, did not require wings, and became the huge unwieldy flightless bird whose picture we are familiar with. And yet it belongs to the family of pigeons! A confirmation of this view is that gigantic land-tortoises, larger than any now living elsewhere on the globe, were developed in the same islands. A striking confirmation of Mr Darwin's theory, that the gay colours of flowers have mostly or perhaps wholly been introduced to attract insects which aid in their fertilisation, is the paucity of insects, and at the same time of brilliant flowers, in New Zealand and the Galapagos Islands. But such curious details are endless.

The principle of distribution used by Mr Wallace should, if sound, apply to the flora as well as to the fauna of the globe. Nor are there

wanting indications that this may be satisfactorily done, and we look forward with some assurance to an affirmative answer to the question: 'Is the distribution of plants mainly dependent on the past depressions and upheavals of the earth's surface?'

In conclusion, it may be interesting to notice a few of the most widely-spread animals, as gathered from the fourth part of Mr Wallace's book. The family of rats is found in nearly every quarter, and bats in every quarter, of the globe. None of the larger land-animals are so widely distributed. Among birds, the most extensively found are swallows, kingfishers, pigeons, falcons, owls, rails, snipes, plovers, herons, ducks, gulls, petrels, pelicans, and grebes. All of these are found in each of Mr Wallace's regions, and also in each of their subdivisions. Crows and swifts are universal except in New Zealand, and cuckoos except in the north of North America. Among reptiles, snakes may be mentioned as nearly cosmopolites, being found everywhere except in New Zealand and the tropical islands of the Pacific; while geckoes or wall-lizards are absent only from the north of North America. Toads are dispersed over the whole world except Madagascar, New Zealand, and the Pacific Islands; and frogs have the same area with the addition of Madagascar.

We have by no means exhausted the interest of Mr Wallace's volumes, but we must stop somewhere, and now refer the reader, with renewed commendations, to the work itself.