

MR. ALFRED R. WALLACE ON THE FAUNA AND
FLORA OF MADAGASCAR IN CONNECTION
WITH ITS PHYSICAL GEOGRAPHY.

DURING the last four or five years a great advance has been made towards a better understanding of the numerous interesting problems involved in the conditions of animal and vegetable life in Madagascar, and of the light which these throw upon the early geographical and geological history of the island. For this we are indebted, in the first place, to the researches and the collections previously made by naturalists, such as Grandidier, Vinson, Pollen and Van Dam, Meller, Crossley, and others (including members of the London and Friends' Missions), who have supplied the materials for a fuller knowledge both of the Fauna and the Flora of the country. But to the eminent naturalist and writer whose name heads this article our thanks are chiefly due for having with masterly skill woven this raw material into a connected whole, and for shewing us the complete interdependence of organic and inorganic nature, as illustrated in the great African island as well as in the other island groups of the world.

It is well known to scientific students that the animal life of Madagascar has for many years past been regarded as of special interest as well as difficulty. Among other obscure points are (or rather, we should now say, *were*): its connection, on the one hand, with the African Fauna, and yet the total absence in the island of the most prominent and important of the mammals now found in the continent; and, on the other hand, the relationships of others of its living creatures with Asiatic, Malayan, Australian, and even Pacific and West Indian forms; also the abundance of one quadrumanous order, the Lemuridæ, only found elsewhere in a few animals of distant relationship, together with the highly specialized character of some of these (as the Aye-aye), as well as of some genera of other mammalian orders, and also of many of the birds. These and other peculiarities have caused the Malagasy group of islands to be regarded as one of the most remarkable zoological districts on the globe, and have engaged the attention of the most eminent naturalists,—as Sonnerat, Bois-Duval, St. Hilaire, Sclater, Bates, Hartlaub, Grandidier, Milne-Edwards, and last but not least, Wallace.

To account for some of these zoological relations with distant countries the notion of a submerged continent in the Indian Ocean, connecting Africa with India, was started by Dr. Sclater several years ago, and was called by him, half in jest, "Lemuria," as the supposed place of origin of the Lemurine group of animals. This idea was accepted by many naturalists, botanists, and geologists as almost an established fact, and indeed still keeps its place, "an example of the persistence of a merely provisional hypothesis after it has been proved to be untenable." Mr. Wallace himself also, only four years ago, in his valuable work on *The Geographical Distribution of Animals*, seemed to give a partial assent to a modified form of the theory, speaking of "a lost continent, or continental island," etc. But in his recently published book on *Island Life : or the Phenomena and Causes of Insular Floras and Faunas*, etc., he proves convincingly not only that there never was such a continent connecting India with Africa (at least in the Tertiary or Secondary geological periods), there being no facts to support the theory, but also, that had there been such a land connection, the anomalies in the distribution of animal life which the presence of this hypothetical continent is supposed to account for could have had no existence. As Mr. Wallace says: "So far from explaining the anomalous facts, the alleged continental extensions, had they existed, would have left no such facts to be explained."

The two works above mentioned will, I venture to predict, be long considered as standard books on the subjects of which they treat, and the chapters in which the animal and vegetable life of the Madagascar group are discussed should be read by all who wish to gain a clear idea of the physical history of the great island and its attendant satellites. *The Geographical Distribution of Animals* is, in the words of one review (*Nature*), "the first sound treatise on zoological geography," and it is one of the first systematic attempts to shew how wonderfully the animal and vegetable life of the earth elucidates the changes which have passed over the earth's surface; so that while geology reveals the presence of extinct and buried creations, these, in their turn, reveal the physical changes to which the earth's crust has been unceasingly subject ever since life was originated on our globe. The earth is divided by Mr. Wallace into six clearly marked zoological "regions," which he names respectively the Palæarctic, Ethiopian, Oriental, and Australian, in the Old World; and the Nearctic and Neotropical, in the New World. Each of these is again divided into six "sub-regions," Madagascar and the neighbouring

islands forming one division of the Ethiopian region, which includes all Africa, except the portion north of the Sahara, which belongs, zoologically, to the same region as Europe and the greater part of Asia (the Palæarctic).

The peculiarities and origin of the Madagascar Fauna are considered in chapter xi. of part iii., vol. i., and, put in as brief and concise a form as possible, are as follows. The mammalian Fauna is tolerably rich in genera and species, but these belong to a very limited number of families and orders, the Lemuridæ and Insectivora (Centetidæ, *trandraka*, *sora*, etc.) being especially abundant, while there are some peculiar Carnivora of small size (Viverridæ, *fosa*, *vontstra*, etc.); but it is entirely wanting in other Quadrumana, in large Carnivora, in (indigenous) Ungulata, and in the thick-skinned animals, all of which are now so abundant on the African continent. Three families, twenty genera, and sixty-six species, are peculiar to the island, and indicate a very ancient connection with South Africa *before* the apes, monkeys, ungulates, and large felines entered it from the north, but while the lemurs and peculiar Insectivora and Viverridæ were still inhabitants of Africa and probably of southern India and Malaysia as well, in all which regions peculiar and isolated forms allied to the lemurs are still found. The ancestors of the numerous lemurs of Madagascar were probably exterminated in Africa by the incursion of the other animals which are now the dominant existences in that continent; while in Madagascar, free from the competition of these rival forms of life, and protected from the large Carnivora, the three groups above mentioned have been slowly modified in the lapse of ages, by climatic and other influences, into the many peculiar and highly specialized forms found there, of which the Aye-aye, the *Cryptoprocta* (*pintsala*), and the *Galidia* (*vontstra*), are conspicuous examples.

As regards its Avi-fauna, Madagascar is exceedingly rich in birds, and in remarkable forms of Passeres. No less than 80 genera and 111 species of land birds have been discovered, and every year some additions are made to the list. The number of peculiar genera (not less than 50) constitutes one of the main features in the ornithology of the island, and many of these are so isolated that it is very difficult to classify them, and they remain to this day a puzzle to ornithologists. There are also 56 peculiar species, and the detailed tables of these shew an amount of speciality hardly to be found in the birds of any other part of the world. Out of 111 land birds inhabiting

Madagascar, only 12 are identical with species inhabiting the neighbouring continents, and most of these belong to powerful-winged or wide-ranging forms. "All these peculiarities speak plainly of enormous antiquity,* of long-continued isolation," and not less plainly of large islands connecting Madagascar with the oriental region (India and Malaysia).

Neither space nor time allow of entering into further detail as to the peculiarities of the reptiles, amphibia, fishes, insects, and molluscs of the Madagascar group, except to notice that the gigantic tortoises now only found in the uninhabited islet of Aldabra were formerly found also in Madagascar itself, and that the extinct tortoises of Mauritius are most closely allied with the great tortoises still remaining in the Galapagos group, on the opposite side of the globe! There are also similar strangely distant relationships in other groups (the serpents, insects, land-shells, etc.), and these anomalies Mr. Wallace shews conclusively are to be explained not by the clumsy and unscientific conjuring up of submerged continents, but much more simply and reasonably by remembering that the groups to which these anomalous forms belong were anciently of almost world-wide diffusion, as proved by their fossil remains in the Tertiary formations; and that these remnants, found now in widely-separated regions, are "survivals" of forms which have become from various causes extinct in intermediate countries, but have maintained themselves in islands and isolated portions of continents. "Madagascar has probably been during long periods of time a refuge for groups that have been dying out in the great continents, but have been able still to preserve their existence in this great island."

The undoubted numerous resemblances between the Madagascar fauna and that of the Oriental "region" (India and the Malay Peninsula and Archipelago) are doubtless due to the former existence of several large islands in the northern Indian Ocean, by which a series of connecting links was formed between Madagascar and southern India. These islands are indicated clearly on a physical map of that ocean by the numerous extensive banks surrounding the Mascarene Islands, the Cargados-Garayos and Saya de Malha atolls, Aldabra and

* It is gratifying to me to see that this conclusion, on zoological grounds, by so eminent a naturalist agrees with the opinion I expressed some time ago in this ANNUAL, from geological and physical considerations, that the elevated interior regions of Madagascar were "very ancient land" (ANNUAL, No. iii., pp. 12, 13).

the Farquhar Isles, the Seychelles, Amirante and Chagos Islands, and the Laccadives and Maldives. These are almost all encircled by coral reefs, and were doubtless formerly of much greater extent than at present; and though probably never forming a *continuous* line—for there are profound ocean depths between them—would afford a means by which birds, insects, and land-shells might gradually spread south-westward from the Oriental region.* Madagascar itself has also a barrier reef of at least 350 miles long on its eastern side, as well as elsewhere off its shores, a proof of recent subsidence; so that during the Tertiary epoch it was probably of much greater extent than it now is, although the fossils of the secondary period found in the south and west of the island shew that in still earlier times it was considerably less in size than it is at present.

These points are clearly established in the sixth. chapter of Mr. Wallace's latest work, *Island Life*, which treats of the Madagascar group as a good example of ancient continental islands, and is illustrated by two suggestive physical maps, one shewing the Madagascar group with the ocean depths surrounding it, and the other a sketch-map of the Indian Ocean between Africa and India.† Some notion of the profoundly interesting problems raised by such groups as the Madagascar one may be gained from the following extract from the opening words of the chapter: "We have now to consider the phenomena presented by a very distinct class of islands—those which, although once forming part of a continent, have been separated from it at a remote epoch, when its animal forms were very unlike what they are now. Such islands preserve to us the record of a bye-gone world,—of a period when many of the higher types had not yet come into existence, and when the distribution of others was very different from what prevails at the present day. The problem presented by these ancient islands is often complicated by the changes which they themselves have undergone since the period of their separation. A partial subsidence will have led to the extinction of some of the types that were originally preserved, and may leave the ancient fauna in a very fragmentary state; while subsequent elevations

* See also a similar argument in the writer's work, *The Great African Island*, pp. 120, 121, in trying to account for the Malay element in the population of Madagascar.

† There is also a third, a physical sketch-map of Madagascar, borrowed from the writer's paper in *Nature*, Aug. 14, 1879, on the Physical Geography and Geology of Madagascar.

may have brought it so near to the continent that some immigration even of mammalia may have taken place. If these elevations and subsidences occurred several times over, though never to such an extent as again to unite the island with the continent, it is evident that a very complex result might be produced; for, besides the relics of the ancient fauna, we might have successive immigrations from surrounding lands reaching down to the era of existing species. Bearing in mind these possible changes, we shall generally be able to arrive at a fair conjectural solution of the phenomena of distribution presented by these ancient islands. Undoubtedly the most interesting of such islands, and that which exhibits their chief peculiarities in the greatest perfection, is Madagascar, and we shall therefore enter somewhat fully into its biological and physical history."

Some of the ground occupied by the chapter on the Madagascar "sub-region" in Mr. Wallace's former work is necessarily gone over again in this later book, but four years' further thought and research upon the numerous problems involved has convinced Mr. Wallace of the utterly untenable character of the "Lemuria" hypothesis, and the whole argument is much more clear and decisive than the views given in *the Geographical Distribution of Animals* on this point. The various sections of the chapter treat of the Physical features of Madagascar and its surrounding ocean and islands; Biological features; Relation of Madagascar and Africa; their Early History; Anomalies of Distribution and how to explain them. In this last-named section the author insists upon one of the principal doctrines which he, I think, conclusively demonstrated in the first part of the book, which treats of "The Dispersal of Organisms, and the Problem of Geological climates," viz., that "in no single case have we any direct evidence that the distribution of land and sea has been radically changed during the whole lapse of the Tertiary and Secondary periods, while, as already shewn in the fifth chapter, the testimony of geology itself, if fairly interpreted, upholds the same theory of the stability of our continents and the permanence of our oceans. Yet so easy and pleasant is it to speculate on former changes of land and sea with which to cut the gordian knot offered by anomalies of distribution, that we still continually meet with suggestions of former continents stretching in every direction across the deepest oceans, in order to explain the presence in remote parts of the globe of the same genera even of plants or of insects—organisms which possess such exceptional facilities both for terrestrial, aerial, and oceanic transport."

The first half of the book is one of the most charming pieces of scientific reasoning that has been written for a long time, and in it not only is the reputation of the author as an eminent naturalist fully maintained, but he must henceforth take high rank as a geologist and physicist. Following the line laid down by the late Sir Charles Lyell in his *Principles of Geology*, he shews how changes in the arrangement of land and sea, such as is certain have frequently occurred, are sufficient to account for the otherwise unaccountable problem of tropical and sub-tropical vegetation in the Arctic regions. He also shews how periods of high eccentricity of the earth's orbit during the lapse of hundreds of thousands of years (a fact proved by astronomical science), *combined* with different arrangements of land so that the warm tropical currents would be entirely cut off from the north polar region and with winter in *aphelion*, are the probable causes of the Glacial epochs;* and as these periods are calculable within certain limits, a beautiful light is thrown by one science on another, and astronomy can be called in to give the approximate dates of certain geological eras. Among the points insisted on by Mr. Wallace are, the general permanence (at least through the age of the fossiliferous rocks) of the present great features of land and water, as opposed to the notion that the profounder ocean depths were ever occupied by continents, or continents, on the other hand, by oceans, although there have been continual oscillations of the land, which has again and again been replaced by *shallow* seas, and so has received the successive strata of which it is now formed. For none of the fossiliferous strata with which we are acquainted appear to have been deposited in deep oceans, but all in seas of moderate depth, and at no great distance from land. Other sections of the chapter on Madagascar treat of the Birds as indicating a supposed Lemurian Continent; Submerged Islands between Madagascar and India; the Mascarene, Comoro, and Seychelles groups, with their Flora and Fauna; the Birds, living and extinct; Flora of Madagascar and the Mascarene Islands; Curious relations of Mascarene plants; Fragmentary character of Mascarene Flora; the Flora of Madagascar allied to that of South Africa, and the Preponderance of Ferns.

* That is, the recent glaciation at the close of the Pliocene period, and another, more ancient, of which there is tolerably conclusive evidence, in the lower Permian conglomerates of the west of England, with possibly others between these long-separated intervals of geological time.

We cannot, however, dwell longer on this book, which must possess a charm for every one having a taste for physical science, and has an especial interest for those who are acquainted with Madagascar; because, as Mr. Wallace remarks in the concluding section of the chapter, "There is probably no portion of the globe that contains within itself so many and such varied features of interest connected with geographical distribution, or which so well illustrates the mode of solving the problems it presents, as the comparatively small insular region which comprises the great island of Madagascar and the smaller islands and island groups which immediately surround it. In Madagascar we have a continental island of the first rank, and undoubtedly of immense antiquity; we have detached fragments of this island in Aldabra and the Comoros; in the Seychelles we have the fragments of another very ancient island, which may perhaps never have been continental; in Mauritius, Bourbon, and Rodriguez we have three undoubtedly oceanic islands; while in the extensive banks and coral reefs of Cargados, Saya de Malha, the Chagos, and the Maldivé Isles we have indications of the submergence of many large islands which may have aided in the transmission of organisms from the Indian Peninsula."

I can only hope that many who read this paper will read Mr. Wallace's book for themselves, and may derive from it some of the same pleasure and instruction it has afforded to myself.

JAMES SIBREE, JUN.

