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ORDINARY MEETING.*

THE PRESIDENT, SIR G. GABRIEL STOKES, BART., M.P., P.R.S., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed, and the following Elections were announced by General G. S. Hallowes, *Acting Honorary Secretary*:—

MEMBERS:—The Ven. Archdeacon Gibson, M.A., South Africa; Rev. W. T. McCormick, M.A., F.R.G.S., Brighton; Rev. J. Oxley Oxland, South Africa.

ASSOCIATE:—Rev. W. L. Paige Cox, M.A., Birkenhead.

The following Paper was then read by the Author:—

THE DISPERSAL OF PLANTS AS ILLUSTRATED BY THE FLORA OF THE KEELING OR COCOS ISLANDS. By H. B. GUPPY, M.B.

THROUGH funds placed at my disposal by Mr. John Murray, I was enabled last year to take advantage of the invitation of Mr. G. C. Ross to make a short stay in the Keeling or Cocos-Keeling Islands. As it happened, however, I remained there nearly ten weeks, and amongst other things devoted my attention to the subject of this paper. It will be seen that I obtained much valuable information from the proprietor of these islands, that I owe much to the courteous assistance of Dr. Treub, the Director of the Botanical Gardens at Buitenzorg, and that I am especially indebted to Mr. Thiselton Dyer, Professor Oliver, and Mr. Botting Hemsley with respect to the examination of my collections at Kew. Mr. Hemsley examined my specimens in the light of his extensive experience in this department of Botanical science; and it will be at once perceived by those interested in this paper that my part has been that of a collector and an observer. Having, however, previously paid some attention to this subject in the Solomon Islands, I was to some

* February 3rd.

extent on familiar ground, and many of the littoral plants of Keeling Atoll were in truth old acquaintances of mine.

My remarks will refer almost entirely to the original plants of these islands, and I shall endeavour to describe the early condition of the flora before the final occupation of the group by man between 60 and 70 years ago. At present the original plants are being rapidly exterminated by the cultivation of the cocoa-nut, so that in a few years' time it would be a very difficult matter to collect the materials for a paper of this kind. According to Mr. Keating (*Holman's Travels*, vol. iv), who left the atoll in November, 1829, after a residence of 12 months, these islands were first occupied by Captain Le Cour, of the brig "Mauritius," in 1825. When Captain Ross, the grandfather of the present proprietor, established his family there a year or two afterwards, he found, according to Mr. Keating, some characters, apparently Arabic, cut on the trees. Not improbably these characters marked the visit of some adventurous Bugis traders, whose prau had been blown there from the coasts of the Indian Archipelago. In fact, Mr. Ross informs me that one of these crafts, with a starving crew on board, had been picked up about 200 miles east of the Keeling Islands. The circumstance that the early settlers in the first quarter of this century found the islands of Keeling Atoll frequented by myriads of sea-birds that have been banished altogether since the final occupation by the Ross family, goes to show that there had been no previous permanent residents on the islands for a considerable period. In truth, after examining the earliest accounts and maps of these islands, I find nothing to show that man has ever inhabited them before the present century. There have been numerous visits, and several ships have probably been lost there; but Mr. Ross assured me, on several occasions, that there never had been discovered any trustworthy evidence of an earlier permanent occupation of the islands; and it cannot be doubted that the original inhabitants would have left some such evidence behind them. I therefore take the standpoint that the Keeling Islands have never been permanently occupied by man before the present century.

This being so, it is remarkable that when these isolated oceanic islands were first settled on, they possessed numbers of cocoa-nut palms. Van der Jagt* and Keating testify to the great prevalence of these palms in 1829, and Darwin, in

* *Verhand. Batav. Genootschap der K.*, Deel xiii; Batavia, 1832.

1836, remarked that the cocoa-nut tree seemed at the first glance to compose the whole wood. In truth, however, we learn from the early edition of Horsburgh's *India Directory*, which was published in 1809, some 15 or 16 years before the occupation of these islands, that they were "covered with trees, principally the cocoa-tree," and that the navigators who had previously landed here had found "no article of utility except cocoa-nuts." Long before this date, in 1749, when Captain Ekeberg visited North Keeling Island, he described "the whole strand" as "full of cocoa-nut trees," whilst the northern shore of the adjacent islands of Keeling Atoll he referred to in his journal as "overgrown with cocoa-nut trees."* Hence it is that in the French atlases of last century, and in the early Dutch maps, these islands are nearly always named the Cocos Islands; and this is the name that they bear in a general map of the Eastern Archipelago and adjoining seas which was published at Amsterdam in 1659 (British Museum Press Mark KAR). I have been unable to find any allusion to these islands by their supposed discoverer, Captain William Keeling (1607–1610), in the accounts of this voyage given by Purchas, Prévost, and others. However, the evidence I have above given is sufficient to establish the fact that the cocoa-nut palm had established itself on this isolated group long before its occupation by man. Of this there is further proof.

In a plan of these islands, attributed to Jan de Marre, the Dutch navigator, in 1729, which is contained in the 6th volume of Van Keulen's Atlas, published at Amsterdam in 1753, the principal islands are represented as covered with these palms, and the following quaint remark, extracted from page 19 of this volume, will serve to introduce the second point that I desire to prove. After referring to the circumstance that these islands are low and wooded, possessing *no inhabitants*, but having plenty of cocoa-nut palms, the writer observes that "it would seem that nature herself has produced these trees." This is an exceedingly interesting point, and I cannot rival the simple language of the Dutch author in thus stating it. Before inquiring, however, into the capabilities of the stranded cocoa-nut for establishing itself on a coral island, it will be necessary to remark that the other vegetation of these islands which has been described or referred to by Van der Jagt, Keating, and Darwin, must have mostly occupied the interiors of the larger islands before the

* Dalrymple's *Plans and Charts*, No. 475.

occupation. North Keeling Island, where the original vegetation has been less interfered with by the cultivation of the cocoa-nut palm, affords proof of this; and I have further corroborative testimony in the recollections of Mr. Ross, who was also familiar with the accounts given by his father and grandfather of the condition of the vegetation before the islands were occupied. In those early days the thick belt of cocoa-nut palms that covered the strand concealed or disguised, to great extent, the character of the interior vegetation of the larger islands, and thus the early navigators, who sailed by these islands and but rarely landed on them, formed a somewhat exaggerated estimate of the prevalence of the cocoa-nut palm.

There are various opinions as to whether the cocoa-nut is able to establish itself on a coral island. Professor Dana doubts it, and he says: "There is no known evidence that any island never inhabited has been found supplied with cocoa-nut trees" (*Corals and Coral Islands*, 1872, p. 281). This is too sweeping a statement; but all the evidence goes to show that the chances against a drifted cocoa-nut finding a home on a coral island are very numerous. Foreign cocoa-nuts are frequently drifted to the Keeling Islands, where they sometimes germinate; but, as Mr. Ross informs me, the sprouting nut is always destroyed by the crabs. It would, however, be unreasonable to suppose that fortune does not sometimes assist this ocean waif. Supposing, even, that only 50 foreign cocoa-nuts are stranded on the Keeling Islands in the course of a year, and that but one of these is able to develop into a tree in the course of a century, the student of nature would not regard 5000 to 1 as inacceptable odds when the field is unlimited, and the time of the competition practically unrestricted. Of course it must first be proved that cocoa-nuts can germinate sometimes after long immersion in salt-water. After considering the evidence in his work on the botany of the "Challenger" Expedition, Mr. Hemsley considers it "doubtful whether oceanic currents have played an active part in their diffusion;" yet he thinks their "present wide area is partly due to this agency," and he cites the instance of cocoa-nut palms having been found on the Keeling Islands when they were first settled on in the early part of this century. He also quotes Jouan, who holds that too much importance has been attached to the influence of oceanic currents in the dispersion of the cocoa-nut, which requires to be first buried up, or else attached to the soil before it can expect to survive. I shall show in a later part

of this paper that in the Keeling Islands many drift seeds and seed-vessels cannot be protected from the crabs, unless first covered over with sand by the waves in heavy gales; and amongst them we may include the cocoa-nut.

Regarding the cocoa-nut palms as having been originally for the most part confined to the strand of these islands, I come to the consideration of the other vegetation. Through the cultivation of the cocoa-nut the original flora of the islands of Keeling Atoll is now but scantily represented; but I very much doubt whether any of the trees or shrubs have in this manner become actually extinct. Their scanty occurrence, however, is sufficient to explain the fact that I have been able to add several new names to the list of littoral plants collected by Darwin in 1836 (*Ann. Nat. Hist.*, i, p. 337, 1838) and by Forbes in 1878 (*Eastern Archipelago*, p. 42), plants, the absence of which had been previously a cause of surprise to me. Notwithstanding, I should have had considerable difficulty in restoring the original flora of the islands of Keeling Atoll if I had had to depend only on the fragments that yet remain. Fortunately, however, I was able to visit North Keeling Island, lying 14 or 15 miles to the northward. This small island, which was visited by neither Darwin nor Forbes, presents the flora of these islands in some parts of its area much as it was before the Ross family were established in this group. From its examination, assisted by facts supplied to me by the residents, I have been able in some measure to give a general idea of the vegetation of these islands before they were finally occupied by man; but it should be remarked that most of the additions to the flora would have been made if I had never visited North Keeling Island, the visit to that island having been mainly productive in enabling me to form a correct idea of the relative proportion and arrangement of the original vegetation.

Neither Van der Jagt* nor Keating,† who described the condition of these islands in 1829, allude to the smaller vegetation, and they refer to the prevalence of the cocoa-nut palm in such a sweeping manner that, to avoid forming an exaggerated idea of the matter, we have to recall the remark of Darwin seven years later, that the cocoa-nut *seemed at the*

* *Verhand, Batav. Genootschap der K.*, Deel xiii; Batavia, 1832.
† Holman's *Travels*, vol. iv.

first glance to compose the whole wood. The Dutch officer, however, was engaged in making a commercial rather than a scientific report to the Netherland Indian Government,* whilst Mr. Keating was content with giving a general description to Mr. Holman, the blind traveller. However, there can be no doubt that in their time, and in that of Darwin, the cocoa-nut palms formed the conspicuous vegetation. Van der Jagt, however, gives the native Malay names and the uses of a few trees on the islands, names and uses which they still retain, and from his report as well as from the description of Keating, and from a paper on these islands, apparently by Mr. J. C. Ross (*Gleanings in Science*, Calcutta, 1830), I gather that the first residents found several other trees on the atoll besides the cocoa-nut palm.

The plants collected by Darwin in 1836, and enumerated by Henslow in the *Annals of Natural History* (vol. i, p. 337, 1838), are given by Forbes in his *Eastern Archipelago*, where they are supplemented by his own additions in 1878, which included, however, numerous plants that had been introduced in the interval. Darwin, in 1836, observed five or six trees besides the cocoa-nut palms; the two, which he said he did not obtain specimens from, were probably *Pisonia* (*inermis?*), as pointed out by Forbes, and *Hernandia peltata*. Amongst my collections in 1888 the following, as identified at Kew, have not hitherto been recorded from these islands:—

Calophyllum inophyllum, Linn. Keeling Atoll.
Thespesia populnea, Corr. Keeling Atoll.
Triumfetta subpalmata, Solander. Keeling Atoll.
Suriana maritima, Linn. Keeling Atoll.
Erythrina indica, Lamk. Keeling Atoll (perhaps introduced).
Canavalia obtusifolia, D.C. North Keeling Island.
Canavalia, sp.
Terminalia Catappa, Linn. Keeling Atoll and North Keeling Island.
Barringtonia speciosa, Forst. Keeling Atoll.
Sesuvium Portulacastrum, Linn. North Keeling Island.
Ipomœa grandiflora, Lamk. Keeling Atoll.
Ipomœa biloba, Forsk (*pes caprœ*, Roth). Keeling Atoll.
Premna obtusifolia, R.Br. North Keeling Island.

* The annual yield of cocoa-nuts for all the islands of Keeling Atoll was estimated by Van der Jagt in 1829 at 431,000.

Hernandia peltata, Meissn. Keeling Atoll and North Keeling Island.
Euphorbia, sp. aff. *E. thymifoliæ*. North Keeling Island.
Casuarina equisetifolia, Forst. Keeling Atoll (introduced).

Almost all the above are common littoral plants, and *all but three in every probability formed part of the original flora of the island.* The evidence for this statement will be found in a note at the end of this paper.*

After I have endeavoured to give a general idea of the other vegetation of the islands of Keeling Atoll before man's occupation, I will refer to the plants of North Keeling Island, and then I will proceed to harmonise the facts with my observations on the dispersal of plants.

On the weather or seaward sides of the islands of Keeling Atoll, *Tournefortia argentea* and *Scævola Kœnigii* lined the beach, just as they do at the present time. It is worthy of note that these plants, in places where they are exposed to the full force of the South-East Trade and of the frequent hurricanes and gales, have a very stunted growth. In sheltered situations, as on the lee or west side of the atoll and in a few places bordering the lagoon, they grow to a much greater height, and possess more abundant foliage, and more numerous flowers. These facts go to show that these two plants do not necessarily prefer exposed situations on the weather coasts of islands. They are most frequent there because the waves first stranded their seeds on the weather-coasts; but if their seeds became a favourite food with crabs and birds, they would soon be distributed all over the interior of the islands. As it is, however, crabs and birds do not assist the spread of these plants in any marked degree, and they are in consequence restricted for the most part to the coasts where first they obtained their footing, whence their seeds are drifted by the waves to the coasts of the other islands, or they may be transported, as I shall subsequently show, in the crevices of logs and floating pumice.

A species of *Pandanus* was also frequent on the southern and eastern coasts; but in clearing the ground for cocoa-nut palms, the pandanus trees have been almost entirely removed, and only survive in any number at the South-East Cape, where exposure to the strong Trade and to hurricanes has given them a stunted growth. Bushes of *Pemphis acidula* grew

* It is of importance that this note should be referred to, because the apparent absence of certain common littoral plants from the flora of this atoll has been a subject of surprise.

on the weather shores, but more often lined the margin of the lagoon, and are still frequent in these situations. Just within the line of these bushes on the shores of the lagoon, but sometimes immediately bordering the water, occurred forests of the Keeling Ironwood (*Cordia subcordata*). At present this tree is only scantily represented, the forests having been destroyed through the agencies of fire and of the axe. Another plant, *Cæsalpinia Bonducella*, that grew near the beach, is now rarely to be found. This is evidently the *Guilandina Bonduc* of the lists of Darwin and Forbes.

In the interiors of the islands, and occasionally on their weather and lagoon shores, grew numbers of trees that have had to make way for the cultivation of the cocoa-nut palm, such as *Pisonia* (*inermis?*), *Barringtonia speciosa*, *Ochrosia parviflora*, *Calophyllum inophyllum*, *Terminalia Catappa*, *Hernandia peltata*, and *Guettarda speciosa*. Two other trees preferred the shores of the lagoon, namely, *Hibiscus tiliaceus* and *Thespesia populnea*; the first may still be often there observed, but *Thespesia populnea* has been almost exterminated, except in Horsburgh Island, where a few trees still occur. *Barringtonia speciosa* is at present only represented by a single tree in the interior of South Island, and by a few trees in the island immediately north of it. Similarly, *Calophyllum inophyllum** is only saved from extinction by the survival of a few trees in South Island. *Terminalia Catappa* is also rare, and like *Hernandia peltata*, *Pisonia* (*inermis?*), and *Ochrosia parviflora*, is only represented in a few localities. *Guettarda speciosa* still flourishes in some of the smaller islands, as in Pulu Kumbang, However, generally speaking, the extermination of the trees has been nearly effectual, and it is only here and there that a few survivors occur. Half a century ago the interiors of South and West Islands were largely occupied by tall forests of *Hernandia peltata* and *Pisonia* (*inermis?*). These rapid growing trees have hitherto managed to resist total extermination; but the forests are gone and only individual trees remain. This is to be regretted, since the preservation in one island at least of the original flora would have added greatly to the attractiveness of these islands. Even if only the forests of *Terminalia Catappa*, *Pisonia* (*inermis?*), *Ochrosia parviflora*, and *Cordia subcordata*, had been preserved in the Settlement

* The proprietors of the islands have in past years planted in their garden *Calophyllum inophyllum*, *Barringtonia speciosa*, and some others nearly extinct in the state of nature.

and Direction Islands, where they once thrived, the lover of nature might have found some consolation for the destruction of the rest.

Now and then, however, the old order of things asserts itself, as when newly formed tracts of sand, which have been added to these islands, receive their first vegetation. A coarse grass, assisted by such creeping plants as *Ipomæa pes capræ*, *Triumfetta procumbens*, and *Triumfetta subpalmata*, first clothes the surface, which is soon after occupied by bushes and young trees of *Tournefortia argentea*, *Scævola kœnigii*, and *Morinda citrifolia*, over the foliage of which *Ipomæa grandiflora* frequently spreads. When these islands were first occupied, *Morinda citrifolia* was scantily represented; but having been re-introduced for commercial purposes, which have been long since abandoned, it now threatens to over-run every island.* . . . . A tendency to return to the original condition of things is again to be seen in the localities where the observant eyes of the proprietor or of those under him have not been cast for some time. For the crabs, who ably assist Mr. Ross in keeping all vegetable intruders out of the islands, as I shall subsequently show, sometimes turn against him in the war of extermination, and do their best whilst storing the fruits of *Hernandia peltata* and other trees in their holes in the ground, to scatter the seeds far and near over the surface of the island. Hence the recrudescence of the *Hernandia* in islands not visited for some time, and the subsequent wrath of the proprietor. . . . . Before proceeding to refer to North Keeling Island, mention should be made of *Casuarina equisetifolia*, introduced into the Settlement Island more than half a century ago by the grandfather of the present proprietor, and now spreading by natural means. Reference should also be made to another tree, *Suriana maritima*, which within the last 20 years has established itself through natural agencies on the weather margin of Gooseberry Island.

North Keeling Island, the vegetation of which I will now briefly describe, as I have before observed, has never been visited by a naturalist. It is a small atoll rather over a mile in length, and has an opening on its eastern side leading into a shallow lagoon. Its soil is richly impregnated with guano, and great numbers of frigate-birds, boobies, gannets, and other sea-birds, still occupy parts of the island. The effect

* It was thus overlooked by Darwin in 1836, but recorded in 1878 by Forbes.

of this is seen in the unusually luxuriant growth of the vegetation that clothes its surface.

Covering the flats on the shores of the lagoon, where they are overflown at high tide, we find *Sesuvium Portulacastrum*. Immediately bordering these flats are the bushes or low trees of *Pemphis acidula;* and directly behind them rise the arched trunks of the Keeling Ironwood (*Cordia subcordata*), which sometimes also borders the water and extends as well into the interior, where most of the larger trees have been burnt or cut down. Within the island, in the localities where the original vegetation has been best preserved, as in the northern part, grow the tall cabbage-tree (*Pisonia (inermis?)*), *Ochrosia parviflora, Hernandia peltata, Terminalia Catappa, Premna obtusifolia,* and *Guettarda speciosa*. In other parts of the island, however, the trees are often barely in sufficient numbers to attest their presence. Formerly, they alone occupied the interior, where the cocoa-nut plantations now thrive. Amongst the trees originally found in the island, as I have previously remarked, was *Morinda citrifolia*. Of late years it has been spread so rapidly by fowls as to become a nuisance. The Papaw tree, introduced by the proprietor many years since, is now being distributed all over the interior by the same agency . . . . In the last place I should refer to the vegetation of the weather coasts where *Tournefortia argentea* and *Scævola Kœnigii* line the beach. Spreading over the foliage of the trees near the sea we observe the climbing leguminous plant *Canavalia obtusifolia*.

I come now to refer to the fact that several familiar littoral trees have not succeeded in establishing themselves in the Cocos or Keeling Islands. We notice their drifted seeds germinating on the beaches, but we do not find their names amongst the flora. It is a remarkable circumstance that, although the low, muddy, lagoon-shores of all these islands are very well suited for the mangrove, the nipa, and *Lumnitzera coccinea*, the place of these widely spread trees is here taken by rows of bushes of *Pemphis acidula* and by the over-arching trunks of *Cordia subcordata*. The fruits of the nipa, the germinated seeds of the mangrove, and the seeds of *Lumnitzera coccinea*, are thrown in numbers on the beaches, where some sprout and begin to take root; but they have never yet obtained a footing by natural means, and never would except through man's intervention. Of the host of other fruits and seeds that are brought by the waves and currents to these islands, many make similar ineffectual efforts to establish themselves. Amongst the stranded fruits that have failed in their attempts,

one recognises some belonging to trees such as *Heritiera littoralis*, *Cerbera Odollam*, and *Cycas circinalis*, which, as we well know, prefer the sandy soil of a coral island. How comes it then, that these trees have not found a home on these islands, though their seeds and seed-vessels drift ashore? In replying to this question, I shall have to draw attention to the necessity, whilst studying the causes of the dispersal of plants, of inquiring into the agencies that destroy the stranded seeds and seed-vessels, and prevent their obtaining a footing. The drifting seed, in fact, is comparatively safe on the open sea, but when it gets stranded on the beaches of the Cocos Islands and begins to germinate, it is at once destroyed by the crabs. Of the 50 or 60 different kinds of fruits and seeds found commonly amongst the vegetable drift on the beaches of these islands, not more than a dozen have succeeded in establishing themselves. The long immersion in salt-water may have injuriously affected some, but the majority are destroyed by the crabs.

I have been informed by the proprietor, that sometimes when a large amount of vegetable drift has been stranded on the beaches, a line of sprouting plants may be shortly observed just above the usual high-tide mark. The tender shoots are soon eaten by the crabs, and in a little time every plant is gone. Many of the seeds that germinate on the beach are beans. In fact, beans, varying in size from those of *Entada scandens* downward, form about one-third of the vegetable drift; but the crabs effectually prevent them from getting a footing. I have come upon stranded seeds and fruits that have been thus attacked and partly eaten.

Many attempts have been made by Mr. Ross to establish the stranded seeds on the islands, but the crabs have nearly always succeeded in defeating his efforts. It was only after many unsuccessful trials that he was able to grow one of the large beans of *Entada scandens* in his garden, where it is now flourishing. A few years since, he made a similar experiment with the seeds of *Calophyllum inophyllum* that had been cast up on the weather beaches. Several hundreds were planted, and many germinated and sprouted; but the crabs destroyed every shoot except one, which survived in a sickly condition.

The square fruits of *Barringtonia speciosa*, which often arrive at these islands in a fresh state, not uncommonly germinate; but only in very rare instances do they escape the crabs. Although this tree has established itself on the islands of Keeling Atoll, it has not yet obtained a hold in North

Keeling Island. However, in August, 1888, I observed two young trees, 1½ feet high, growing on the shores of the North Keeling lagoon. They evidently owed their preservation, as Mr. Ross pointed out to me, to the circumstance of the fruits having been concealed when germinating by the bed of fine drift pumice that had been deposited on the shores of the lagoon after the Krakatoa eruption. It is probably owing to this, or to some similar accident, such as the heaping up of sand over vegetable drift after a gale, that stranded fruits and seeds, when they begin to sprout, are ever able to escape the notice of the crabs in these islands. Although the fruits of both *Barringtonia speciosa* and *Calophyllum inophyllum* are often washed up on the shores of North Keeling Island, neither tree has succeeded in permanently establishing itself. On the islands of Keeling Atoll, where these two trees have nearly been exterminated to make way for the cocoa-nut plantations, and where the few survivors only exist on sufferance, neither has been able to regain its footing, although unfailing supplies of their drifted seeds and fruits are washed up on the beaches.

In truth, vegetable waifs in these islands meet with a fate as ruthless as that which used to await shipwrecked mariners on the shores of the Pacific Islands. In this work of extermination the proprietor ably assists the crabs. Thus, to take the case of the triangular seeds of *Carapa moluccensis*, which are amongst the commonest fruits of the vegetable drift. Although during their lengthy passage to these islands these fruits are often attacked by the Teredo and other boring molluscs, a goodly proportion arrive in an entire condition and often sprout on the beach. Such germinating fruits are not only killed off by the crabs, but also by the proprietor of the islands himself, to whom the tree is not of any value. However, as above remarked, Mr. Ross has sometimes endeavoured to give the ocean waifs a chance. His father tried to introduce the mangrove into Horsburgh Island, the germinated seeds of which often occur amongst the vegetable drift. But the crabs frustrated his efforts in all parts of the island except around the shores of the enclosed lagoonlet where the mangrove survived and is still thriving. Reference has been made to the circumstance that the sprouting fruits of the nipa are always destroyed by the crabs. In consequence, although the fruits drift here in considerable numbers, they have never obtained a hold. I have said so much about the exclusive dealings of the crabs, that it is only fair to them to add, as also pointed out by Mr. Forbes, that they are important

though ignorant agents in distributing over the islands the seeds and fruits of trees already established there, such as those of *Cordia subcordata*, *Hernandia peltata*, and *Morinda citrifolia*. When these seeds germinate amongst the vegetation in the interior of the islands, they often escape the attention of the crabs: whereas, when they attempt to sprout in full exposure on the beach, they can rarely evade their notice, unless they are concealed by sand or pumice.

Since the occupation of these islands about 62 years ago, the frigate-birds, gannets, boobies, and other sea-birds, that once nested here in myriads, have been driven away; and in consequence one of the important agencies of seed distribution no longer exists. So many disturbing elements, in fact, have been created in these islands, during their occupation by man, that even if the group was deserted for ages, the ancient condition of things could never be restored. By accident or design, a great number of strange plants have been brought here through human agency. A brief comparison of the lists of the flora made by Mr. Darwin in 1836 and by Mr. Forbes in 1878 will at once convince those interested in this subject that such is the case. But more important still, many mammals, birds, and new insects have been introduced accidentally or intentionally during the last half century, which have exercised a very noticeable disturbing influence in the plant-life of these islands. Sheep, deer, cats, rabbits, pigs, rats, fowls, &c., now play, or have recently played, an important part in the floral economy of this group by distributing some plants and exterminating others. For instance, as already observed, the fruits of *Morinda citrifolia* are eaten by sheep, deer, fowls, &c., and the seeds pass unharmed through their digestive canals and are voided in a fit state for germination. Hence, the tree is spreading with great rapidity all over the islands, and is a cause of much trouble to the proprietor. In North Keeling Island the Papaw tree rapidly increases in numbers through the agency of fowls in a similar fashion. In a like manner fowls have been the means of spreading another introduced plant, *Canna indica*. Some years ago, a cassowary that was kept on the Settlement Island, was a very efficient distributor of seeds. The fruits of *Ochrosia parviflora* were his especial favourites; and, as a consequence, the undigested seeds were scattered everywhere, and the young trees became so numerous that they had to be destroyed. As an example of the manner in which the struggle for life amongst the animals may affect the survival of plants, I may refer to the circumstance that

for many years rabbits found a home in Horsburgh Island and in North Keeling Island, and played their part in the distribution of seeds. They have now been exterminated in the latter island by the Cocoa-nut Crab; and in Horsburgh Island the crabs have nearly succeeded in destroying them all.

I now come to consider the means by which this group of the Cocos or Keeling Islands received its original flora. My observations in this locality, as well as my previous experiments in the Solomon Islands, throw much light on this subject. First, with regard to the common littoral trees, *Scævola Kœnigii* and *Tournefortia argentea*, which, as in the Pacific Islands, line the beaches on the weather coasts. It is often difficult to ascertain whether the seeds of these trees have been brought from distant regions by the currents or whether they have been derived from the trees already growing on the coasts of these islands. However, there is no doubt that the fruits of *Scævola Kœnigii* will float in sea-water during a considerable period. Some ripe fruits, that I picked off a tree, continued to float buoyantly after they had been kept for 50 days in sea-water, losing during the early days of their immersion their white fleshy covering. Notwithstanding this long immersion, nearly all the seeds readily germinated after having been sown out by Dr. Treub at Buitenzorg. (The series of experiments commenced by me in the Keeling Islands and completed by Dr. Treub at Buitenzorg are given further on in this paper.) Although doubtless usually transported directly by the currents, the seeds of *Scævola Kœnigii* are probably at times carried about in the crevices of floating pumice and logs.

By a similar experiment I found that the freshly-picked fruits of *Tournefortia argentea* remained floating after 40 days in salt-water. During the first fortnight these small round hard seed-vessels split into halves and lost their outer dark skin, this being the condition in which they are found in the vegetable drift. Seven of these hemispherical seeds were subsequently sown out at Buitenzorg, and all readily germinated. But there is another means of transport for the seeds of this wide-spread tree. They occur in considerable numbers on the sand in the vicinity of the trees, and in this way often get into the crevices of stranded logs and pumice. I found an old log beached just above the usual high-tide level on the weather coast of one of the eastern islands. It was thoroughly honeycombed by the Teredo, long since dead, the empty cavities being largely filled with sand, fine

pumice, pebbles, a little mould, and a very considerable number of the seeds of *Tournefortia argentea*, with a few other small seeds. There were no trees in the vicinity that could have supplied the Tournefortia seeds, and it was evident that this log had been washed away from some other part of the coast where it had been lying for a long time near a Tournefortia tree. During unusually high tides and gales, sand, seeds, and pumice had been washed into the empty burrows of the Teredo; and after a time the log was swept away and stranded in its present position. I examined some other honeycombed logs, just beached, in which the Teredo was still fresh, though dead. No sand, pumice, or seeds occurred in their cavities.

Mr. Ross informed me that not infrequently, later on in the year than the time of my visit, he has observed the seeds of *Pemphis acidula*, *Scævola Kœnigii*, and *Triumfetta procumbens*, sprouting from pumice on the beach. The pumice is generally old pumice drift which has been washed up during gales under the littoral trees, where it becomes partially covered with sandy soil and leaves, and seeds often drop into the crevices. When such old pumice is carried off by an unusually heavy sea and stranded on another part of the coast, the seeds often germinate, but the crabs soon bite off the shoots. I have never found seeds in recently-arrived pumice, though I have observed grass growing in the cells of pumice that has lain a long time on the ground. It is, however, easy to perceive from the foregoing remarks how logs and pumice that have been lying for some time on the shores of an island under the shadow of littoral trees, may often be swept away into the open sea and carry seeds in their crevices over a wide extent of ocean.

The numerous Pandanus seeds that occur in the vegetable drift on these coasts in certain times of the year, at once explain how this tree originally reached these islands. The origin of some of the littoral trees does not admit of so easy an explanation. Take, for instance, *Suriana maritima*, which, in spite of the circumstance that it is found on nearly all tropical shores, both insular and continental, has only *established itself* here within the last 20 years. It is not included in the lists of Darwin and Forbes, and the Cocos Islanders take such an interest in the plants of their atoll that there is no reason to doubt the recent appearance of the shrub on the weather side of Gooseberry Island. Its seeds are small, rather soft, and are ill suited for drifting on the sea, since they sink after floating between two and six days.

Probably enough they were brought here in the crevices of a drifting log. Why is it, however, that these insignificant seeds have not germinated here successfully before?

Many of the trees that originally took a prominent place in the flora of these islands have been long known to be distributed by the ocean currents. Thus, the drifting fruits of *Barringtonia speciosa*, *Calophyllum inophyllum*, and *Terminalia catappa* are very commonly stranded on these islands, and I have already referred to the fact that those of the two first-named trees have been found germinating on the beaches. The Ironwood tree (*Cordia subcordata*), which is widely dispersed in the Indian and Pacific Oceans, is evidently distributed by ocean currents. Its fruits, which are frequently transported by the sea to these islands, float for long periods on its surface, their corky or suberous outer covering eminently adapting them to withstand immersion.* It is necessary, however, before they are fitted for flotation, that they should first lie on the ground for some time, in order that they may become dry and lose their thin green skin. Such fruits I have found to float buoyantly after remaining 40 days in sea-water; and after the experiment 7 fruits were sown out at Buitenzorg; 10 out of a total of 28 seeds germinating. If, however, the experiment is made with ripe fruits, freshly picked from the tree and still bearing their outer skin, most of them will become rotten and sink in from two to four weeks, and only a small proportion will survive. *Pemphis acidula* is often associated with *Cordia subcordata* at the borders of the lagoon. Its small seed-vessels sink when freshly picked, but after a fortnight's drying they will float between two and five days, a period, however, quite insufficient to explain the wide distribution of this small tree or bush over the coral islands of the Pacific and Indian Oceans. Its seeds, also, are very small and ill suited for drifting on the sea, although they float, whilst the seed-vessel, when freshly picked, sinks. Probably, sea birds are the agents mainly engaged in its distribution. It is on the bushes of *Pemphis acidula*, bordering the lagoon of North Keeling Island, that the frigate-birds and boobies nest in thousands, and it is of the small sticks and twigs of this bush

* A corky covering is commonly found to invest fruits and seeds that occur in numbers in vegetable drift, as in the case of those of *Terminalia Catappa*, *Scævola Kœnigii*, *Guettarda speciosa*, *Cerbera odollam*, *Ochrosia parviflora*, and other trees. It is this covering that adapts the seeds of the Teak tree for transportal by the ocean currents.

that they construct their nests. In that island these birds have often been observed to be greatly incommoded by the number of the seed-vessels that have been entangled by the broken stalks in their plumage; and I have been informed by the residents that sometimes the bird has been killed by this cause. Although in the main distributed by sea birds, the seed-vessels of *Pemphis acidula* are also probably transported in the crevices of floating pumice and drift-wood. As already remarked, the young plant has been seen growing out of a piece of pumice stranded near one of the trees.

Other well-known littoral trees in these islands, trees that are also to be found, like nearly all the larger plants, on the coral islands of the Pacific, have, without doubt, reached this isolated group through the agency of ocean currents. Such are *Ochrosia parviflora* and *Guettarda speciosa*, the fruits of which are often to be observed amongst the vegetable drift stranded on the beaches. The fruits of *Guettarda speciosa* float when newly picked. After they have lost their outer green covering they float more buoyantly. Those that I experimented on in this condition continued to float after remaining 50 days in sea-water. Two fruits were subsequently sown out by Dr. Treub, and one seed germinated.

The wide-ranged *Hibiscus tiliaceus* and *Thespesia populnea*, that originally spread their branches over the sheltered waters of the lagoon of Keeling Atoll, where they may be still observed, have evidently reached these islands through the same agency of the ocean currents. After the capsules of *Thespesia populnea* had been about a week in sea-water, they began to get rotten and to break up, so that the seeds escaped and floated buoyantly. It happened in one instance, however, that the fruit sank before the seeds were liberated. Out of several seeds that I placed in sea-water, a few sank in about a month, but the majority floated during 40 days without any apparent injury, and would have doubtless floated for a still longer period. After the experiment, seven or eight of the seeds were sown out at Buitenzorg, and of these only one germinated, a proportion, however, of from 12 to 14 per cent., which is quite sufficient to establish the fact that the seeds of this tree can germinate after a transportal over a wide tract of ocean. Unlike those of *Thespesia populnea*, the capsules of *Hibiscus tiliaceus* dehisce on the tree, when the seeds drop, sooner or later, to the ground. Its small, hard, reniform seeds are more likely to escape notice than the much larger seeds of *Thespesia populnea;* but they will float on salt water for a long time. These that I experi-

mented upon continued to float after remaining during 40 days in the water. Six of these seeds were sown out on November 11th, but up to February 20th none had germinated. It is probable, however, that these small and hardy seeds may often drop into the crevices of stranded logs and pumice, and be distributed in the manner before described. Birds may also aid in their dispersal. There can be no doubt that the seeds of a tree so useful and ornamental as *Hibiscus tiliaceus* have often been carried from place to place by man; but we learn from Van der Jagt that in 1829, two or three years after its occupation, Keeling Atoll already possessed the Waro tree, which is still the name of *Hibiscus tiliaceus* in these islands, as well as throughout a large part of the Indian Archipelago.

We have already seen that *Morinda citrifolia* is being rapidly spread over these islands through the agency of fowls, sheep, &c. In all likelihood sea-birds or migrant land-birds may sometimes similarly carry these seeds in their stomachs and intestines over a considerable expanse of ocean to some distant island. Yet these seeds might with equal, if not with greater, probability have been transported to this group by the ocean-currents. The ripe fruit floats in sea-water; but in a few days it begins to rot, and the seeds, of which it contains a great number, drop out and float buoyantly. Ten of the seeds were placed in sea-water, and after 53 days they still floated. They were all afterwards sown out at Buitenzorg, and five germinated. Probably when Hemsley finds an explanation of the wide dispersal of this plant in its varied economic uses, and when Jouan prefers to call in the aid of ocean currents (*Botany of the Challenger*), they are both in a measure right, though to the agencies of man and of the waves, we should add that of birds and other animals.

Conspicuous amongst the larger trees that originally occupied the interiors of these islands, where they are yet scantily represented, were *Hernandia peltata* and *Pisonia (inermis?)*. It seems strange that the former tree should have escaped the notice of previous observers. It grows very rapidly, and a fine specimen is now to be seen over the grave of a British commodore buried 50 or 60 years ago in South Island. The marble-like seeds of the Hernandia continued to float after remaining 42 days in sea-water: of those experimented on, five or six were sown out and one germinated. The spiny and glutinous seeds of the *Pisonia*, according to Forbes, often prove fatal to the herons and boobies

that nest in the branches. Hence, as he observes, "it is easy to perceive how widely this tree might be disseminated by the birds that roost on it." (*The Eastern Archipelago*, p. 30.)

There are yet a few Cocos plants that need especial reference. Unfortunately I had no opportunity of experimenting on the seeds of *Ipomœa pes caprœ;* they occur, however, commonly amongst the seeds stranded on these islands. The seed-vessels and seeds of *Ipomœa grandiflora* float both in the green and dry condition; the capsules, however, soon open in the water, when the seeds escape, but sink usually in six or seven days, only a few seeds surviving that period. I was surprised, however, to find two seeds out of nine still floating at the end of six weeks. One of these two seeds was sown out by Dr. Treub, but it did not germinate. . . . . Further observations are needed with reference to the dispersal of these two widely spread species of *Ipomœa*, especially of *I. pes caprœ*, which is one of the first plants to establish itself on a coral island.

Amongst the precursors of the vegetation on such an island is *Triumfetta procumbens*. The fruits float both in the green and dry condition; but as they sink in from three to seven days, they evidently require some intermediary agent or vehicle to enable them to traverse the wide expanses of sea in the Indian and Pacific Oceans that they have crossed in past ages. We have not long, however, to look for a means of transport, since one of the seeds has been observed growing in the crevice of a piece of stranded pumice at the Cocos Islands. Probably also sea-birds aid in the distribution of this plant, for I learn from Mr. Ross that he has sometimes found the seed-vessels attached to the feathers of boobies, the soft investing spines with recurved points well adapting them to this end. There is another species of *Triumfetta* (*T. subpalmata*) not very common in the Cocos Islands, which is also one of the pioneers of the vegetation. Its seed-vessels float; but I did not carry the experiment further: the spines investing it are not recurved.

There is another littoral shrub, *Cæsalpinia Bonducella*, that grows near the beach on the weather coasts of these islands, the young plants of which may be sometimes seen growing amongst the vegetable drift just above the ordinary high-tide level. Its hard grey marble-sized seeds are often brought there by the ocean-currents; but, as I am informed by the residents, they are sometimes found in the stomachs of frigate-birds and boobies, so that here we have another means of transportal for this plant, though probably a less

certain one. The pods of another leguminous plant, *Canavalia obtusifolia*, that climbs over the foliage of trees in North Keeling Island, also float on sea-water; but I do not know how long the beans will stand immersion, though judging from the wide dispersal of this plant, they probably will withstand it for a long period without injury.

The small cones of *Casuarina equisetifolia*, a tree that has been introduced intentionally into these islands, require a considerable amount of drying and exposure to the sun before the seeds will germinate. Mr. Ross has found it necessary to bury them for some time, and then to expose them to the sun and rain before he could succeed in raising trees. This explains why none of the fallen and apparently well-dried cones that strew the ground under the trees ever germinate in that situation. Such cones will only float for one or two days in sea-water, a circumstance which shows that my experiment on the cones of *Casuarina equisetifolia* in the Solomon Islands (see *Botany of the Challenger*) was not carried far enough. Hence it is probable that they can only be transported by a drifting log or some similar agency. It is noteworthy, however, that although this tree is now spreading itself by natural means from island to island, it was not included, as far as we know, in the original flora of the group.

Here end my observations on the flotation and mode of dispersal of the plants of this atoll. There are, however, some of the trees with the mode of dispersal of which I am not acquainted, as, for instance, *Premna obtusifolia*, found both on North Keeling Island and on the south coast of Java. Then again, how did the tiny seeds of *Portulaca oleracea* succeed in reaching this atoll?

EXPERIMENTS ON THE FLOTATION AND SUBSEQUENT GERMINATION OF SOME OF THE COMMON FRUITS AND SEEDS OF THE PLANTS OF THE KEELING ISLANDS.

Name.	Floated in* sea water.	Sown out at Buitenzorg on Nov. 11th, 1888.	Germinated up to Feb. 20th, 1889.
Cordia subcordata ..	40 days ..	7 fruits	10 seeds.
Hernandia peltata .	42 „ ..	5 or 6 seeds	1 „
Guettarda speciosa ..	50 „ ..	2 fruits	1 „
Thespesia populnea ..	40 „ ..	7 or 8 seeds	1 „
Scævola Kœnigii ..	50 „ ..	3 fruits	5 „
Morinda citrifolia ..	53 „ ..	10 seeds	5 „
Tournefortia argentea	40 „	7 „	7 „
Hibiscus tiliaceus ..	40 „ ..	6 „	0 „
Ipomœa grandiflora ..	42 „ ..	1 „	0 „

It is a noteworthy circumstance, not brought out in the above table of results, that the seeds most ready to germinate during the first month in the ground were those of *Scævola Kœnigii*, *Tournefortia argentea*, and *Cordia subcordata*, of which the two first are the commonest trees and shrubs on the weather coasts bordering the beaches, whilst the last was a few years ago one of the most frequent trees bordering the lagoon. The seeds of *Morinda citrifolia* mostly germinated during the second month in the ground. Those of *Thespesia populnea* and *Hernandia peltata* are slow to germinate, whilst none of the seeds of *Hibiscus tiliaceus* had germinated up to February 20th.

It will have been noticed that I was indebted to Dr. Treub, the Director of the famous Botanic Gardens of Buitenzorg, for the important completion of my experiments on the flotation of the Keeling seeds and fruits. It will, however, have been observed that the seeds and seed-vessels of several well-known littoral trees of coral islands are not represented in the list. The fact is, that believing that those of *Barringtonia speciosa*, *Calophyllum inophyllum*, &c., had often demonstrated their powers to cross an ocean and still germinate, I preferred to select some of those seeds and seed-vessels concerning which our evidence had been, if not less certain, at least not so familiarly demonstrated. The results, to use the words of Dr. Treub, have been very satisfactory.

* The numbers of days here given refer to the length of the experiment, and not to the time during which these seeds can float in sea-water, which is probably in nearly all the cases considerably longer than the duration of the experiment.

It might have been thought that I had proved that Keeling Atoll has been mainly stocked with plants by the waves, assisted by birds. It is, however, quite open to some to suggest that the arguments can only be clinched by taking an instance of an island that is absolutely bare of vegetation, and then following the process. This has been accomplished by Dr. Treub* in the case of the volcanic island of Krakatoa, which, as he conclusively proves, was entirely deprived of vegetation by the thick covering of fiery ashes and pumice that invested its slopes, from the sea margin to the summit, at the time of its great eruption in 1883, forming a soil proved by chemical analysis to be completely sterile. When he visited the island nearly three years after the eruption, he found stranded on its shores seven seeds and fruits, all of which are very familiar amongst the seeds and fruits stranded on the Keeling Islands: they were those of *Heritiera littoralis*, *Terminalia Catappa*, *Cocos nucifera*, *Pandanus* (two species), *Barringtonia speciosa*, and *Calophyllum inophyllum*. Excluding the first-named, and remembering that the species of Pandanus were not identified, it may be said that nearly all these trees have established themselves on Keeling Atoll. What, however, is more important, is the fact that on the shore Dr. Treub observed growing nine young plants, of which at least four, *Calophyllum inophyllum*, *Hernandia peltata* (syn. *sonora*), *Ipomœa pes caprœ*, and *Scœvola Kœnigii*, belong to species well known in the flora of Keeling Atoll. Seven species of flowering plants had already begun to ascend the slopes of the volcano, two of them being *Tournefortia argentea* and *Scœvola Kœnigii*, so characteristic of the weather shores of the Keeling Islands. I cannot doubt but that the waves were mainly instrumental in presenting the island of Krakatoa with these familiar coral island plants, which were evidently derived from the shores of the Sunda Strait, and from the coasts in its vicinity. Dr. Treub, however, ascertained that ferns formed the prevailing vegetation (eleven species having been collected), and that a thin coating of algæ, which covered the pumice and ashes on the slopes, prepared the soil for the growth of the fern-spores, the ferns in their turn performing the same service for the flowering-plants. It is evidently to the agency of the winds that we must attribute the presence of the ferns

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* *Annales du Jardin Botanique de Buitenzorg*, vol. vii, p. 213. See also *Nature*, August 9th, 1888.

and algæ on Krakatoa; and this brings me to refer to the remarkable absence of ferns in the Keeling Islands, or rather to the fact that they have never been recorded from there. Its crytogams were represented at the time of Darwin's visit by a moss and a fungus; but no species of fern is shown in his list. This is a singular circumstance when we remember what a conspicuous part ferns take in such isolated islands as Juan Fernandez, Tristan d'Acunha, the Kermadecs, &c. Even the remote coral-group of the Paumotus in the central Pacific contained *Asplenium nidus* and a *Polypodium*. (Gray's *Botany of the Paumotus*.)

In the next place I will refer to the drift fruits and seeds that are continually being stranded on the weather or southern and eastern beaches of the Keeling Islands, and which the navigator can observe for himself on the ocean's surface during the voyage to and from this atoll. In August and September, 1888, I collected between 50 and 60 different kinds, of which, as previously observed, one-third were beans, including those of the large seeds of *Entada scandens*, which are cast up in numbers. Probably later in the year, as I was informed by the residents, I would have made a yet larger collection. Many of these drift fruits and seeds are incrusted with serpulæ, polyzoa, and cirripedes. Amongst the most numerous are those of *Barringtonia speciosa*, *Terminalia Catappa*, *Ochrosia parviflora*, *Cerbera odollam*, *Nipa fruticans*, and the large triangular seeds of *Carapa moluccensis*, which last are often occupied by the Teredo and other boring molluscs, though a goodly proportion are not thus attacked. Amongst other seeds and fruits also commonly found are those of a species of *Pandanus*, and the germinated seed of the mangrove,* with those of *Calophyllum inophyllum*, *Hernandia peltata*, *Guettarda speciosa*, *Cordia subcordata*, *Heritiera littoralis*, *Aleurites moluccana*, *Cycas circinalis*, *Ipomœa pes capræ*, and *I. grandiflora*; and amongst the leguminous plants, those of *Cæsalphinia Bonducella*, *Mucuna macrocarpa*, *Erythrina indica*, and more than one species of *Entada*. Of these stranded seeds and seed vessels, not more than a dozen or thirteen have ever succeeded in finding a home on this group of islands. I now append the list of stranded seeds and fruits, as determined at Kew:—

* The seeds of the Pandanus and Mangrove were not included in my collections. They are thrown up in numbers later in the year.

DRIFT SEEDS AND FRUITS FROM THE KEELING ISLANDS.

(The asterisk indicates those plants that have established themselves on the island).

Anonaceæ,
Pangium edule, Reinw.
**Calophyllum inophyllum*, Linn.
Guttifera ?
Heritiera littoralis, Dryander.
**Triumfetta procumbens*, Forst.
Carapa moluccensis, Lam.
Vitis sp. ?
Erythrinæ spinæ ?
Erythrina indica, Lam.
Mucuna macrocarpa, Wall.
„ *gigantea*, D.C.
„ spp. ? (3 or 4).
Dioclea reflexa, Hook, f.
Phaseolus ?
Cynometra cauliflora, Linn.
**Cæsalpinia Bonducella*, Fleming.
Entada scandens, Bth.
Leguminosæ ? huge cotyledons.
Rhizophora, sp.
**Terminalia Catappa*, Linn.
Lumnitzera coccinea, Wight et Arn.
**Barringtonia speciosa*, Forst.
„ sp.
**Guettarda speciosa*, Linn.
**Scævola Kœnigii*, Vahl.
Cerbera Odollam, Gærtn.
**Ochrosia parviflora*, Hensl.
Lactaria salubris, Rumph.
**Tournefortia argentea*, Linn.
**Ipomœa grandiflora*, Lam.
**Ipomœa pes caprœ*, Roth (*biloba*, Forst).
„ spp.
**Hernandia peltata*, Meissn.
Aleurites moluccana, Willd.
Excœcaria indica, Muell. Arg.
Quercus spp.
Casuarina equisetifolia, Forst.
Gnetum sp.
Cycas circinalis, Linn.
Nipa fruticans, Wurmb.
**Pandanus* sp.
Caryota ?

Various drift seeds not identified.

It is not a difficult matter to ascertain the direction from which this vegetable drift comes. Almost all of it is thrown up on the southern and eastern coasts, and it is evident that they have been brought by the equatorial or westerly current from the adjacent islands of the Indian Archipelago, and from the north-west coasts of Australia. It has been surmised by Mr. Keating that these fruits and seeds in order to reach this group from the Indian Archipelago have first been drifted down to Western Australia, whence they have been transported by the equatorial current to the Cocos or Keeling Islands. I do not believe that the vegetable drift from the archipelago follows such a circuitous course of over 2,000 miles. This would imply a sea-passage of several months, seeing that the first half of the distance depending on the uncertain force of the north-westerly winds during the monsoon season would necessarily be very protracted. Rather I would hold that the equatorial current or westerly drift brings the fruits and seeds in a fairly direct course from their original source, whether it be from the Indian Archipelago or the north-west coast of Australia.

What are the facts that support such an opinion? In the first place the westerly drift has not a constant direction

from the south-east, although this is the prevailing direction of the trade-wind and therefore of the surface current. For days together, the winds during the height of the trade season at the Cocos Islands may blow freshly from east-north-east to east, and in this manner by the deflection of the prevailing surface current coming from the south-east many seeds and fruits are stranded on the Cocos Islands, which otherwise would have drifted to the northward of the group. This circumstance explains how it is that vegetable drift together with floating pumice usually reaches these islands in large quantities at a time, and not as a regular and continuous supply. Again, the residents tell me that the vegetable drift arrives in greatest abundance in the months of December and January, when the trade-wind is less steady and is interrupted by the variable westerly, northerly, and north-easterly winds. It is just at this time that drifting fruits and seeds from the Indian Archipelago would be deflected towards the Cocos Islands. Thus it will be seen that our acquaintance with the winds and currents of this part of the Indian Ocean does not render it necessary to suppose that the vegetable drift from the islands of the Indian Archipelago has first to be transported to the vicinity of Western Australia before it can arrive at the Cocos or Keeling Islands.

There are, in fact, many proofs that the passage is accomplished direct from the Indian Archipelago. Many of the fruits and seeds cast up on the Cocos Islands are in a very fresh condition, and show no signs of having been more than a few weeks in the water. Others, again, however, have an ancient sodden appearance, and may have been floating for a much longer period. Yet it is a most improbable circumstance that three or four living snakes which during the last few years have been drifted on bamboos and logs to the eastward coasts of these islands, could have performed the passage thither from the Indian Archipelago by the circuitous route of Western Australia, a circumstance which would imply a sea-voyage of some 2,000 miles in length and of several months' duration. Undoubtedly they came either direct from the nearest coasts of the Indian Archipelago, 700 miles away, as is most likely in the majority of cases, or direct from Western Australia, 1,200 miles distant, or from the islands intervening between these two localities. Again, it is highly improbable that a crocodile, that arrived at these islands on a large log a quarter of a century ago, could have performed a sea-passage of 2,000 miles. No doubt, it

originally came direct from the Indian Archipelago: for in such cases it is necessary that we should assume that the nearest land is the starting-point. Again, the Krakatoa pumice arrived at the Cocos Islands in great quantity a few weeks after the eruption in the Sunda Straits, a circumstance showing that it must have pursued a course fairly direct from its source.

Hence we must conclude that most of the vegetable drift takes a course fairly direct to the Cocos Islands, whether from the Indian Archipelago or from the western shores of Australia. My experiments and those of Dr. Treub make it quite clear that several of the seeds of the trees already established on these islands can germinate after floating 6 or 7 weeks in sea-water. During this period they might have been transported by a surface-current running only one knot an hour a distance of from 1,000 to 1,200 miles, which is all that we require to establish the possibility of their germinating after a passage from the islands of the Indian Archipelago or from the nearest coasts of Australia.

Java and Sumatra, with the islands adjacent to them, probably supply a large proportion of the fruits and seeds stranded on the eastern shores of this small group. According to Mr. Keating, as quoted by Mr. Darwin, many of the familiar woods, seeds, and fruits of the region of the Indian Archipelago arrive at the Cocos Islands. A canoe has been thence drifted, and I may add that Java water-bottles, made of bamboo, and the large bamboo fishing-stakes employed in that part of the archipelago, are now frequently beached on the Cocos Islands. However, I must leave to those who determine my collections the task of ascertaining more definite facts concerning the source of the vegetable drift. I may, however, add that, as shown in the note appended to this paper nearly all the Cocos Island plants are to be found on the adjacent south coast of Java.

The part taken by sea-fowl and migratory birds in stocking these islands with plants has yet to be investigated. It is obvious, however, that birds are less certain agents in the process. The frigate-bird, for instance, when it takes its flight over the inland regions of Java and returns to Christmas Island and to North Keeling Island, where it nests in great numbers, must sometimes aid in the distribution of plants in the manner I have already instanced in the case of *Cæsalpinia Bonducella*. The species of *Pisonia* distributed in the Cocos Islands is evidently distributed in the fashion before remarked. I have also pointed out that the seeds of *Pemphis acidula* and

Triumfetta procumbens are also dispersed by sea-birds. Notwithstanding these facts, it is evident to my mind that in comparison with the agency of the westerly drift, birds have played a secondary part in stocking these islands with plants. The absence of the fruit-pigeon has deprived the flora of the Cocos-Keeling Islands of many of the conspicuous features of the vegetation of a coral atoll in the Western Pacific or of the numerous coral islands of the adjacent waters of the Indian Archipelago. The littoral trees so familiar to me on the beaches of the Solomon Islands, 4,000 miles to the eastward, and occurring with equal frequency in the yet more distant islands of the Central Pacific, are in truth nearly all represented in the Cocos-Keeling Islands, owing their extended distribution from ocean to ocean mainly to the common agency of the currents. But here in these remote coral islands in the Indian Ocean, I missed the huge banyans and other ficoid trees, the tall Kanary, and the yellow-flowered *Eugenia*, that give height and character to the interiors of the numberless coral islets of the Western Pacific. Fruit-pigeons have not found a home here. Hence the westerly drift has held the sway, and these islands have become stocked with a monotonous and sombre flora. Rather, I should write in the past tense, since a few years hence but little of the original vegetation will remain, and some brief record, such as these lines record, will be all that is left to remind the visitor of the condition in which man first found these islands.

Note on the Littoral Plants of the South Coast of West Java.

Since there can be no doubt that the Cocos-Keeling Islands have largely derived their flora from the neighbouring coasts of the Indian Archipelago, it will be of interest to learn what are the common littoral plants on the coast most adjacent to them, namely the south coast of West Java. Having been engaged for nearly six weeks in examining the geological structure of the southern sea-border of West Java, between Java Head and Cape Mandaran, promontories about 200 miles apart, I am also able with some degree of confidence to describe the general character of the littoral vegetation of this coast.

The greater portion of this extent of coast is low and sandy, and for the most part destitute of coral reefs. Here the sea-border is formed by a low, sandy belt, usually 200 to

500 yards wide, backed inside by low hills and inland cliffs, and terminating at the beach in a mound or dune of sand raised from 5 to 10 feet above it. Here and there a headland descends to the sea, and in places the coast terminates in cliffs, usually of moderate height, and formed of foraminiferous tuffs and clays, limestones, and volcanic rocks. Where coral reefs occur, they are usually scanty and broken, and belong to the fringing class. It is only along shores fringed by reefs that the sea-border may be swampy. Numerous rivers, mostly shallow, and widening out at their mouths into large lagoons, descend to the south coast.

The sand mound that borders the beach, forming, as I have just described, the raised border of the low sandy belt which is the prevailing feature of the south coast of West Java, is covered for the most part with *Crinum asiaticum*, *Calotropis gigantea*, *Scævola Kœnigii*, *Pandanus* sp., *Ipomœa pes caprœ*, *Triumphetta subpalmata*, and last, but by no means least frequent, *Spinifex squarrosus*. In many localities, in fact, *Spinifex squarrosus*, *Crinum asiaticum*, and *Calotropis gigantea* together occupy the entire surface of the mound, or it may be covered only with Pandanus. Just inside the mound littoral trees occur, *Cycas circinalis* and *Hibiscus tiliaceus* being often noticeable; but the greater portion of the sandy belt inside is covered with short grass and spurges, being only dotted here and there with occasional pandans and some of the commonest littoral plants, such as *Crinum asiaticum* and *Calotropis gigantea*.

Such are some of the more conspicuous characters of the prevailing littoral vegetation on the south coast of West Java, that is to say, wherever the sea-border is low and sandy. Where the coast is cliff-bound, pandans are very frequent. It is, however, along those shores that are to a greater or less degree fringed by coral reefs that we usually find the most varied littoral flora. On the coasts between Capes Mandaran and Genteng, where the sea-border is for the most part low and sandy and nearly destitute of coral reefs, we find in consequence the more varied flora only at rare intervals. For instance—to take the only locality with which I am personally acquainted—along the reef-girt shores a few miles east of Ranzaherrang occur the familiar and widely spread littoral trees, *Scævola Kœnigii*, *Tournefortia argentea*, *Calophyllum inophyllum*, *Terminalia Catappa*, *Guettarda speciosa*, and others; whilst *Crinum asiaticum* also may be sparingly represented. It is, however, on the coast west of Wynkoops Bay, especially on the Bantam coast in the vicinity of Tjiara,

where it is irregularly fringed by coral reefs, that we find most extensively represented these and other common littoral trees. A little within the belt of pandan trees and of *Crinum asiaticum* that immediately lines the beach, the coast-road for several miles traverses a forest of fine old trees of *Hernandia peltata*, with which is associated also in considerable numbers *Cerbera odollam* and *Premna obtusifolia*, together with *Terminalia Catappa*, *Guettarda speciosa*, and an occasional *Calophyllum inophyllum*. It is scarcely necessary to refer here to the ubiquitous *Ipomœa pes caprœ*, which commonly clothes the ground near the beach in this locality as well as along the whole south coast of West Java. . . . It may perhaps be of interest to those who have not the time or the inclination to visit the remote south coast of Bantam, to learn that along the west shore of Wynkoops Bay between Palabuan and Tjisolok the littoral trees are well represented. Bordering the beach there we find pandan trees, *Crinum asiaticum*, *Scævola Kœnigii*, *Cerbera odollam*, &c., whilst immediately within, the coast-road traverses a belt of handsome old trees of *Calophyllum inophyllum* and *Terminalia Catappa*, with which are also associated banyans and the familiar *Hibiscus tiliaceus* . . . . . I should, in the last place refer to a species of *Tacca* (*T. pinnatifida*), of which one observes, but only at rare intervals, a few solitary individuals growing a little within the vegetation lining the beach.

The mode of dispersal of the majority of the plants above mentioned has been already referred to in my remarks on the Cocos-Keeling Islands; and it will be at once perceived that these islands might have largely been stocked with their flora from the south coast of West Java. There are, however, some of their trees that did not come under my observation on this coast, as, for instance, *Barringtonia speciosa* and *Cordia subcordata*. Doubtless, however, they do occur, though not in many localities; yet it should be remarked that I very rarely came upon the fruits of the first-named tree among the vegetable drift on the beaches, whilst those of *Cordia subcordata* did not come under my notice at all. Then, again, I may be permitted to record the rarity, if not the absence, of *Pemphis acidula* on this part of the Java coast. Probably the sea-birds, to which as before shown this tree evidently in the main owes its dispersal, do not nest in any numbers on this coast.

It is remarkable that two of the commonest littoral plants of this part of the coast of Java, namely, *Crinum asiaticum* and *Calotropis gigantea*, do not occur in the Cocos-Keeling

Islands. The fruits of both float in salt-water,* but I do not know for how long; they, however, do not occur in the drift fruits of these islands. Then, again, *Cycas circinalis*, common enough in some parts of this coast a little way in from the beach, is also unrepresented in the Cocos-Keeling Islands, though its fruits deprived of their fleshy covering occur there amongst the vegetable drift. I should here observe that these fruits are better fitted to be transported across wide tracks of ocean than a single experiment a few years ago in the Solomon Islands led me to believe. Then I found that out of ten green fruits picked off the same tree only one floated in salt-water. When, however, I repeated the experiment on the south coast of Java, I found that out of three green fruits all floated in sea-water, though heavily. After stripping the fleshy outer covering off one of these fruits I noticed that it floated more buoyantly; but by allowing it afterwards to dry for some time, I ascertained that its buoyancy was still greater, this being the condition in which these fruits are stranded on the beaches of the Cocos-Keeling Islands, where the crabs often break them open to get at the pulpy seed inside . . . . . There is another plant represented (though sparingly) on the south coast of Java, which does not occur in these islands, viz., *Tacca pinnatifida*. I ascertained that the freshly picked fruits float heavily in sea-water, whilst the seeds sink.

In the following list I have enumerated the plants that came casually under my notice on the south coast of West Java. The asterisks denote those that are found in the Keeling Islands; and a single glance will be sufficient to convince one that the Keeling Islands have largely derived their plants from the adjacent coasts of the Indian Archipelago, of which the south coast of West Java may be taken as fairly typical as regards its littoral vegetation.

Littoral Plants on South Coast of West Java.

(As observed casually by the Author.)

**Calophyllum inophyllum*, Linn.
**Hibiscus tiliaceus*, Linn.
**Triumphetta subpalmata*, Soland.
**Terminalia Catappa*, Linn.
**Guettarda speciosa*, Linn.
**Scævola Kœnigii*, Vahl.
Cerbera odollam, Gærtn.
Calotropis gigantea, R.Br.
**Tournefortia argentea*, Linn.
**Ipomœa pes capræ*, Roth (*biloba*, Fork).
**Premna obtusifolia*, R.Br.

* The fleshy seed of *Crinum asiaticum* has not the appearance of a seed that would float more than a week in salt-water.

**Hernandia peltata*, Meissn.	*Crinum asiaticum.*
Cycas circinalis, Linn.	*Tacca pinnatifida*, Linn.
**Pandanus*, sp.	*Spinifex squarrosus*, Linn.

Note.—Most of the plants in the above list I was already familiar with. I am, however, indebted to Dr. Treub and to the officials at Kew for the identification of the specimens belonging to those of which I was uncertain, namely, *Triumfetta subpalmata, Cerbera odollam, Calotropis gigantea, Premna obtusifolia, Hernandia peltata, Cycas circinalis, Crinum asiaticum, Tacca pinnatifida*, and *Spinifex squarrosus*.

Note on the Vegetable Drift of the South Coast of West Java.

The drift fruits and seeds that came most frequently under my notice on this coast were those of *Terminalia katappa, Cerbera odollam, Pandanus* sp., *Calophyllum inophyllum, Heritiera littoralis*, with numerous beans, most of them familiar to me amongst the drift on the beaches of the Cocos-Keeling Islands, especially *Mucuna macrocarpa*. The fruits of *Barringtonia speciosa* rarely came under my observation. There were also several other fruits and seeds; and amongst them I picked up on the beach a seed of *Crinum asiaticum* in a germinating condition. Amongst those of less frequent occurrence were the triangular seeds of *Carapa moluccensis*, and the hard black seeds of *Aleurites moluccana*. On the south coast of Bantam in the vicinity of Malingping I found on the beaches numbers of acorns of a species of *Quercus* which occur also amongst the drift of the Cocos-Keeling Islands; the tree is found in the interior of Java, amongst other localities, in the elevated region of the Genteng Promontory.

In all probability the great majority of these drift fruits and seeds were derived from trees on the same coast; some, however, were brought down by the rivers from the interior of Java, there being usually an accumulation of the seeds and fruits of non-littoral plants on the beaches at the mouths of the rivers. The importance of the agency of rivers in bringing down to the sea the fruits and seed-vessels of inland plants is, I think, rather apt to be overlooked. Such an agency readily explains the occurrence of the fruits or seeds of inland as well as cultivated plants, as the *Quercus*, sp. (above mentioned), *Pangium edule*, &c., amongst the drift of the Cocos-Keeling Islands.

Although, as above stated, the great majority of the fruits and seeds of the vegetable drift are evidently derived from the trees on the same coast, since they may be

observed in all conditions, from the green state to the dry, yet this does not affect the importance of their occurrence, seeing that it is of interest to ascertain not only what seeds and fruits have come from distant regions to any particular island, but also the manner in which such seeds and fruits start upon their ocean journeys, and the locality from which they may have been transported. It is probable enough that many of the familiar seeds and seed-vessels of the vegetable drift of tropical seas lie for some time on the beaches, in the vicinity of which the parent trees are growing, before unusually high tides, or the seas of a heavy gale, sweep them off into the ocean. This preliminary stage of preparation, though not always necessary, gives the fruit or seed a better chance of being drifted across a wide expanse of sea. It is in this manner that the fruits of *Terminalia Catappa*, *Ochrosia parviflora*, *Cerbera odollam*, *Guettarda speciosa*, and many others lose their outer fleshy covering before they commence their ocean voyage. In fact in some cases, as in the instance of *Cordia subcordata*, it is, as I have before shown, almost essential that the seed should first lose its outer skin; otherwise it rots in the salt-water.

There are, however, some of the seeds and fruits occurring amongst the vegetable drift on the beaches of the south coast of West Java, that almost certainly have been derived from more distant islands. Take, for instance, the triangular seeds of *Carapa moluccensis*, which I have found on these beaches with their interiors hollowed out and occupied by the empty tubes of the Teredo: it is in this condition that these seeds usually occur amongst the drift of the Cocos-Keeling Islands.

The following is the list of drift seeds and fruits picked up by me on the south coast of West Java, as determined at Kew:—*Calophyllum inophyllum*, Linn; *Heritiera littoralis*, Dryander; *Carapa moluccensis*, Lam.; *Pometia eximia*, Hook, f.; *Mucuna macrocarpa*, Wall.; *Mucuna gigantea*, D.C.; *Mucuna*, sp.; *Pongamia glabra*, Vent.; *Entada scandens*, Benth.; *Terminalia catappa*, L.; *Cerbera odollam*, Gærtn; *Ipomœa biloba*, Forsk ?; *Quercus*, spp.; *Aleurites moluccana*, Willd; *Excœcaria indica*, Muell-Arg.; *Pandanus*, sp; *Crinum* (*asiaticum?*) . . . It is to be noticed that of the 17 drift seeds and fruits here named, 14 occur in my list of the seeds and fruits stranded on the Keeling Islands, the exceptions being those of *Pometia eximia*, *Pongamia glabra*, and *Crinum* (*asiaticum?*).

My paper is now brought to a close. In it I have omitted

little that does not push my argument home concerning the stocking of this coral atoll with its plants. I have described its original vegetation, before man's disturbing influence began; I have demonstrated by observation and experiment the facilities for dispersal possessed by the plants, and have pointed out the reason of the absence of certain familiar species; I have dwelt in detail on the seeds and fruits brought by the currents to these islands, and have ascertained the direction in which they drifted; I have followed these ocean waifs to their principal home on the coasts of the Indian Archipelago, and have observed the parent plants growing on those shores; lastly, I have referred to an instance of an island in these seas, absolutely bare of vegetation, where the process of plant-stocking has been carefully observed, and where amongst the first of the flowering plants to grow from the seeds and seed-vessels stranded on its shores were those of familiar Keeling Island species. This method of itself would be conclusive, as long as the facts are trustworthy, and for this I can safely vouch.

Conclusions.

The principal points of this paper may thus be summed up:—

(1.) The evidence goes to show that the cocoa-nut palms established themselves on these islands before their occupation by man.

(2.) Several coral island plants, not recorded by Darwin in 1836, but which there are good reasons for believing originally existed in these islands, occur in my collections (see page 272).

(3.) Crabs, by eating the seeds stranded on the beaches, are important agents in preventing certain common littoral plants from establishing themselves on these islands (page 276). Thus it has happened that not more than one-fourth of the numerous seeds and seed-vessels brought by the currents have found a home on this atoll.

(4.) It is well known that the familiar fruits of *Barringtonia speciosa*, *Calophyllum inophyllum*, *Terminalia Catappa*, &c., will float for a long time in sea-water unharmed; and the experiments recorded on page 287 show that several other coral island plants will germinate after floating from six to seven weeks in sea-water.

(5.) The flora has been mostly derived through the agency of the currents from the adjacent coasts of the Indian Archi-

pelago, though it is probable that sea-birds have assisted in the process.

(6.) Since this paper was written, Mr. Hemsley has removed my difficulties concerning the transportal by currents of such small seeds as those of *Portulaca oleracea* and *Suriana maritima*, which seem ill fitted for this end. They may be carried in the seed-vessels attached to the floating plant or branch.

Mr. Hemsley has very kindly read the proof of this paper, and has made some suggestions and corrections; but I am entirely responsible for the opinions and conclusions it contains, and of course I cannot expect assent on all points. He has ascertained for me that the stranded seed of a species of *Crinum* (*asiaticum?*), which I picked up in a germinating condition on the coast of Java in January, 1889, has developed into a healthy plant a foot high at Kew (January, 1890).

NOTE ON THE PLANTS REFERRED TO IN THE EARLY ACCOUNTS OF THE KEELING ISLANDS.

From the accounts of these islands given by Van der Jagt,* Keating,† and Ross,‡ all of which were written in either 1829 or 1830, only two or three years after the establishment of the settlement, and some six or seven years before the visit of Mr. Darwin, it is evident that amongst the vegetation found by the first settlers on these islands there were several littoral trees, some of which were observed by Mr. Darwin, whilst others, owing to the shortness of his visit and on account of their probable paucity, were not recorded. I have marked with an asterisk those which are not to be found in Mr. Darwin's list: they are characteristic coral island plants, and they are still, though scantily, represented.

**Barringtonia speciosa.* "A large tree with a square nut of about 6 inches in diameter and rusky on the outside" (Ross).

Hibiscus tiliaceus. "The Waroe or Warroo" (Ross and Jagt). This is a common Malay name for this tree in the Indian Archipelago, and the Keeling Islanders still only know it by this name. Its ornamental and useful purposes are noted, such as supplying fibres for fishing lines and nets, &c.

**Thespesia populnea.* "A tree like the Waro, growing near the shore" (Ross).

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* See footnote on the second page of this paper.

† Holman's *Travels.*

‡ *Gleanings in Science:* Calcutta, 1830. Also *Journ. Roy. Geogr. Soc.*, vol. i, 1831. Mr. Ross carefully distinguishes the indigenous from the introduced plants.

**Hernandia peltata.* "A tree with a fruit like that of the Jack-in-the-box of the West Indies" (Ross).

**Morinda citrifolia.* "A tree with a fruit like plum-cake, and with a root that has a scarlet dye" (Ross).

Cordia subcordata. The Keeling Islanders now call it "Grongang," and in 1829 it was known as the "Borongang" (Jagt), which is simply the name with the Malay prefix of "bua," a fruit. All the earlier accounts refer to the arching mode of growth of this tree, to its durable wood, and to its suitability for ship and boat building.

Scævola kœnigii. The "Bessie of Jagt and the Gagabœssan of some parts of the Indian Archipelago. The Keeling Islanders now call it "Kankong-cumbang-sabla," *i.e.*, the half-flowered plant, referring to the gaping corolla.

Pemphis acidula. Its present name of "Burung" or "Bœrœng" is the same as "Hœrœng," with the prefix of "bua," the name in the early days (Jagt). The tree was described then as with foliage like that of the box-tree, and with reddish or yellowish wood, employed for houses.

**Pisonia* (*inermis ?*). The "Ampol" of 1829 (Jagt), and of the present day.

**Pandanus*, sp. (Jagt and Keating).

"Chinkauen" or "Dadap," a soft-wooded, green, and thorny-barked tree (Ross).

"A tree resembling the *Protea* species, with a very soft wood and a silver leaf" (Keating).

"A tree somewhat similar to the Norway pine, growing about 30 feet high, and with a heart-shaped leaf" (Keating).

Three of the trees marked with an asterisk as not appearing in Mr. Darwin's list were included in Mr. Forbes' list of 1878, namely, *Morinda citrifolia*, *Pisonia* (*inermis*), and *Pandanus*, sp.

On referring to the list of *previously unrecorded* plants given on p. 272, it will be noticed that two trees there named, namely, *Calophyllum inophyllum* and *Terminalia catappa*, are apparently not mentioned by the early settlers. In this paper, however, I have shown the probability of their having been then on these islands. The currents bring their fruits in numbers to this atoll. *Suriana maritima* is referred to on pp. 275–281. *Erythrina indica* and *Casuarina equisetifolia* have been probably introduced by man. All the other unrecorded plants, perhaps excepting the Euphorbia, are common coral island plants.

The PRESIDENT (Sir G. GABRIEL STOKES, Bart., M.P., P.R.S.)—I will ask you to return your thanks to Dr. Guppy for his very interesting paper.* I am sure all will be sorry to hear that the

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* Letters were received from some unable to be present at the Meeting, including one from Mr. W. H. Hudleston, F.R.S., lamenting the prospective disappearance of the original flora of the Keeling Islands, and one from the (now late) Sir Warington W. Smyth, F.R.S., regretting that ill health prevented his presence at the Meeting. Sir Warington has since passed away, and the scientific world has lost one of its most esteemed and valued members.—ED.

cause of the absence of our Honorary Secretary, Captain Petrie, is that he is very dangerously ill.

Dr. CUTHBERT COLLINGWOOD referred to a visit he had made to the uninhabited Pratas Coral Atoll where he had observed two influences at work, the destructive influence of the crabs and the carrying agency of the birds. When on a small island off the coast of Borneo, he had observed the hermit crab to live almost entirely on the tender parts of the Mango, and in the Keeling Islands, where they abounded, he could well understand their not permitting any tender shoot, of the cocoa-nut tree, for instance, to survive. As regards the producing force he was surprised to find sea birds considered to be carrying agents for seeds, as they usually fed on fish; on the islands he had alluded to as having visited, the birds were numerous and very tame, although they would not permit one to approach them, always vomiting their food (apparently fish), and flying away when anyone did. On shooting frigate birds he had always found fish in their stomach. He did not mean to contravert the statements of the author and could only suppose that in the absence of fish the birds might sometimes feed on seeds.

Rev. F. A. WALKER, D.D., F.L.S., remarked that in one part of the paper the author said "New insects have been introduced accidentally or intentionally during the last half century," and asked what insects had been found and what was the fauna known to exist in the Keeling Islands, 50 years ago, and whether the fact of new insects having been introduced pointed to efforts at acclimatisation by any of the present residents in the Keeling Atoll. As the Solomon Islands had been mentioned in the paper he might add that it was worth while to notice that it was curious to find there not only a new species of bird wing (ornithoptera) but also the species known as the swallow-tail. Nearly every island of the Malay archipelago had a species of bird-wing butterfly peculiar to itself, and the Malay group of islands was the only one in the world containing many large and handsome species of butterflies that had not been found on the adjacent continent also.

The AUTHOR.—My other duties have prevented my paying much attention to insects, but Mr. Forbes was on the islands in 1878, and made a collection, which, however, he unfortunately lost in Java, through the upsetting of a boat, but he has published his

observations in an account of his travels in the Indian archipelago. As regards frigate birds not bearing seeds, of course, I only hold that they do so very rarely, perhaps one in a thousand, but several people showed me the seeds, *Cæsalpinia Bonducella*, and I think that there is no doubt about the mode of their conveyance. When I was cruising in H.M.S. "Lark" in the South Atlantic we caught a Cape pigeon and found a small seed inside it. We were 700 miles from the nearest land and these birds followed us across the Indian ocean, in fact, they go round the globe. Of course the subject of the dispersal of plants is one which we are only beginning to know something about, and therefore there must be a good deal of guess work in respect to it, and the only way is to investigate by experiment whenever we can. Most of the specimens I have here are very common in the Coral Islands. One is *Barringtonia speciosa*, another is *Pangium edule*, which is eaten in Java, and it is often carried to the Keeling Islands, but never germinates, for the crabs eat the kernel.

The Meeting was then adjourned.

REMARKS ON THE FOREGOING PAPER.

Professor T. RUPERT JONES, F.R.S., &c., writes:—"I was unable to attend the meeting and hear Dr. Guppy's paper, but I have read it with much pleasure and advantage.

"It is full of fact and good inferences relative to the struggle for existence among plants and animals, and will be a rich source for philosophical scientists to gather notions from in the future. The scientific care and precision of the observations, experiments, descriptions and conclusions are very noteworthy, and make the paper highly worthy of any Society that takes up the subject."

Mr. JOHN MURRAY, of the "Challenger" expedition, writes:—"I have read, with very great pleasure, Dr. Guppy's paper, and I do not think I can speak too highly of it as a solid contribution to the history of a coral island. His explorations and observations are well known; his experiments and the way he has worked up his collections will, I am sure, be fully appreciated by all naturalists who take an interest in the distribution of organisms over the face of the earth, and in a very special manner by all who are interested in oceanic islands."

NOTE.—A most interesting example of the way in which vegetation spreads has been furnished by Krakatoa, which after the great catastrophe of 1883, was left absolutely bare of life; the heat was intense, for the whole island was covered with a layer of cinders three feet thick. And yet already, after the short space of six years, the island, on being examined by an enthusiastic botanist, has been found to have a number of ferns flourishing on its unpromising soil. He writes:—"these would not have obtained a footing had not some of the lower forms of microscopic plants first established themselves, and rendered the soil a little gelatinous and moist for the fern roots. The ferns in their turn are preparing a surface soil on which stray seeds of the higher plants will be able to germinate. This illustration of the process by which a heap of cinders is converted into a palmy South Sea Island is the most striking on record. The fern spores must have been borne on the winds."—ED.

AUTHOR'S FURTHER REPLY.

Dr. H. DE VARIGNY, in the *Revue Scientifique* for March 28, 1891, gives a lengthy review of my paper. He has there not only given the artist's touch to my bare narrative of facts and experiments, but has given point and clearness to many of my imperfectly expressed conclusions, and for method and arrangement his review is certainly superior to my original paper. "L'étude de M. Guppy," thus he concludes the notice, "méritait mieux qu'une simple mention: c'est une œuvre faite avec beaucoup de soin, répondant aux exigences de la critique expérimentale, et qui certainement fera beaucoup pour établir sur une base solide l'hypothèse d'après laquelle les courants océaniques jouent un rôle important dans la dispersion des êtres. Ce n'est même pas aller trop loin de dire que M. Guppy a fait de l'hypothèse une réalité, de la théorie un fait acquis."

The following additional experiments on the flotation of the seeds and seed-vessels of coral island and tropical plants have been recently made by me (the author).

On June 8th, 1890, I put in sea-water a single bean of *Entada scandens*, a bean of another species of *Entada*, a seed of *Cæsalpinia Bonducella*, and a seed of *Aleurites moluccana*, all of which were

collected in the autumn of 1888 amongst the drift thrown up on the Keeling beaches. They were all still floating in the first week of June, 1891, and were seemingly as buoyant as ever. Five seeds of *Morinda citrifolia*, a seed of *Thespesia populnea*, two fruits of *Scævola Koenigii*, a fruit of *Cordia subcordata*, and a seed of *Ipomœa grandiflora*, all obtained in the fresh condition in September, 1888, from their respective plants in the Keeling Islands, were placed in sea-water on June 8th, 1890, and were still afloat just twelve months afterwards, in June, 1891, apparently unharmed. Four fruits of *Tournefortia argentea* (from Keeling plants) that I picked up from the ground in September, 1888, remained afloat in sea-water in June, 1891, after being just twelve months in the water. Five seeds of *Tacca pinnatifida* from a fruit that I picked off a plant on the coast of Java in November, 1888, were placed in sea-water on June 8th, 1890, and are still afloat after an interval of twelve months. When I obtained the fresh fruits I noted that they floated heavily in sea-water, while their seeds sank. Two pods of *Pongamia glabra*, found washed up on the Java coast in December, 1888, were placed in sea-water on June 8th, 1890; one sank after 125 days, and the second floated 202 days before sinking. Three seeds of *Hibiscus tiliaceus*, obtained from a tree on the Keeling Islands in September, 1888, were placed in sea-water on July 20th, 1890; the first sank on September 18th, 1890, the second early in February, 1891, and the third in the second week of March, 1891. A single *Teak* fruit (*Tectona grandis*) from Java has now been floating just twelve months, having been kept dry previously for nearly two years. The beans of three or four species of *Mucuna*, collected by me in the vegetable drift of the beaches of the Keeling Islands and of the Java coast during the latter part of 1888, were placed in sea-water in June, 1890; but their powers of flotation varied greatly, three beans of one species sinking in from three to eight days, two beans of another species sinking in from 60 to 100 days, whilst two beans belonging to other species are still floating buoyantly after twelve months in the water. I have remarked in my paper that the seeds of *Suriana maritima* sink in a few days, but I should have said "fresh" seeds. Six seeds that I had by me for over two years, seeds obtained from the identical tree to which the fresh ones belonged, were placed in sea-water on March 9th, 1891, and four of them were still afloat about four months afterwards. Three seeds of *Coix lachryma*, obtained in the Solomon Islands in 1884, floated only from two to six days in sea-water in 1891. (The sea-water in

all these experiments was shaken about every few days, and the position of the floating seeds and fruits frequently changed.)

I am now completing the experiment. Most of the seeds will take a long time to germinate, but those of *Thespesia populnea* and *Ipomœa grandiflora*, have already germinated after floating a year in sea-water. An interesting point in connection with this experiment is that it has been carried out in London, and all the seeds and seed-vessels that have been afloat twelve months, were exposed to a degree of cold in the winter, that kept fresh-water frozen for three weeks on the same table. I am bold enough to think that a Coral Island seed might be carried, in summer, across the North Pole, and yet germinate, that is, if there is a current to carry it.

ORDINARY MEETING.*

H. CADMAN JONES, ESQ., M.A., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed, and the following Elections were announced:

LIFE MEMBER:—The Ven. Archdeacon J. Ingham Brooke, M.A., Halifax.

MEMBERS:—The Rt. Hon. Lord Brassey, Sussex; the Rt. Hon. Lord Teynham, Kent; the Rt. Rev. the Bishop of Columbia, Victoria; Sir Sydney Webb, K.C.M.G., D.L., J.P., Twickenham; A. Boutwood, Esq., Southgate; S. Causton, Esq., Kent; Rev. C. Pickering Clarke, M.A., Surrey; Rev. A. Fairbanks, M.A., London; Rev. W. D. Fanshawe, M.A., London; Rev. H. Griffin Hellier, London; Isaac Hoyle, Esq., M.P., Prestwich; J. F. Hewett, Esq., Surrey; Rev. E. A. Knox, M.A., Leicester; J. Monro, Esq., C.B., London; J. M. Peebles, Esq., M.D. United States; Rev. Reuen Thomas, Ph.D., D.D., United States; T. Ward, Esq., J.P., F.G.S., Northwich.

LIFE ASSOCIATE:—Anson Phelps Stokes, Esq., United States.

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* December 1st, 1890.