

On Endemism and the Mutation Theory.

BY

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THE history of the rise and fall of species of plants or animals is a subject of great interest, and it is one which has very seldom been worked out. Dr. Willis has, however, lately, in a paper to the Royal Society, *Phil. Trans.*, B, ccvi, p. 307, and one published in the 'Annals of Botany' (vol. xxx, 1916, p. 1), attempted to formulate a law dealing with the rarity or commonness of species and its bearing on the endemic plants of Ceylon. He bases his argument on a study of Trimen's 'Flora of Ceylon', in which work Dr. Trimen states under the description of each plant whether it is very common (VC), common (C), rare (R), and very rare (VR). Now it is known that Trimen in putting these notes merely referred to the number of specimens in the Ceylon herbarium, and Dr. Willis (*Ann. Bot.*, l. c., p. 4) admits that the figures 'are based on herbarium specimens'. Dr. Trimen himself in vol. i, p. ix, writes as to general distribution and comparative frequency: 'Very much has yet to be done in tracing out the distribution of plants through the island, and the information here given is very imperfect and will be much modified and increased by further investigation.'

No further investigation on these lines has apparently been done in Ceylon. In Dr. Trimen's day Ceylon was not so easy of exploration as it is now, and even now large areas are difficult to get at, and would require a large staff of botanical collectors to take a thorough census of the various species throughout the island. I do not think that this has been done indeed for any region of the world except the British Isles.

The number of specimens of a species in a herbarium does not show at all the abundance or rarity of any given plant. Frequently a tree in the tropics does not flower for very many years, and collectors do not collect specimens which are not in flower or fruit. One of the commonest trees in Sarawak is *Koompassia parvifolia*, the Tualang. The only flowering specimen known is one in the Florence herbarium picked up by Beccari, and the only fruiting ones were collected by me last year. Thus in herbaria this would figure as VR (very rare), whereas it should be VC (very common).

Conversely, a plant only known from a single tree often in flower and easy of access might be extensively represented in herbaria, as every

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collector who happened to be in its neighbourhood would naturally collect specimens.

In an extensive tropical area like that of Ceylon, to make a census of scientific value upon which one could safely base deductions, a very large staff of collectors and botanists would be required; in fact, a botanical survey such as has been of late years commenced for India would have to be organized. The number of botanists mentioned in Dr. Trimen's *Flora* is under twenty, and this includes several who only resided a year or two in the island, and practically only Hermann, Koenig, Champion, Gardner, Thwaites, and Trimen collected on anything like a large scale. Dr. Trimen did the best he could with what time and materials he had, but, as he says, his work is incomplete.

Dr. Willis (*Ann. Bot.*, l. c., p. 22) states that 'A very small accident may kill out a species while at or below the stage represented in the Ceylon classification by VR, whilst it will need a geological submergence or some such accident to kill out one represented by VC', and 'There is no evidence whatever that any of the angiospermous species of the Ceylon flora are dying out, and from analogy we may imagine this to be generally true'.

I first visited Ceylon in the autumn of 1888 and stayed for a month at Peradeniya with Dr. Trimen. At that time *Hedygium coronarium*, L., and *H. flavescens* were conspicuously abundant all round Peradeniya and Kandy, and Dr. Trimen marks both of them VC in the *Flora*, vol. iv, p. 245.

I visited Ceylon several times later in 1912 and 1913, and went to Peradeniya on these occasions; but it was not till my last visit that I noticed that both species had entirely disappeared, and I asked Mr. Lyne, the Director of the Gardens, if he had seen them anywhere, and he was surprised to hear that they had ever been common, as he had not seen a plant at all in Ceylon.

Here is a case in which a plant, which in 1888 was very common, in twenty-five years has become at least very rare, without any geological cataclysm to account for it. It is difficult to give any reason for its disappearance, as no observer at the time seems to have noticed it. But as an example of the way a common plant may at least become rare, I would mention some observations of mine on *Lantana mixta* in Singapore. When I first arrived in Singapore in 1888, this shrub was very abundant all over the waste ground in Singapore; on my last visit there it had become comparatively scarce—one had to look about the country for it. I found a plant in the edge of the wood by the roadside, and on examining it found that every one of the young fruits on the whole bush was perforated by a small green bug, and that all these fruits which had been sucked by the bug withered up and never came to maturity. Now as *Lantana* is widely dispersed by birds, which swallow the ripe seed and pass it unharmed, the occurrence of the bug and its attack on the young fruit consequently

entirely prevented the propagation of the plant. The bug appeared to me to be identical with a species which attacked the Cotton plant in the same manner, and was one of the two species which prevented our cultivation of Cotton in the Malay Peninsula. I will add that a large part of the *Lantana* which was destroyed throughout the island was destroyed by the extensive planting of Para Rubber in Singapore, whereby the lands which after the Chinese had abandoned the cultivation of Gambir and Pepper there had been largely covered with *Lantana* were again cleared of weeds and bushes, including the *Lantana*. The action of man in destroying species I will refer to later.

The action of enemies, whether insects, fungi, or bacteria, in the destruction of a species in a natural state has not yet received that attention of field naturalists which the subject requires; but every tropical agriculturist knows that an insect or fungus which commonly lives on one particular plant may adapt itself so as to attack another allied plant, and, if the latter grows in abundance in any area, may practically exterminate it.

An excellent example of the destruction of a species completely within a very limited space of time is furnished by the extermination of the two rats of Christmas Island.

This island was first visited by any naturalist in 1886, when the *Egeria*, with Mr. Lister as naturalist, visited the island. At that time the island swarmed with both species of rats, especially *Mus Macleari*, the white-tailed rat, of which, judging by accounts, there must have been millions. In 1904 Dr. Hanitsch and I visited the island to collect the flora and fauna, and though we went far into the forest and set traps for rats, not one of either species was to be met with. On inquiring of the residents on the island, we were informed that the white-tailed rats had totally disappeared, and the last one that was seen was rambling about apparently very sick in the neighbourhood of the settlement. What had happened? The only probable solution was that the destruction was caused by the introduction of the common brown rat; not from this animal having eaten up the food of the white-tailed rat, for the rat's food, the fruits of the trees in the island forests, lay untouched on the ground in abundance, but in all probability from the introduction of some bacterium (possibly the plague) by the stranger. The brown rat itself had not spread over the island to any extent, and mainly confined itself to the neighbourhood of the settlement.

A very similar case appears to have occurred also in the island of Fernando de Noronha, where, when this island was discovered, there was great abundance of a large rodent described by Mazarredo in 1774 as the *paca* or *mulita* of Buenos Aires. This animal has apparently utterly disappeared, for in my expedition to that island in 1887 we were unable to discover any trace of it, nor did any of the residents know of its existence. If such destructions of an animal species may occur in so short a time, why should not the same thing occur in plants?

The disappearance of *Hedychium coronarium* and *H. flavescens* in Ceylon and that of *Lantana mixta* in Singapore seem to show that this may occur.

DESTRUCTION OF SPECIES BY MAN.

The first botanist that came to Singapore, Dr. Wallich, in 1822 found the whole island densely covered by forest, and a few of a wild tribe of men known as the Orang Selitar lived chiefly in boats on the southern sea-shore. It was the custom, it appears, for ships travelling to the East to go through the Johor Straits, to avoid the pirate Orang Selitar and the pirates in Galang and the other islands to the south, which shows that the northern part of Singapore and South Johor were but little inhabited.

Wallich's collections were apparently chiefly made in the south of Singapore where the town now stands. Raffles later, to open up the island, introduced the Chinese, who felled for export a great deal of the timber trees and opened up, cleared, and burnt large areas for the cultivation of Pepper and Gambir, moving from place to place as they exhausted the soil and firewood. When I arrived in Singapore in 1888 only a very few forests remained in the island and the south of Johor. Over the rest of the island the forests had been replaced by Lalang grass (*Imperata cylindrica*), *Lantana mixta*, and other introduced plants, and by secondary growth. The sandy shores on the south were first planted with rice, then with coconuts; but a patch of the original flora of this area containing *Vaccinium*, *Melaleuca*, *Leucopogon*, and *Capparis Finlaysoniana* remained for some time more or less unaltered, but has since been destroyed, and as this was the only known spot for this beautiful *Capparis* it is probably quite extinct.

The remaining scraps of forest persisted, till a few years ago, under the control of the Forest Department, but were practically destroyed at length, with the exception of a few acres.

The demand for land for Rubber cultivation finished off most of them. The especially sought for trees valued for timber were naturally destroyed first, such trees, e.g., as *Dialium* and Dipterocarpeae. Where the ground was cleared on the edge of the forest, the bright sunlight let in destroyed speedily many of the delicate herbaceous plants like *Pentaphragma Ridleyi*, at one time very abundant on Bukit Timah, but which has been nearly exterminated by the making of a quarry and felling of timber which let the light into the rest of the forests. Grass fires on the jungle edge contributed to the destruction of the original flora within the forests.

My early collections here contained nearly all of the species collected by Wallich and Maingay, but many were then very rare, and some are now undoubtedly extinct. I will mention a few species only known from Singapore and now believed to be quite extinct, *Capparis Finlaysoniana* has already been mentioned.

Strophanthus Maingayi, Hook. fil. 'Climbing extensively over trees', Maingay. This beautiful plant, with white flowers as big as a wine-glass it is said, was again collected by Hullett at Changi before 1888. I visited the spot where he found it with him, but it was gone and has never been seen again anywhere.

Melastoma molle, Wall. Collected in Singapore by Wallich, 1822, reduced to a variety of *M. decemfidum*, Roxb., by Clarke, but certainly distinct, reported to have been obtained in Luzon by Cuming. I found a single small plant without any signs of flowers in dense jungle on Bukit Timah. The plant had disappeared on my next visit, and it has not been seen again anywhere.

Endopogon Ridleyi, Clarke. The whole of the country lying north-west of Bukit Timah has long been felled and cleared. It was being felled for timber in Wallace's time, 1854, as described by him in his 'Malay Archipelago'. There remained, however, a small patch of wood through which ran a small stream; on its banks grew abundance of *Endopogon Ridleyi*, and near it grew a fine Ginger, *Zingiber chryseum*, Ridley. In 1911 this patch of jungle was felled and burnt, and both species are probably now extinct.

Pinanga singaporensis, Ridl., grew in another patch of wood surrounded by extensive cultivated land. I have failed to find it anywhere else. Probably on account of the limited number of plants occurring here, and consequent want of cross-fertilization, it did not set fruit, and this wood was destroyed some years later.

Didymocarpus Perdita, Ridley. I found two plants of this on a bank in the centre of Singapore surrounded by extensive cultivation. It has never been seen again.

Euthemis minor, Jack., was described by him from Singapore, apparently common in 1820-2. After much search I discovered a single patch in the farther corner of Singapore. It is a sea-coast plant of the south of Singapore, but the greater part of the sea-coasts have long been cleared of their endemic vegetation.

Close to the Botanic Gardens stand no less than three unique trees, the remains of high forest formerly covering the ground, left because they were too high to destroy. Usually in this case the tree soon dies because of the exposure of its roots to the hot sun; these trees being better placed have survived. They are *Shorea gibbosa*, Brandis, *Parishia* sp., a male tree only, and *Ormosia macrodisca*, Bak.; this latter is said to occur in Sumatra, and there is a tree in the Buitenzorg Gardens. Otherwise no other trees of these species are known, and, as so often happens in cases of isolated trees, they failed to produce any healthy offspring.

In 1889 in the Kranji Mangrove swamps I found on the trees no less than forty-six species of Orchids in abundance. In 1915 I visited these swamps again to look for them, and could only find four or five of the

smallest kinds. The forest had been let for timber-cutting and the bigger trees bearing most of the Orchids cut out, and a patch of forest which shaded the edge of the swamp was destroyed, letting light and heat into the swamp.

The extermination of plants by man is not only effected by plantations on a large scale and destruction of the forests. Pulau Tawar is a Malay village of some size and antiquity on the Pahang river. On a visit there I observed that there were no Rattans (*Calami* and *Daemonorops*) in the neighbourhood, even seedlings, except one species of *Daemonorops* which had no value in the eyes of the Malays.

The Malays, who are insatiable for Rattans for house use and sale, cut the long stems when sufficiently developed, that is to say when they are big enough to flower. This constant cutting prevents the plant ever reproducing itself, and it is only a matter of a comparatively few years before the Rattans are utterly exterminated. The wild tribes, too, search the forests in which they live thoroughly for eatable *Dioscoreas* and Palms, as also for Rattans, Rubbers (*Willughbeia*), and destroy the big *Dipterocarpus* trees by boring them for wood-oil. Even if some few plants remain scattered here and there, they are apt to die out from want of cross-fertilization.

The extermination of species by man in the Malay Peninsula has really been only extensive within the last fifty years. It is very different in Ceylon, a heavily populated island for over 2,000 years. Any one who visits the forest country round Anuradjapura will be struck by the small size of the trees covering the area which many centuries ago was a thickly populated district. Here are the remains of temples which, with the houses of the inhabitants, must have been largely built with timber of the felled forests. What trees were they that were used for the beams and wood-work of the temples and houses? The valuable *Dipterocarpeae*, giving good timbers, are given in Trimen's Flora as six common, twenty-four rare or rather rare, twelve very rare, and four or five apparently extinct. Dr. Trimen points out the difficulty of obtaining specimens of these trees, and says our knowledge of the Ceylon species is very imperfect; but the numbers given above are about what one would expect of first-class timbers in a heavily populated country where timber of large size had been required for 2,000 years. It is now highly probable that these plants had formerly a very much larger area of extension. A large proportion of the plants labelled very common by Dr. Trimen are introduced weeds, and indeed, when in Peradeniya in 1888, I had to go a very long drive and walk before I got to a hill where the real Ceylon flora could be seen. Dr. Willis does not, so far as I can see, distinguish between the very common introduced plants and the very common indigenous plants. What were the plants on the ground before these weeds were introduced?

ALTERATIONS OF THE FLORA DUE TO CLIMATIC CHANGES.

A comparatively small change of climate may very easily cause the destruction of species on a large scale: (1) by actual destruction of species; (2) by allowing the development of an entirely fresh flora which would swamp the indigenous flora.

A diminution of the rainfall, for instance, due to excessive destruction of trees, could entirely destroy the epiphytic flora of a region. I have shown how on a small scale in the Mangrove swamps at Kranji in Singapore, and the felling of the jungle on the slopes of Bukit Timah, the light and heat let in destroyed the epiphytic flora and herbaceous plants in these forests.

I have another instance of such destruction. Some years ago, 1905, in Singapore, we had an extraordinarily dry and hot spell which lasted for a month or two, during which period the epiphytic Fern *Polypodium sinuosum*, of which there was a great abundance on some of the trees, was completely dried up, and almost every plant of it in the gardens utterly perished, and no young plants of it ever came up again on these trees.

At present we have very little information, at least collected together, of modification of climate and consequently of floras in a natural condition of things, and alterations due directly or indirectly to the action of man. These are subjects well worthy the study of naturalists. Changes of climate have occurred without any geologic cataclysm in past years we know, e. g. the glacial period of Europe, and I understand the desert period of the south of England. In Nicol's 'Three Voyages of a Naturalist', chap. iv, in describing South Trinidad, he notices great numbers of standing and fallen trees apparently dead for many years covering the whole island, and the disappearance too of the goats which formerly inhabited it. There is no clue as to the cause of the destruction or its date, and he considers it improbable that it was caused by volcanic action, as at the summit trees and tree-ferns still flourish, and there are no traces of fire. However, as it is a volcanic island, the destruction might have been caused by the emission of the poisonous gases or water, as was reported to me as occurring in the Hawaii islands some years ago.

That floras do change without human interference we know from Clement Reid's researches into the early floras of Britain and Holland, species entirely disappearing and being replaced by others, but from what causes we are still ignorant. There is no evidence whatever to show geological cataclysms in all such cases. The process may be and probably is slow at most periods.

ENDEMIC SPECIES.

An endemic species or genus is one confined, so far as is known, to one definite area, and is not known to occur outside that area. Such a species may be one which has evolved within that area, and for some reason never spread farther, or it may have at one time or other occupied a wider area from which, except in one region or locality, it has disappeared. Before we can say definitely a plant is endemic we must have a complete knowledge of the flora of the nearest countries, but this in many cases we do not possess. Thus, though there are a very large number of what have to be recorded as endemic plants in the Malay Peninsula, we know comparatively little of the floras of the adjacent countries, Sumatra, Borneo, and the islands south of Singapore, Siam, and Cochin China. The nearest land to Ceylon is southern India, Madura, and the Carnatic. Has this region been so thoroughly explored that we can say for certain that many of these so-called Ceylon endemics do not still occur there? I doubt it very much. This part of India has been very long heavily cultivated and thickly populated. How many of the now endemic plants of Ceylon were not formerly abundant over this area?

Dr. Willis himself, on p. 12 of his paper in these Annals, gives an important clue to the history of endemics in Ceylon when he says, 'The second point that shows at once in these diagrams is that the enormous majority of the endemic species are in the wet zone'. Exactly what would be expected if the climate of southern India and the remainder of Ceylon had been formerly a wet district like the Malay Peninsula, and by land changes, denudation of mountains, felling of forests, changing rainfall or other climatic changes had become xerophytic except in the still wet zone of the south-western quarter of the island. In that case we should find exactly what we do find—the remains of an old rain-forest flora isolated in the wet zone.

We find evidence of a reverse action curiously in the case of the limestone rocks of Selangor in the Malay Peninsula. These rocks, attaining a considerable altitude (about 1,000 feet), lie at present thirty-two miles from the sea, though there is still a tradition of the sea having washed their bases in the time of man. Between them and the sea is a flat area of wet rain-forest which has crept up their sides for some distance. At the top of these precipitous rocks there is much mica in the soil, which must have come from granite mountains in close proximity to the limestone and higher than it. These mountains are now gone. On the top of the limestone rocks we get a distinct flora largely identical with that of the Tenasserim limestone, including two species of *Boea* closely allied to plants of Tenasserim and Borneo, and *Calanthe vestita*, only known from the limestone rocks of Tenasserim and Borneo. Here we have the remains of a xerophytic flora

persisting on the wet limestone rocks, surrounded by a geologically modern rain-forest flora, which has swamped it everywhere but on the summit where the big rain-forest trees could not grow.

‘Endemic species confined to small areas are really species in the earlier stages of spreading, and, given time enough, they might ultimately be found covering large areas. Endemic species begin as VR in some given country, and gradually extend their area, passing upwards through the stages R, RR, RC, &c.’¹

This general statement could only be correct if these endemics were found to have all arisen from other species now in the island. Dr. Willis gives a list of genera containing endemic species, but omits all the endemic monotypic genera, *Trichadenia*, *Fulostyles*, *Pityranthe*, *Pseudocarapa*, *Glenniea*, *Pericopsis*, *Schizostigma*, and many others, and does not mention the fact that a large number of the endemic species are the only ones of their genus in the island. How can these be species in the early stages of spreading? Furthermore, most of them are rare, and some almost, if not now quite, extinct.

On examining the affinities of these endemics we find that a very considerable proportion are Malayan. Now the connexion of the Malay region with Ceylon must have been at a very long distance of time ago. The genera containing endemics are nearly all rain-forest country plants, and appear to be now nearly confined to the wettest region of Ceylon. Exactly what we should expect if there was at a very long distance of time a land connexion with the tropical rain-forest region, which being destroyed, this very old flora persisted in the wet mountain regions till a large portion of it was destroyed by man, directly or indirectly, by felling the forests and causing diminution of the rainfall over a large area. This will account for the state of the flora and its constituents, but Dr. Willis’s theory will not.

‘Ceylon, though equatorial in position’ (which it is not), ‘has but a small flora (2,809 species) compared with the islands of the eastern peninsula of India. . . . This has always been a difficult matter to explain, and the Natural Selectionists have had two rival hypotheses. . . . The first is that Ceylon has a less “tropical” climate than Malaya, having greater extremes of wetness and dryness and of heat and cold. The second is that Ceylon has but a poor soil, . . . it being all the product of the decay of gneiss and granite.’² I do not see how these two theories are ‘mutually contradictory’, nor do I know who the Natural Selectionists are who have made these suggestions. It is obvious to every one who has at all examined the flora of Ceylon, that, as already pointed out, an immense quantity of the original flora has been destroyed by man but replaced by imported weeds which largely bulk in the VC’s of Trimen’s Flora. This destruction was

¹ Ann. Bot., l. c., p. 5.

² l. c., p. 21.

going on as late as 1900 (see Brown's article on the Forests in the Appendix to Trimen's Flora). A very large proportion of the species in the Malay region are epiphytes, especially Orchids. These are the first to disappear when timber is felled and the country exposed to the sun. The very small number in the plain districts of India illustrates this. In Ceylon there are only eighty species against over 130 in Singapore island alone.

THE MUTATION THEORY.

The theory of the evolution of species by Natural Selection is, as I understand it, as follows :

An organism produces forms which in various ways are not identical with the parent form. These forms are known as varieties or mutations. Should any of these forms be adapted in any way so as to be more suitable for the surrounding conditions than the parent form, they may persist and reproduce themselves in the mutation form. The mutations do not necessarily reproduce their replica, but may revert to the original form. If, however, selection comes into play and the mutation is continually selected, the form becomes a fixed mutation. I shall give instances in the case of *Antigonon* and other plants.

Should the forms connecting the fixed mutation with the original form disappear, and the alterations be sufficiently distinct and important to warrant it, we call the new form a species.

For a mutation to become a fixed one it is necessary that it should be able to reproduce itself successfully and continuously.

In most or more probably in all cases of successful fixed mutations the determining factor is the surrounding conditions environing the original plant. Thus a plant adapted for the dense shade of the forest may disseminate its seed nearer the edge where the light is greater. Here natural selection comes into play, and the mutations more adapted for greater light will grow and reproduce along the edge. If the forest be near the sea, the mutations gradually getting nearer and more adapted for sandier and sandier spots may in time be so selected that they take on a maritime form. This form in time becomes so far adapted to a littoral life that it cannot revert to the jungle form, and remains as a species.

This is only one sample of the evolution by Natural Selection ; others are connected with adaptations for climate, fertilization, dissemination, &c., the object being that an organism can by mutating fill up a space, or state of conditions, which in its original form it cannot do.

This theory accounts for the great number of species in the world and their adaptation to their surroundings and conditions of life, and can be tested and proved by a study of mutations. No other theory has been produced which can account for the facts.

Dr. Willis's theory of mutation is described in the 'Annals of the Roy. Bot. Gard., Peradeniya,' as that new characters are supposed to arise at one step: once they have appeared the new characters are hereditary and the new form does not go back to the old one.

In other words, all mutations are at once fixed. This is easily shown not to be the case. Nor does the theory in the least explain the adaptations to surroundings, e.g. why *Calophyllum inophyllum*, adapted as its fruits are for sea dispersal, occurs only on the sea-shore, or why *Crinum asiaticum*, with long-tubed white fragrant flowers only fertilizable by a crepuscular sphingid, only opens its flowers at exactly the time of the appearance of the moth. In fact, the theory is the old special creation hypothesis with the creator left out, and no substitute given.

Every gardener and field botanist of ordinary observing powers knows that very many variations (or mutations as Dr. Willis prefers to call them) occur in plants which do not appear again in their offspring.

Many years ago in Singapore we obtained a variety of *Antigonon leptopus* in which the normally pink flowers were pure white. This variety, though it came true from cuttings, did not come true from seeds. All its seedlings gave pink flowers for a considerable period. After some years (the mutation not being fixed till then) we obtained a few white-flowered seedlings. Zinnias grown in the garden at Singapore from cultivated plants from Europe in three years reverted to the form of the original small-flowered wild plant. The same thing happened with the garden *Balsam* and other cultivated plants. But this is well known to every gardener. Very striking cases in a natural state will be shown later on in this paper.

The argument that specific differences which plants possess have never been shown to be of practical use now or of some use in the past, does not hold good in view of the extensive literature on fertilization and dissemination, and on the relations of plants to their surroundings.

The whole life-history of any single plant is not at present really known—its physiology and habits; its insect, fungal, or other enemies; its requirements due to the action of light, heat, electricity, rain, dew, frost or drought; its food and water-supply; its means of fertilization, protection, and reproduction; in fact, the whole physiological and ecological history of the plant from the seed to its reproduction and death by day and night, in normal and abnormal weather, at all seasons of the year, and in all geological or climatic changes for the period of its existence as a species. Until this is known, it is impossible to give the cause of *all* specific differences. I do not believe this is known of any common English plant, still less of any tropical one.

In Ann. Roy. Bot. Gard., Perad., vol. iv, p. 2, Dr. Willis writes: 'A point that has so far escaped attention is, that the characters that distinguish genera

and species are largely characters of the floral organs; the struggle for existence is almost entirely among the seedlings and young plants in which these organs are not present. To take an example, is it conceivable that in *Dillenia* it can make any difference whether these leaves are acute or obtuse, or the petiole one inch or one and a half inches long? These are the only characters that can show till the plants are at least ten years old, by which all that are going to die out will have done so.' But the struggle for existence does not cease in any plant when it has developed out of the seedling stage. It is surely well known that the struggle continues throughout the whole life-history of the species. I need not, however, go into this, as plenty has been written to show this both by Darwin and later botanists.

The lengthening of the petiole and acute or blunt apex of the leaf may have the utmost importance to the *Dillenia* in the relations of the leaf to sun and rain. But I will give one or two examples of 'infinitesimal variations' which have the greatest importance to the life and propagation of a plant.

Metroxylon Sagus, Rottb., and *M. Rumphii*, Mart., the two Sago Palms, are very closely allied plants, but the latter is armed with spines especially on the leaf sheaths, the former is unarmed. In parts of Borneo it is impossible to cultivate successfully *M. Sagus*, because the wild pigs (*Sus barbatus*) attack and devour the young shoots as fast as they come up. *M. Rumphii*, guarded by its spines, is immune from the attacks of this animal. Here the development of spines protects the spiny Sago, which would otherwise be exterminated as the smooth Sago is. Another instance of a totally different character is shown in the case of the Macarangas, as described in my paper on Ants and Plants in the 'Annals of Botany', vol. xxiv, p. 471, where it is shown that in certain species of the genus the young leaves are liable to so serious an attack by caterpillars that the plant may be severely injured, if not killed; the very slight variation of the longer persistence of the bud sheaths for some days, and the development from the glands (common in most species of the genus) of food bodies attractive to ants, by inducing ants to take up their abode in the hollow stem, protect the plant from caterpillar attacks.

Castilloa elastica in the Malay Peninsula is attacked by a beetle, *Epepseotes luscus*, the larva of which tunnels the stem, causing the destruction of the tree. The insect can only escape through the scar of a fallen leaf, as it is the only part of the trunk not guarded by laticiferous vessels through which it cannot pass. A comparatively slight thickening or hardening of the texture of this point would effectually stop the beetle from escaping, and render the tree invulnerable; and from some such slight variation I found trees immune from the attack of this beetle, while others standing close by were destroyed.

I cultivated in Singapore two kinds of Lilies, of which one, *Lilium*

auratum, had narrow, the other—I think *L. croceum*—slightly broader leaves. Rain falling on the latter was retained round the bud by the broader leaves, which formed a kind of cup, the buds were destroyed, and the plant failed to flower. In the other species, the narrow leaves did not meet at the edges, and through the space between the narrow leaves the rain-drop fell and the buds were uninjured, and the plants flowered.

A most amusing passage occurs in one article, showing, I think, a want of careful thought by the author: 'Can it for instance be supposed that the hereditary fasciation of the Cockscomb is of any use to that form?' To this I reply it certainly can, for specimens that are not fasciated (which do not rarely appear) are worthless from a gardener's point of view, and quickly find their way to the garden bonfire.

A very common variation occurs in the form of variegated leaves, which are blotched or streaked with white. Now every gardener knows that this mutation is often very unstable, and the plant readily reverts to the original green-leaved form. There is a variegated form of *Arundo Donax* very commonly cultivated with leaves edged or otherwise marked with white; when cultivated for some time the plant produces branches bearing typical green leaves. If these are not removed, in a few years the whole plant reverts to the original plain green colour. Here is a case of reversion of a mutation which Dr. Willis states does not exist. Let us compare this with the Aroid *Aglaonema costatum*. This plant has three forms—one with blackish green leaves mottled with white, one with dark green leaves with a central white midrib, and one with light green leaves with white spots. These three forms grow in limestone districts north of the Malay Peninsula. Unlike the *Arundo* they do not revert, but each variety reproduces the same form. No variety with plain green leaves has been seen. Both of the first two grow in the same area, the third farther north in southern Siam. Here are variations which keep true under any form of cultivation, and would be cited by Dr. Willis as proofs of his theory. But if so, it would be incumbent on him to show why the *Aglaonema* comes true in all its three forms, and why the *Arundo* does not. Here his theory completely breaks down.

Now it is well known that it is in limestone districts that one always finds the largest number of plants with white variegated leaves. Near the limestone districts in Sarawak I went one day for a stroll and collected a single plant of everything I could find with variegated leaves. In an hour I had my arms quite full of variegated plants of many different orders. The reason for this is quite obscure to me, but it is clear that some advantage must be gained to the plant by this variegation, and that it is of so much importance to the plant that it is a permanently fixed mutation. Why are other plants similarly variegated not equally permanently fixed as a variation, as they should be by Dr. Willis's theory? Another instance. The Tahan

river is a rapid running, rocky mountain stream flowing through the forests. Along the banks of this stream I found a whole series of plants which possessed long narrow leaves of willow-leaf shape. They included species of *Calophyllum* (Guttiferae), *Ixora* (Rubiaceae), *Hygrophila* (Acanthaceae), *Didymocarpus* (Gesneraceae), *Podochilus* (Orchideae), *Antidesma* (Euphorbiaceae), *Ficus* (Urticaceae), *Melastoma* (Melastomaceae), *Rhyncophylla* (Aroideae). These fringe the rocks and are often submerged by a very violent torrent. All or almost all are allied to species living out of the reach of the water, with broad lanceolate leaves. Should these broad-leaved plants be subjected to the rush of the torrent, their leaves would be torn to bits and the plants destroyed. But the form of the leaves varies occasionally, e.g. in *Ixora*, farther in the forest, we get forms with more narrow lanceolate leaves. According to the theory of natural selection by variation, the *Ixoras* with lanceolate leaves could establish themselves along the stream edge more readily than the broad-leaved ones which have their leaves destroyed by the torrent. A variation with narrow leaves could approach nearer the edge where the rush is more violent, and so it could go on till we found, as we do among the rocks where the torrent at certain times is excessively furious, the *Ixora* growing with foliage more like that of a stream-water plant, thriving and holding on with a mass of strong woody roots, and a tough short stem, with none of its leaves injured or its boughs broken. The theory of Natural Selection by infinitesimal variations will account for this, but the mutation theory will not.

On the sandy shores of the Pahang river grows a species of *Vitex*, a prostrate creeping shrub, throwing up short branches four to six inches tall, with simple ovate blunt leaves 1 to 1.10 in. long; the flower spikes are a little over an inch long, with rather showy blue flowers. As this looked likely to prove an ornamental plant suitable for bedding, I brought some to Singapore, where it immediately turned into *Vitex trifolia*, an erect shrub or small tree about 10 feet tall with trifoliate leaves; the leaflets obovate acute or elliptic, 2.5 in. long, 1 in. wide, with a petiole 0.4 in. long, and raceme or panicle of smaller flowers 6 inches long. The sea-shore form was abundant and occurs elsewhere, and would certainly be considered a distinct species, differing as it does importantly in all its parts—stem, leaves, inflorescence, and flowers. Yet Dr. Willis says that ‘no evidence has ever been brought forward to prove that local species are adapted to local conditions; it is simply an hypothesis’ (Ann. Bot., l. c., p. 15).

Microcarpea muscosa, R. Br., is a small scrophularineous plant which grows on the edges of ponds. Where the water subsides and the plant is left on the bank it can be seen to be erect, 3–4 inches tall with little violet flowers, but beneath the water it forms large, short tufts, and the corolla scarcely projects beyond the calyx, the limb of it, almost reduced to a rudiment, bearing mere traces of its violet colour. There are numerous instances of similar

occurrences recorded by botanists, and I would especially refer Dr. Willis to Hiern's paper on 'Forms of Floating Leaves' (Camb. Phil. Soc., xiii), and call his attention to the well-known variations in *Polygonum amphibium*.

The whole meaning of these adaptations of local species to local conditions is not always clear. I do not clearly see why, for instance, the Alpine plants of the high mountains of the Malay Peninsula and Ceylon have a tendency to the reduction of the whole plant in size, the thickening of the leaves, and their having a tendency to become eventually quite round, orbicular in fact, and in the case of compound leaves, simple, a state of affairs which does not occur in any of the species of the same genus in the wet forests at the base of the mountains; but there cannot be a shadow of doubt that it is of importance to the plant, and that the plants have been gradually adapted to their surroundings. Dr. Willis seems to be puzzled as to why different species of a genus occur in the same region. Why, he asks, in the 'Annals of the Roy. Bot. Garden, Peradeniya,' vol. iv, p. 11—why should *Dillenia retusa* with its obtuse leaves and small flowers be found alongside *D. indica* with acute leaves and large flowers? In the eastern peninsula again live *D. ovata*, *D. meliosmaefolia*, as well as *D. indica*. Why should they be better suited to the eastern peninsula while *D. bracteata* suits Mysore and *D. retusa* Ceylon? I have not seen *D. retusa* or *D. bracteata*, and we must add *D. dentata*, Thunb. (*Wormia triquetra*, which is a true *Dillenia*), growing wild, so I can give no answer as regards them, but the story of the *Dillenia*s of the Malay Peninsula I can at least partly give.

D. indica is exclusively confined to wet ground, chiefly river banks. It would not grow in the ordinary soil of the gardens of Singapore, but planted on the edge of ponds and in swampy grounds it did well. Its fruits are very large and round with immensely thickened and enlarged sepals, and measure 4–6 in. through. These sepals are not sweet to taste, nor is the fruit eaten by any animal. It is adapted for dispersal by river. River and sea-dispersed fruits have a tendency to become very large, e.g. *Calophyllum macrocarpum*, *Barringtonia speciosa*, *Cerbera Odollam*, &c., and this entails in many cases a corresponding enlargement of the flower, well seen in *D. indica*. *D. ovata*, Wall., and *D. aurea*, Sm., inhabit dry, xerophytic spots in rocky or sandy localities. They have bright yellow flowers and smaller-sized fruits; both are rare in the peninsula, as the climate, except in the north, is unsuitable. They appear to have originated in a dry region and have pushed a short way into the peninsula from Siam. *D. meliosmaefolia*, Hook. fil., is a small jungle tree occurring in our wet forests. To adapt it for that life the leaves and shoots are densely hairy, to throw off the rain which otherwise would injure the leaves. Hairy leaves such as these I find dry after rain quicker than smooth ones, besides retaining less water on the leaf during a shower. The leaves and buds of the trees in the forests are all guarded in various ways from the action of rain, or rather from the action

of the sun's rays after a rainfall, which burns the leaves. This hairiness is one system. The flowers are small and yellow; the fruit is orange-coloured, sweet, and eatable. It is small, hardly an inch through, so that birds can easily swallow it, and so disperse the seeds. It is obvious that a tree habituated to live in thick tropical rain forests would not thrive in a xerophytic country like Ceylon, though should it get there possibly it might exist in the small wet area. *D. Scortechinii* is a tall jungle tree attaining a height of upwards of one hundred feet; its flowers appear never to possess any petals, and it seems to be self-fertilized. Owing to its great height and comparative rareness of flowering I have not been able to make many observations on it. Like *meliosmaefolia* it inhabits wet jungles, but being a lofty tree its coma of foliage gets a full supply of light, and probably by reason of its being exposed to wind its leaves are able to dry faster and are not liable to injury from rain and sun. The fruits are of the same size as those of *meliosmaefolia*, but are green, glabrous, and not sweet. They appear to be dispersed by rolling and possibly by squirrels, rats, or bats. The absence of colour shows that they are not intended for dispersal by birds.

Now here we have four or five species in this one region, but the whole of their life stories are quite different, and they do not grow alongside each other as Dr. Willis says of the Ceylon species. Do the other two species in Ceylon grow in the same situation and surroundings as *D. indica*? We have no evidence from him or from Dr. Trimen that they do. Dr. Trimen describes the fruit of *D. retusa* as 1-1½ in. through, and orange. This suggests at once that it is bird-dispersed. The fruit of *D. dentata* is small and apparently whitish green. Both these plants require careful study in the field before we can say anything more definite about them. In the genus *Calophyllum* he states, p. 13, that an endemic species, *C. parviflorum*, lives beside the almost cosmopolitan species of the eastern tropics, *C. inophyllum*. The two are very much alike, but the latter has a globose fruit, the former an oblong, rostrate one. The latter lives in beach-forests, the former more inland (how then can they be living beside each other?). Now is it to be supposed that the shape of the fruit can have any effect upon the life of the species sufficient to account for its being evolved by a natural selection of infinitesimal variations, though it may be correlated with some internal character fitting it for life more inland?

I am met at once with a difficulty: I cannot find any species of *Calophyllum* named *parviflorum* except a species of Bojer's from Mauritius, but I must take it that Dr. Willis refers to one of the other ten species recorded in Dr. Trimen's Flora. It is probably *C. Burmanni* to which he refers, as it occurs in the low country near the sea and has more or less oblong fruit, though that species differs from *C. inophyllum* in almost every other part of the plant, including the flowers, for it is apetalous. Indeed there is no species in Ceylon which really resembles *C. inophyllum* except in general character.

Now *C. inophyllum* is a very peculiar tree ; it grows to a large size on sea-shores in sand, and its fruits are adapted specially for sea-dispersal. The fruit is green, globose, and resinous ; the endocarp is thin and woody ; it is adapted by its lightness for sea-dispersal, and its wide distribution is due to this. It is easily nibbled through by rats and squirrels which destroy the seed, a catastrophe not likely to occur to any extent in its native habitat, where these animals are scarce ; besides, owing to the globose form of the fruit, on falling from the tree it usually rolls at once down the sloping shore into the water and is drifted out of the reach of the animals. In trees in the Botanic Gardens at Singapore, however, the seeds were destroyed in hundreds by these animals ; in one year, at least, hardly one escaped. The fruit, on account perhaps of the resin, and certainly on account of its size, is not swallowed by birds or eaten by bats so far as I have seen. The tree does not thrive at any distance from the sea, and does not propagate to any extent in scrub or thick forest. It is not to the tree's interest therefore that birds or bats should carry its seeds away inland.

In *C. Burmanni* we find the fruit is half an inch or little more long and bright orange-coloured. This colouring is unusual in *Calophyllum*, and with its size suggests that the plant is bird-dispersed. Most of this class of fruit are green or purplish and seem to be dispersed by fruit-bats. *C. inophyllum*, being a maritime plant adapted for inhabiting sea-shores, was in all probability evolved in the Polynesian islands, and has been distributed by sea as far as the Mascarene islands. The head-quarters of the other inland *Calophyllums* is undoubtedly the Malay Archipelago and peninsula. The Ceylon flora possesses a considerable element of Malay forest plants ; indeed, nearly all the Ceylon Guttiferae have Malay affinities and all the genera and some of the actual species are Malayan. All the evidence of this order as of others goes to prove a former land connexion with the Malayan region. In this case it is clear that the inland *Calophyllums* may have invaded Ceylon by land at a very early date, while *C. inophyllum*, which occurs practically on every sea-coast it could grow on between Polynesia and the Mascarene islands, came by sea, perhaps hundreds or thousands of years later, and, as the seeds are still commonly to be found drifting along in the sea, may be still landing on the Ceylon shores. What then is remarkable in finding *C. Burmanni* and *C. inophyllum* in the same area ? and what bearing has the one on the other ?

It is unfortunate that Dr. Willis seems to base so many of his arguments on statements made in books rather than on observations made in the field ; thus he states (Ann. Roy. Bot. Gard., Perad., iv. 2) that *Ranunculus bulbosus* differs from *R. repens* mainly in the fact that the former has the sepals reflexed and the latter has them spreading ; but surely the bulbous root of one and the stoloniferous habit of the other are important differences, not to mention differences in the leaves. In vol. iv, p. 69, he gives a study of the tree

Dilleniaceae of the East as illustrating his mutation theory, which study is based, I imagine, on the first volume of Hooker's *Flora of British India*. He states that *Tetracera laevis* is found in Ceylon, Malabar, and in Java and Borneo. This species is closely allied to *T. assa*, and is peculiar to Ceylon and Malabar, and does not occur elsewhere so far as is known, the other localities quoted being erroneous. *Delima laevis*, he says, has only been collected in Malacca. 'If we accept the theory of infinitesimal variations we must either admit that *D. sarmentosa* was evolved near Malacca and afterwards spread enormously, while *D. laevis* has not spread, or else that there has been a vast amount of destruction, reducing *D. laevis* to one locality or destroying the other species that were evolved with it. It is, however, very nearly allied to *D. sarmentosa*. The small spread of *D. laevis* is easily accounted for on the mutation theory, for it may have been quite recently evolved, and not having a very efficient distribution mechanism would not travel very far except in a great length of time.' An examination of the type specimen of *Delima laevis* in the Kew Herbarium shows that it is *Tetracera borneensis*, Miq., a well-known and not very rare species, which has no connexion with *Delima sarmentosa* at all.

Of *Wormia* he writes (p. 72): '*Wormia triquetra* is confined to Ceylon; it belongs to the sub-genus *Eu-Wormia*, to which also belong *W. pulchella*, *W. meliosmaefolia*, *W. Scortechinii*, and *W. Kunstleri*. All the last three may be supposed to have split off from *W. pulchella*.' Now strange as it may appear, *Wormia Scortechinii* and *W. Kunstleri* are the same species, and with *W. meliosmaefolia* are not *Wormias* at all but *Dillénias*, and have no connexion with *Wormia pulchella*, a true *Wormia*. Further *Wormia triquetra*, from Dr. Trimen's description and figure and specimens preserved at Kew, is also a *Dillénia*—*D. dentata*, Thunb. The two genera are distinguished by their fruit, those of *Dillénia* being indehiscent with no aril to the seeds; those of *Wormia* opening out into a rose-shaped pink or white circle of carpels widely dehiscing and exhibiting the seeds invested by a scarlet aril.

I confess I do not understand Dr. Willis's interpretation of the simple facts of evolution of a species as generally understood by naturalists. He states that the idea that endemic species were evolved to suit local conditions is based largely upon Wallace. Who ever possessed such a curious idea? Let us take some examples of endemics. *Aphyllanthes monspeliensis* is a liliaceous plant occurring in a limited area on the Mediterranean where it is distinctly endemic, a monotypic genus of the Sowerbieae section with no relations nearer than Australia. *Helxine Solerolii*, Req. (Urticaceae), is an endemic of Corsica and Sardinia and has no relations at all in this region. *Dioscorea pyrenaica*, Bub., is endemic to the Pyrenees and the only species of its genus in Europe. How could these plants be evolved to suit local conditions, unless they are the relics of floras of which the rest is extinct?

There is nothing within thousands of miles of them now from which they could be evolved.

In cases like this, and there are very many, his mutation theory utterly collapses.

But what really puzzles him is the case of endemic species apparently actually evolved on the spot, such as *Castelnavia*, the various locally evolved *Eugenias*, *Sonerilas*, *Impatiens*, and such genera where one finds a number of peculiar species in one area. To assume that because we have not worked out the whole life-histories and conditions of environment of all these different species, their specific differences cannot be due to local differences in condition, and they must have been produced by special creation, for that is what his mutation theory amounts to, is hardly scientific.

In most cases of mutation and especially where one organ is much altered, other organs are also modified; e.g. a dwarfed plant of *Liparis longipes* was imported into Kew Gardens many years ago, in which not only the pseudo-bulbs but the leaves and inflorescence and all the organs of the flower down to the lip were shortened and broadened. Another example is the case of the *Vitex trifolia* previously described, where, though almost every organ in the littoral form was altered in shape, the plant proved to be not even a fixed mutation.

Species absolutely isolated, either by the extinction of all allied forms or by accidental position, do not produce a series of mutations.

There are only two species of the order Dioscoreaceae in Europe at the present day, the plants of this order being chiefly tropical. These are *Dioscorea pyrenaica* of the Pyrenees and *Tamus communis*. Though these plants must have inhabited Europe for an immense series of years, being undoubtedly the relics of an early tropical era, they have not produced yet anything that could be called a mutation. The same remark applies to *Aphyllanthes monspeliensis*, and many other instances might be deduced. A great contrast to this is the case of such genera as *Hieracium*, *Rubus*, *Rosa*, and *Saxifraga*, in which genera the number of mutations is very large. The same phenomenon occurs in all parts of the world. I would call attention to the endemic plants in Christmas Island in this connexion. This island has never had any connexion with any other land, being a volcanic island dating, it is believed, from the Eocene period. The flora which had not been interfered with by man, when it was first examined, consisted of plants nearly all of Javanese affinity; many were sea-shore species of wide distribution. The endemic flowering plants are thirty-one in number, all belonging to separate genera, except two *Grewias*, two *Phreatias*, and two *Pandani*. Here, in spite of the long period during which this island has been above water and capable of bearing a flora, there has been no evolution of a large number of any one species comparable with

the evolution in *Hieracium* or *Rubus*, nor even to the *Grewias* of the Malay region or the *Pandani* of Madagascar.

Again, in Europe we have of Gesneraceae, *Ramondia pyrenaica*, Lam. (Pyrenees), *R. serbica*, Panc. (Serbia), *R. Heldreichii*, Boiss. (Thessaly), *Haberlea rhodopensis*, Friv. (Thrace).

These grow in much the same kind of locality as the *Saxifrages* do, but what a contrast! Of *Saxifrages* in Europe we have over a hundred species and innumerable forms. The nearest Gesneraceae to our four European species are in tropical Africa¹ and the Himalayas, while the *Saxifrages* range over the whole of the north temperate zone and even South Africa, Australasia, and South America. Now look at the Gesneraceae of the East Asiatic tropics; of *Didymocarpus* we have over fifty species in the Malay Peninsula alone; the closely allied *Chirita*, 7, *Loxocarpus*, 4, *Paraboea*, 13, *Boea*, 12. We find a large number more of *Didymocarpus* in India, Borneo, Java, and Sumatra; *Chiritas*, about fifty more in Cochin China, Assam, Ceylon, Java; *Loxocarpus*, several in Borneo; *Paraboea* in Siam and Assam; *Boea* in Borneo, Java, Siam, and Cambodia. All these countries are in actual land contact with the Malay Peninsula, or were formerly so. They differ much in climate and soils.

Let us assume that a species of *Didymocarpus* has been evolved in the Malay region, and spread gradually as far as the countries and localities would admit of its growing. In various spots, and perhaps distant parts of these countries, mutations formed, and became fixed mutations or what we should call species. A species is formed, let us say, on the Tenasserim limestone rocks; it pushes down along the limestone chain again to the Malay Peninsula. Here it meets with allied species with which it can cross, and a fresh series of mutations is formed, some of which, adapted to special circumstances, can live and thrive on spots where the original species could not.

We have the European Gesneraceae and Dioscoreaceae, and *Aphyllanthus*, all isolated species, with no relatives near enough to hybridize and cause the production of an extensive evolution.

We have *Saxifraga* in Central Europe, in Arctic Europe, the whole of the temperate regions of Asia and America. The wave of cold in the glacial period must have driven out many species in Europe, but there were mutations which had adapted themselves to the cold and survived; and these returning hybridized with the species surviving in the warmer valleys of the south and started a new series of mutations. *Hieracium*, *Rubus*, *Rosa* have all the same distribution and story.

But the European Gesneraceae and Dioscoreaceae and Sowerbieae (*Aphyllanthus*), the relics of an old long-lost flora, isolated by thousands of miles from any allied species, remain unaltered, with no series of mutations.

¹ *Saintpaulia*.

Just in the same way in Ceylon we have isolated species like the Dipterocarpeae and *Acrotrema*, a native of South India and of the Malay Peninsula, both countries formerly connected with Ceylon, and from both of which mutations or species may have come, and by crossing, formed the seven recorded species of *Acrotrema* (the largest number of species of the genus known anywhere) now inhabiting Ceylon. Indeed both Thwaites and Trimen considered it probable that some of these species were natural hybrids. I have only been able to outline this suggested cause of the state of affairs which the distribution of plants and the great preponderance of species in one group and the rarity of others seem to evidence. To give fuller instances and to give such evidence as is known would require a large-sized volume. Nor do I at all intend to intimate that this alone accounts for the immense number of species and genera we see in the world, and the facts of their comparative abundance or rarity. The whole subject is more complex than that.

It is perhaps as well to point out that it is not necessarily the change to another *country* that is the cause of fixation of mutations; every country, every district, has a variety of localities into which a plant may push by a suitable mutation. Given just the similar conditions for the plant, there is no probability of any mutation for the form which finds its way there being in any way more suitable, but where conditions are different, a mutation even slightly more suitable would be necessary for the plant to establish itself. Thus *Ixora Lobbiai*, Loud., is a tall, broad, oblong, lanceolate-leaved shrub, the leaves about two inches across. It grows in thick forest, where, owing to the comparatively scanty sunlight, it requires broad leaves to receive a sufficient supply of light. Through the forest runs the rapid stream Tahan. The seeds of the *Ixora* (dispersed by birds) must frequently be dropped nearer the river edge. The vegetation is thinner here, and there is more light. At certain times the river rushes in spate through the wood-edge, and a narrow-leaved form would be less injured by the water-rush than a broad-leaved one. On the actual rocky edge of the stream the rush is much more violent and constant, and only very narrow leaves can stand against it. Gradually, by eliminating the wider-leaved mutations, there appear forms with very narrow willow-like leaves, var. *salicifolia*. This edge of the river is in bright sunlight, so that the advantage of broad leaves to the plant is lost. Now suppose a fall of the lofty hill-side so as to block up and divert the Tahan river, leaving the *Ixora* in an area quickly covered by dense forest. Owing to the reduction of sunlight, the narrow leaves are now an injurious mutation, the plants with slightly wider leaves would supplant those with willow leaves, and eventually by the elimination of the narrow-leaved forms the plant would revert to the jungle form.

The 'struggle for existence' is not of course merely the struggle

for life of an individual or species, it is the struggle for successful continuous propagation. In most cases thousands of the seeds produced are absolutely wasted, only those are not which find a suitable spot for their future reproduction. A species modified for life in the full sun of a heath may, increasing the width of its leaves, first push into the thin scrub of the forest edge, and, gradually modified, may eventually become adapted for life in the dark, wet forest; or it may modify itself to grow in salt mud, swamp, the sand of the shore, or on coral rocks or on mountain tops.

VERY COMMON PLANTS.

On p. 17 of Ann. Bot., vol. xxx, Dr. Willis in dealing with very common plants writes: 'Why should a species that ranges over Ceylon and Peninsular India be commoner in Ceylon than one that only ranges over Ceylon?' and makes the advocates (of Natural Selection I suppose) reply: 'Because it has a wider range.' This, he says, is simply an appeal to ignorance; and here I heartily agree with him, merely suggesting he should refer the question to an observer of plants in place of such advocates. His suggestion is, that the reason why mere wide range should involve commonness is their greater age within the country.

Let us examine the story of some common plants, and first take *Imperata cylindrica*, the Grass known as Lalang in Malay and as Illuk in Ceylon. It was, when I first reached the Malay Peninsula, the commonest plant in the peninsula. There was over large areas much more of it in bulk than any other plant, and far more than of any indigenous Grass in the whole peninsula.

It is generally believed to be a native of Africa, and was probably introduced somewhere about 1822 into the Straits, when the forests of the country were cleared. According to Dr. Willis's theory it must have been a much older inhabitant than, say, the indigenous endemic *Saccharum Ridleyi*, confined to the sandy heaths of Pahang. But we know that it is quite a modern introduction. Why should it be so much more abundant? The plant has an underground rhizome which can grow at a depth of 16 inches below ground, and if dug up can propagate itself rapidly from portions of the rhizome. Excessive heat and drought do not affect it, as the rhizome is too deep in the ground to be injured. Fire passing over the ground merely burns the leaves, which spring up again, growing an inch a day. The plumed seed is readily carried along into distant spots. I have even seen it growing in the sulphurous smoke of a volcano in Java, where hardly another plant could hold its own. We have another species in the country—*I. exaltata*, Brongn. This appears to have originated in South America, and occurs too in the New Hebrides and Malay islands, and the Malay Peninsula as far north as Mergui. It is closely allied, a rather taller

plant with the same plume-borne seeds. It was probably introduced into Singapore about the same time as the Lalang, *but* it has no deeply protected rhizome. It is unable to defend itself against great heat, drought, and fire. It occurs only sporadically here and there, and is in fact comparatively rare, and does not grow near volcanoes nor survive a forest fire.

Some years ago, in writing about cultivation of lawns, I had to point out that only Grasses with creeping rhizomes should be used, because in dry weather those which had not creeping rhizomes died out from the heat, while the rhizomatous Grasses creeping over each other prevented the ground from giving off the moisture (chiefly dew) all day during the heat.

Paspalum platycaule, Sw., is a creeping Grass, native of South America. It is now very common in Java. One day I found a patch of it in Singapore by the road-side, the only patch I had ever seen; in fact, it was VR. I removed some to the gardens, where it grew very fast; it now spread all over the Singapore road-sides. It has since become a nuisance, having become in a few years VC.

But the whole story of weeds (i. e. plants introduced by man) is the same. Look at *Ageratum conyzoides*, an American plant now extraordinarily common all over the Eastern tropics; *Clitoria cajanifolia*, formerly a rather rare local plant in Pernambuco, whence for many years only one or two specimens had been obtained, now common in Java and in Singapore, spreading to Borneo, thanks to the fact that, unlike other species of the genus, the seeds are viscid and adhere to the passing cattle; or again *Tithonia diversifolia*, Gray, a Mexican plant—'though only introduced (into Ceylon) as a garden plant so recently as 1851 it is now one of the commonest and most conspicuous plants in the island' (Trimen's Flora).

The obvious reason why wide range (as in the case of *Imperata cylindrica*) involves greater commonness is that for some reason the plant has advantages which enable it to spread and propagate its seed successfully and continuously, and has nothing to do with the period at which it entered the country.

What the advantages are in each plant is only to be known by careful study in the field, and an extremely interesting study it is, especially as they are different in almost every species, and due to modifications in all parts of the structure from root to seed, and even in some cases the chemical contents of the cell. Let the botanist find out why *Ageratum conyzoides* has spread over the whole tropics in spite of man, and *A. peruvianum* has failed though helped by man; why *Capsicum minimum* has established itself on tropical Eastern limestone rocks in immense abundance and *C. annuum* failed.

These stories can be elucidated in the field, but not in the library.

SUMMARY.

Dr. Willis bases his arguments on the number of plants marked VC, VR in Trimen's 'Flora of Ceylon', and states that a VC plant cannot disappear without a geological catastrophe. It is shown that the rarity or commonness of plants in Ceylon, as based on this book, is unreliable for practical purposes, and that the VC species can and do disappear without any catastrophe.

Endemic species in Ceylon and elsewhere are nearly all the relics of an old flora rapidly disappearing, and in most cases cannot be evolutions of a later date, as there is nothing in the land from which they can have evolved, and therefore they must be the oldest, not the youngest part of the flora.

The mutation theory that new characters arise at a step, and that once they have appeared they remain hereditary and do not revert, is not in accordance with the facts. The theory fails to account for the adaptation of plants to their surroundings, and no theory yet proposed, except that of Natural Selection, does so.

The struggle for existence (more correctly the struggle for continuous reproduction) is not confined to the seedling, but is continuous throughout the life of the plant, and a mutation, however apparently trivial, of any organ in the plant may be adapted for this end.

It has been of course impossible in this paper to do more than give illustrative examples on any one point; the amount of evidence against the mutation theory and the various points controverted above is too enormous for even one book. This class of work can only be done in the field. Arguments based on calculations made from a book, however well written, are unreliable and misleading.

Dr. Trimen's Flora, on which Dr. Willis bases his arguments, is a good Flora for its date, but a great deal of research work has been since done on the countries adjacent to Ceylon, and from which the Ceylon flora took its origin. Most of the Ceylon species require critical examination again. There have been many misidentifications and errors in the geographical distribution, and very many of the species are but little known at present. With this work the study of the Ceylon flora commences, but the story is by no means complete yet, nor will it be till all the plants have been carefully and completely studied, one by one, in their relations to all conditions in which they occur in their natural wild state.