are equal; the surface is in two ways locus of points with fixed distance to a given right line (each of the axes). If those two distances are equal, $\frac{\pi}{4}$ each, the surface divides elliptic space into two congruent parts [1]).

Botany. — *"On the distribution of the seeds of certain species of Dischidia by means of a species of ant: Iridomyrmex myrmecodiae Emery."* By Dr. W. DOCTERS VAN LEEUWEN and Mrs. J. DOCTERS VAN LEEUWEN—REYNVAAN. (Communicated by Prof. F. A. F. C. WENT).

SCHIMPER [2]) in his well-known work on American epiphytes, has arranged these plants in a number of groups according to the methods by which their seeds are distributed. Obviously it is necessary for these plants, that their seeds should ultimately reach the places, in which the adult plants generally grow. The seeds of epiphytes may be distributed through the agency of fructivorous animals, and through that of the wind. The representatives of the first group are characterized by the possession of edible portions of the fruit or seed. Various members of this group are known among the orders *Rubiaceae, Melastomaceae, Artocarpeae,* etc. The wind may distribute the seeds if they are very light, as is the case with Orchids for instance; the spores of epiphytic *Lycopodiaceae* and *Filicinae* are also carried from tree to tree by air-currents. Other plants have seeds provided with a floating mechanism such as representatives of *Gesneraceae* and *Asclepiadaceae.*

Among well known epiphytes belonging to the last named order are various species of *Dischidia,* of which *D. Rafflesiana* has already been dealt with in several works. Since our arrival in Java, we have had repeated opportunities of observing this plant, both in its natural habitat and in our garden. Not only *D. Rafflesiana* but also *D. collyris* and still more *D. nummularia* are especially abundant in the immediate neighbourhood of our present abode. On the

[1]) Likewise we find elliptic space S_{2n+1} of an odd number of dimensions divided into two congruent parts by the quadratic Q_{2n} containing the points at fixed distance $= \frac{\pi}{4}$ from a given plane S_n as well as from its reciprocal polar S_n with respect to Ω_{2n}.

[2]) A. F. W. SCHIMPER. Die epiphytische Vegetation Amerikas. Bot. Mitt. a. d. Tropen, Jena 1888.

hills in the vicinity of Semarang, i.e. on the last off-shoots of the Oengaran mountain, the numerous *Mangifera*'s and *Tectona*'s are often completely draped with these epiphytes. They are also found in thousands in the teak woods of Mańkang, Djerakah, Tempoeran and Kedoeng Djattie. As long as three years ago when we first found these plants in the wild state, in the forest of Tempoeran, we noticed that trees over-grown by these *Dischidia* species, were full of a small dark-coloured species of ant. At the slightest touch the insects swarm over the trunk and the plants growing on it, and, in spite of their small size they can bite very unpleasantly. Since then we have noticed, that in numerous places, where the *Dischidia*'s occur abundantly, the same species of ant also inhabits the trees in large numbers. In the neighbourhood of Kediri, a small town at a distance of a day's journey from Semarang, one of us also saw these plants in large numbers in the tops of the shade-trees of a coffee plantation. Attention was drawn to their presence by the fact that on a certain spot the coffee trees were badly attacked by a small species of ant, which destroyed the bark and built channels within it, so that a large number of coffee trees died off. It was found to be the species of ant already mentioned in the title. That there was a connexion between the life of the three above-mentioned species of *Dischidia* and the species of ant had been clear to us for a long time, but we were only able to discover the nature of this connexion in the last two rain monsoons.

Some time ago there appeared a paper by RIDLEY on symbiosis between plants and ants, in which this investigator states that there can be no question of a true symbiosis between ants and *Dischidia Rafflesiana*. Possibly his opinion might have been different, had he known the connexion which exists between these ants and the seedlings, although we consider that as yet there is not sufficient evidence to assume the existence of symbiosis. We propose to publish our own results on this point in a detailed paper, but as the time we have at our disposal for research, is limited and the portion of the work mentioned in the title of the present paper, forms a rounded off whole, we here give a brief survey of the facts we have observed.

The seeds of *Dischidia Rafflesiana* and *nummularia* agree completely as to shape (we are not yet acquainted with those of *D. collyris*), but those of *D. Rafflesiana* are about $1^1/_2$ times as large as those of *D. nummularia*. Both have at one end a fine pappus of long white hairs. The seeds are compressed laterally and have on their narrow side and opposite the pappus, a thin white crest, which contrasts strongly with the testa, which is dark brown or almost

black. This crest is broadest at one extremity of the seed; it gradually gets narrower towards the opposite end and ceases completely about half way. The crest is composed of thinwalled cells containing oil and protein; it is clearly shown in the drawing of the seed of *D. Rafflesiana* published by SCHIMPER (Pl. 6 fig. 6).

When walking on a quiet sunny day under the *Mangifera's*, which are sometimes completely draped with the grey strands of *D. nummularia*, one sees, when the seeds are ripe, the white pappus floating in the currents of air. If the seeds come into contact with a tree, they attach themselves more or less firmly, but can also be carried on again. At first sight one would therefore imagine, that these plants are disseminated by the wind alone. In our own garden and in that of the High School, in which a large number of trees are grown, we have carried on germination experiments with the seeds. They were stuck by means of a little water to the trunks of various trees and were regularly watered during the first few days. The seeds germinate extremely rapidly; the seedling attaches itself by the lower end of the hypocotyl and after a few days the cotyledons already appear. (Later we hope to describe the germination in detail). If the seedlings are now left on the trees without being taken care of, i.e. if they are not watered regularly, they soon begin to languish, although they are able to support much drought. The cotyledons keep crumpling up and become again turgid after a shower of rain. Although the past monsoon was very damp, not a single one of all the seeds, which were sown, survived. They all died off after a few weeks of drought.

SCHIMPER writes that the seeds themselves may get down deep into the fissures of the trunk, but we have never observed anything of the kind; on the contrary the hairs of the pappus completely prevent the penetration of the seed itself into the fissures of the bark. It is further known that these plants, and especially *D. Rafflesiana* prefer to grow on trees with slight foliage or high up in the crown, so that they are exposed to the intense rays of the sun. It seemed to us worth while therefore to investigate in what manner the distribution and germination of the seeds really takes place.

After many abortive journeys through the habitats known to us, we saw the first young seedlings appear on the trees at the beginning of the wet season. They all, without exception, came up from deep down out of the fissures in the bark. Moreover we now saw them arise in all sorts of places out of the channels of the *Iridomyrmex*-ant, already well known to us. The seedlings were found most numerous in those places where the ants build their, very

primitive nests. Besides building between the branches and the roots and in the pitcher leaves of *Dischidia Rafflesiana*, these insects make their nests from enlargements of the tunnels, which diverticula are built with the same bitten-off particles of bark as the tunnels themselves. They prefer to make these enlargements on the lower side of a lateral branch, where such a branch emanates from a thicker one, but also on the lower side of the point, where two thinner twigs come off together. It would of course have been very peculiar, if the seeds had become attached in larger numbers just at these places and had afterwards been covered by the ants. By these discoveries the problem was solved and later journeys and observations confirmed us more and more in our view.

When this fact has once been noticed, it takes very little trouble to collect a few hundreds of seedlings or more within a short time. Although germination takes place very rapidly, the further growth is, at least in the beginning, very slow. In the teak forest of Tempoeran we found very good evidence that we had not been mistaken. Among thousands of pitcher leaves of *D. Rafflesiana* we found a single specimen which had a narrow slit in its wall. This pitcher was inhabited by a large number of ants, which had divided its lumen into various chambers and passages. The peculiar thing was that from this slit there issued the two cotyledons of a seedling of *D. nummularia*, while the hypocotyl axis was long drawn out and grew out from the innermost part of the ant passages.

The ants often live in large numbers on the small trees of *Protium javanicum*, which have been planted along the village roads and owing to continual pruning have assumed the aspect of pollard-willows. The widened, often half mouldered portions appear to be excellent nesting-places for the ants. *Dischidia's* indeed grow on these small trees in large numbers. We do not know why, but in various places one finds numerous ants on one side of the road and none or hardly any, on the other side. Without exception there were in such cases numerous *Dischidia's* on one side of the road and few on the other. It is indeed in these places that the dissemination by ants is readily observed. We were moreover able to take a large number of photographs which will be reproduced in the more detailed publication.

This point in the investigation was reached very rapidly but the principal evidence was still wanting. We had never directly observed the ants dragging away the seeds. Experiments made in our garden were unsuccessful, for the *Iridomyrmex* was always driven away by other species of ants. But after a long and abortive search we

were able to make more successful observations in the actual habitat of the plant.

It was on the morning of a sunny day, with a very gentle breeze. All around us we saw the light seeds floating in the wind. Whenever a seed stuck to a tree at a spot, where there were ants, the latter soon came running up from all sides in large numbers. The small ants are not able to take hold of the seed itself. They pull it by the hairs of the pappus. Among these hairs there are two kinds: a large number of long ones which break off easily, and a smaller number of short ones, which are less fragile. First the long fragile hairs are pulled off by the ants seizing them with their jaws and pulling in all directions. Then the seed is dragged away by a small number of ants and is seen to disappear among the leaves and stems of the *Dischidia's* already present. If no *Dischidia's* are near, the seeds are drawn into the fissures of the bark and are then carried further. Since the ants make their tunnels in the upper, as well as in the lower parts of trees, the seedlings also are found growing in all sorts of places. The beautiful young seedlings of *D. Rafflesiana* are found everywhere. At first they grow slowly, but as soon as they have become somewhat arger, long, strongly heliotropic, climbing stems arise, on which but few leaves are developed. In this way the plant soon grows up to the higher parts of the tree, where, as is well known, it lives by preference. *D. nummularia* and *D. collyris* however also grow with equal luxuriance in the shade.

In trees which are grown over in this way, the ants prefer to build their nests in between the *Dischidia's*. The roots of these plants then spread through the walls of the passages and nests, and sometimes form thick networks.

We thus arrive at the following conclusions:

1. that the seedlings which simply germinate on the trees without further intervention have a languishing existence.

2. that the healthy seedlings are to be found in the passages or nests of a certain species of ant.

3. that these ants drag away the seeds.

4. that the distribution of *D. Rafflesiana* and *nummularia* (and also of *D. collyris*, in which species we have not yet, however, observed the dragging away of the seeds) corresponds with the distribution of a species of ant. In the environs of Kediri, Semarang, Djerakah, Mangkang, Kedoeng Djattie, Tempoeran, Pekalongan and Koeripan this species is *Iridomyrmex myrmecodiae* Emery. It is of

course quite possible that in other places a different species of ant takes over the function of *Iridomyrmex*.

The ants have been determined by professor FOREL, through the intervention of Mr. JACOBSON; professor FOREL further states, that this species of ant inhabits in large numbers the tubers of *Myrmecodia* and *Hydnophytum*, a fact which we ourselves could observe in plants from Tjilatjap and Buitenzorg. Another species of *Dischidia*, namely *D. sagittata* Decaisne, which we found in large numbers on *Hibiscus tiliaceus* on the sea shore at Koeripan, germinates and grows on the trees in our garden more readily than the two other species. So far we could not find here any trace of myrmecophilous dissemination. In addition to their being distributed by ants, the three *Dischidia's Rafflesiana, collyris* and *nummularia* agree with one another in a variety of other points. We hope to be able to show this later.

Physics. — "*Isotherms of monatomic substances and of their binary mixtures. X. The behaviour of argon with respect to the law of corresponding states.*" (Continued). By Prof. H. KAMERLINGH ONNES and C. A. CROMMELIN. Comm. N°. 121*b* from the Physical Laboratory at Leiden.

(Communicated in the meeting of May 27, 1911).

§ 4. *Comparison of argon isotherms with those obtained from the mean reduced equation of state, and with those for isopentane.*

Two tables which we have already published, one of them [1]) containing the individual virial coefficients for argon calculated from the experimental results, and the other [2]) the corresponding coefficients deduced from the mean reduced equation of state VII.1 afford, on comparison with each other, a means of determining the behaviour of argon with respect to the law of corresponding states. Of this behaviour, which finds expression in systematic deviations from VII.1 we have tried in Plate I to give a comprehensive representation which seems to us a suitable manner of giving striking expression to the characteristic deviation of the reduced equation of state for the monatomic substance argon from the reduced mean equation for

[1]) Proc. Ac. Amsterdam, Dec. 1910. Comm. N°. 118*b* Table II.

[2]) Proc. Ac. Amsterdam, March 1911. Comm. N°. 120*a* Table I.