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On the Biology of some Javanese *Loranthaceae* and the role birds play in their life-historie

by

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CONTENTS

Dedicated to the memory of Prof. Dr B. H. Danser, the eminent taxonomist and plant geographer. His fundamental studies of the Loranthaceae made my work possible.

INTRODUCTION.

I began my investigations about the galls of the *Loranthaceae* in Salatiga in 1908 and continued this work in Samarang from 1909 to 1915. Here I also examined the germination of the seeds. From 1915—1918 I stayed in Bandung where I had little opportunity to continue my investigations. From 1918—1932 I lived in Buitenzorg (Bogor) where I could resume my studies on the *Loranthaceae*, not only as to the germination of the seeds, but also the pollination of the flowers. For this purpose I sowed many species of *Loranthaceae* on shrubs in the neighbourhood of my home, so that I could easily check the development and had ample material at my disposal.

The investigations were hampered by the chaotic conditions of the systematics of the Indomalayan *Loranthaceae* in 1909. In Samarang for instance I found that the germination of various species followed a different course, but could not work it out comparatively, because most species could not be indentified with certainty. The material I collected in Salatiga and Samarang was compared by Dr J. J. SMITH, at the time on leave in Holland, with *Loranthus*-material in the Leyden Herbarium. Only a few of them could be identified with sufficient certainty, many of them could only be classed with some genus and some of them could not be classified at all. The result was that in the first publication on the germination of the seeds (DOCTERS VAN LEEUWEN-REIJNVAAN, 1915: 220) some species could only be indicated by a digit, an unsatisfactory solution.

Conditions altered when B. H. DANSER during his stay at Buitenzorg was charged with the critical elaboration of the Indomalayan *Loranthaceae*. He made a profound investigation of the material which is so rich in species and published the results in 1931 in an article: "The *Loranthaceae* of the Netherlands Indies", Bulletin du Jardin botanique de Buitenzorg, serie III, vol. XI, livr. 3—4.. Until his too early death DANSER continued to work out Old World material of this family and published many articles about the results. Part of the titles can be found in the list of literature at the end of this paper.

Well elaborated material was now at the disposal of all those who wanted to study the biology and anatomy of this plant-family. I have gratefully availed myself of this opportunity and acknowledge my indebtedness to DANSER for his suggestions and criticism. With DANSER one never applied in vain for help. My admiration for his profound knowledge grew constantly during my own investigations. Therefore I dedicate this essay for which he showed great interest as a posthumous homage to this prominent botanist.

I begin the discussions of each species treated in this essay (chapters 3 to 12) with the description of the vegetative and generative parts of the plants. Most of the outlines are necessary for understanding the following anatomical details, essential for the study of the pollination. They were for the greater part taken from DANSER's work, allthough curtailed here and there. In order to avoid repetition I have not stated it seperately for each plant, but mention it here for all of them.

When I retired from Java in 1932 I had not yet collected all data about the investigated species. I had been looking forward to revisit this country where I spent the best years of my life to complete my studies. The voyage was planned for 1940, but the war prevented my going. I now publish what I found between 1908 and 1932.

In the text I have omitted the names of the authors of the scientific names of the plants and animals discussed. They can be found in the index.

At the celebration of my 70th birthday many good friends have contributed toward the finantial support for publishing this essay. Moreover, finantial help of the *Hollandse Maatschappij der Wetenschappen*, de *Nederlandse Maatschappij voor Natuurwetenschappelijk Onderzoek van Oost en West Indië*, and the *Natuurkundige Commissie van de Koninklijke Nederlandse Akademie van Wetenschappen* (*Insulinde Fonds*) enabled me to have this article printed. I am very grateful for their effective assistance.

I take this opportunity to acknowledge my indebtedness to Dr H. C. D. DE WIT for translating the first part of my manuscript. The remaining part has been translated by Mrs. Dr R. E. L. VAN DER WAERDEN to whom I am obliged for her help.

Leersum, "Lebak Saät".
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CHAPTER 1.

General Notes

The family of *Loranthaceae* is considered to consist of two tribes, *Loranthoideae* and *Viscoideae*. The latter tribe comprises small and very small species though some exceptions occur, viz *Viscum articulatum* and *V. liquidambaricolum*. The present study deals mainly with representatives of *Loranthoideae*, particular those indigenous in Java.

Most species are characterized by a bushy habit because they branch profusely, some branches being erect and the majority drooping. The species of *Scurrula* are comparatively small though many species may become very large. As a rule they are connected with their host at a single spot, but a number of species extend along the branches or trunk of the host plant and may be attached repeatedly. A striking instance of that habit is observed in specimens of *Baratranthus exanthus*, which seem to scale the trunk of the host tree and look like climbers without their bases rooting in the earth. Species of *Amyema* often seem to adopt this manner of growth. In New Guinea I noted this characteristical habit for *Amyema speciosa*. The plant climbed with a runner upwards along the stem of the host tree. On Buru, TOXOPEUS collected a specimen of *Amyema umbellata* and wrote on the collector's label: "climbing parasite, 3½ m long" (DANSER, 1931 : 353).

The majority of species, however, is not attached to the trunk but fastens on the branches. Often large warty knobs emerge at the place of attachment, a reaction of the host plant to the parasite. These knobs may grow to a large size and in German are described as "Holzrosen". It is to be noted that sometimes a species of *Loranthus* is attached on top of a protruding bulky knob whereas the same species may also be found to grow without the appearance of a knob, or almost so. Possibly the species of host plant is partly or wholly responsible for the presence or absence of a knob. This peculiarity is well illustrated by *Korthalsella opuntia* (Chapter 11). As a rule the spot of attachment is not, or only very slightly, thickened. I observed this parasite in Central Java in large numbers on the branches of a *Symplocos*. Warty emergescent knobs were not present. In the mountain garden at Tjibodas, on the other hand, my attention was attracted to the large knobs which had appeared on the branches of *Altingia excelsa* at the place of attachment (plate X). At first sight I believed that the knobs were galls caused by some insect or other parasitic animal, but on closer inspection I found that the knobs carried the branches of *Korthalsella opuntia*. The knobs develop immediately after the germination of the seed and the penetration of the haustorical root. In *Korthalsella* the presence or absence of a knob at the place of attachment seems to be connected with the kind of host plant. The evidence from other instances is not so easily explained. Should the formation of knobs be seen as a kind of protective measure by the host plant? The point certainly needs further investigation.

Occasionally a branch dies off above the place of attachment. It then seems that the *Loranthus* acts as a kind of continuation of the branch. This habit is often adopted in a most illustrative manner by *Viscum ovalifolium* (plate VIII B). Below the parasite the branch is clavately swollen and on top the parasite emerges. In other species the branch of the host plant merges with that of the parasite and in appearance the result is the same as that of a grafting. It often occurs in the natural development that the branch dies above the place of attachment of the parasite. I observed this very clearly in *Lepeostegeres gemmiflorus*, a parasite on *Rubiaceae* in the Botanic Gardens at Buitenzorg. A specimen of *Dendrophtoë pentandra* also caused the death of the upperpart of the branch of a *Citrus* on which it had established itself. More examples can easily be given.

Many *Loranthaceae* attain very large proportions. Some species develop branches longer than 3 meters, hanging from the crown of the host tree. *Viscum liquidambaricolum* favours high growing stations up in the crowns of *Altingia excelsa* and forms bunches of pendent branches of more than 2 meters in length.

It seems certain that many of *Loranthoideae* live only a few years. There are exceptions and some long living species may grow to tremendous size. A tree profusely attacked by *Dendrophthoë pentandra* may carry numerous knobs without a living parasitic plant, becauce many individuals have already died.

Some species appear to be subject to a kind of periodicity. This is clearly demonstrated by *Korthalsella opuntia*. At the insertion of its branches small, green knobs develop which will produce new twigs. This occurs after a crop of fruits has been produced. The old branches die and shortly after the green buds develop into new branches. This periodicity is not connected with alternating wet and dry seasons because it is possible to find simultaneously specimens with flowers and others with fruits. Other specimens may carry young branches, or young buds, only. I have not noticed these phenomena in other species.

Concerning the giant, long living species I wish to say that the connection of parasite and host is sometimes so perfect that the place where they merge is scarcely traceable. A good instance is that of *Elytranthe albida*, a parasite on *Castanea* or *Quercus*. *Elytranthe* has thick branches and they merge often invisibly into those of its Fagaceous host. The base of the branch is as it were a continuation of the branch of the host.

A most illustrative example was provided by a new species, described by DANSER as *Dendrophthoë magna*. It occurred on the slopes of Mt. Gedé, above Tjibodas in West Java. This specimen was very large, almost a tree in itself and it formed a continuation of the crown of its host, *Quercus pseudo-molucca*. The oak was about 20 m tall; and only its lower branches were left. The trunk of the host, being about 40 cm through, merged into that of the parasite, which formed a dense bushy mass of branches and leaves on top of the decapitated oak. The circumference of the *Dendrophthoë* was almost 10 metres. The lateral branches were 7 cm through. The whole picture was that of a parasite grafted on top of the oak. It was a peculiar point that the wood of the *Dendrophthoë* was much of the same structure as that of the *Quercus*, though more brittle, as is usually the case in Loranthaceae. This raises the question whether the leaves of the *Dendrophthoë* had taken over the function of the leaves they "replaced". Was this a kind of symbiosis ?

Commonly, Kapoc trees which are full of large tufts of *Loranthus* appear to produce few leaves of themselves (see plate II), and this near absence of their own foliage is maintained even in the rainy season. KORTHALS (1839 : 227) stated that he saw *Erythrina* trees which were almost without leaves but all profusely studded with hanging bushes of *Scurrula atropurpurea*. It is possible to meet with similar phenomena in other species of trees and to all appearances the trees scarcely suffer from the accumulation of *Loranthus* specimens. In a garden at Buitenzorg (cf. DOCTERS VAN LEEUWEN, 1927 : 123) was an approximately 10 m tall tree of *Canangium odoratum*. It had only a few leafy branches of its own and the crown was composed of some leafless branches of the host and bushes of *Dendrophthoë pentandra*. The weight of the Dendrophthoës became so large that the tree began to list and had to be felled. The parasitic plants were removed and proved to weigh in total 215 kg. It was another striking example of a living tree covered by parasites and with only a few leaves of its own. This case raised the question again whether the host was benefited by assimilation products from the parasite.

The answer is not an easy one and evidently experiments are required to find a solution. Obviously the host will ultimately die. Is this due to the fact that in the long run the parasite is not able to provide the host with sufficient assimilation products ? Or is the death of the host caused by that of the parasite which might imply that the death of the parasite entails the starvation of the host ? TUBEUF has posed (1923 : 564) the question whether parasitism and symbiosis between host and parasite take place simultaneously. Of course, this symbiosis can never be accepted as true symbiosis, because the host certainly does not require a parasite to thrive and grows better without it. TUBEUF noted that *Picea* and *Pinus* trees bearing *Viscum album* remained alive during several years even if all needles were shed. This is nearly identical with my observation in tropical *Loranthaceae*. PITRA (1861 : 53) conducted a number of experiments by cultivating parasites on host plants to establish whether *Viscum* drew food from its host or that the host obtained nutrition from the parasite. His result was that the host received no nutritional substances from the parasite. On the other hand BÖHM (1865 : 633) executed similar experiments and concluded that the host actually received food substances from the parasite. VAN POETEREN (1912 : 101) published a note on the grafting of 3 Viscums on the apical part of the stem of a *Sorbus aucuparius*. Notwithstanding the fact that the *Sorbus* remained without leaves, the Viscums developed vigorously and the trunk of the *Sorbus* thickened. After two years the *Sorbus* died from an unknown cause. HEINRICHER (1913 : 1261) and MOLISCH (1920 : 98) conducted similar experiments with the same results. In addition, TUBEUF (1923 : 574) carried out many experiments. Although a considerable amount of data are now available it is still not demonstrated with certainty that assimilates or other substances produced by the parasite are provided to the host. The leafless Kapoc trees bearing numerous bushes of *Loranthus*, and in particular the large specimen of *Dendrophthoë* *magna* replacing the crown of a large *Quercus*, very strongly suggest that certain products from the parasite are made available to the host. The anatomy of the wood of *Dendrophthoë magna*, which was, as we have seen, largely similar to that of *Quercus*, seems to be in support of that view.

Experiments should be started in the tropics in the same manner as those carried on *Viscum* in Europe. The rapidly growing species of *Loranthus* certainly would prove to be suitable objects. I myself started work in 1930 but various other duties and my departure for the Netherlands soon after, caused that no clear results ensued. This might be suggested as an item on the research program of some forest experimental station in the tropics.

Tropical *Loranthaceae* are, in general, highly indifferent as to their host species. There are some exceptions. *Korthalsella dacridii* so far has been only found on two species of Conifers, a *Dacridium* and a *Podocarpus*. *Viscum liquidambaricolum* grows, in Java, only on *Altingia excelsa* but, on Formosa, was observed to settle on some other trees, e.g. a species of *Quercus*. *Elytranthe albida* parasitizes on *Castanea* and *Quercus*. *Viscum articulatum* is a hyperparasite on several *Loranthaceae* and grows on some Dicots such as *Evodia*, *Fluggea* &c. Further examples could be added. Nevertheless, the large majority of tropical *Loranthaceae* are decidedly polyphagous. This characteristic is carried to an extreme by *Dendrophthoë pentandra*. It may be found not only on numerous Dicots but also on Monocots (see ARENS, 1912 : 564), on Conifers (e.g. *Araucaria*, *Dammara*, see KOERNICKE, 1910 : 680) and now and then even on a Fern (e.g. *Angiopteris evecta* (DOCTERS VAN LEEUWEN, 1936 : 24), plate VIII A).

It has been a subject of discussion why *Dendrophthoë pentandra* avoids some species of trees (KOERNICKE, 1910 : 671). KOERNICKE composed lists of host species and drew attention to the fact that even plants containing milk sap and a high percentage of bitter substances are commonly strongly attacked by this loranthaceous parasite. There was no explanation for its occasional absence on host plants which might be considered to be suitable. Only extensive experiments can throw a new light on this problem. There is a possibility that *Dendrophthoë pentandra* comprises a number of physiological races in a same way as were found to exist in *Viscum album*. The same might exist in *Viscum articulatum* which parasitizes on *Loranthaceae* and a few Dicots. It is interesting to note that SCOTT (1871 : 133) observed that in Calcutta, *Melia azederach* is without *Loranthaceae* whereas KOERNICKE (1910 : 685) stated that this tree, at Buitenzorg, is heavily attacked by those parasites. This could also be explained if physiological races of the parasite existed. Nevertheless, it is necessary to be cautious when drawing conclusions from negative observations and experimental control is indispensable.

Viscum album produces roots or haustoria in the bark of its host which emerge laterally from the primary stem thus enabling the parasite to extend itself. It has been a point of protracted discussion whether these lateral emergences are true roots or stems. At present they are taken to be roots though their anatomy is aberrant and a normal root-cap is absent. An exhaustive survey of this question, accompanied by commentary on the literature, was given by WANGERIN (1937 : 1069).

I do not know if tropical *Viscoideae* produce similar lateral roots spreading through the bark of the host. In *Korthalsella opuntia*, parasitizing on *Altingia excelsa*, they are certainly absent. Every specimen is attached on top of a knob of the stem of the host plant and when, in the course of time, additional stems appear, they are situated close together. ERNST (1942: 281) remarked that in *Korthalsella dacridii* it seems that the haustoria of the parasite spread more or less in the same way as a mycelium, over large distances under the bark of the host. He does not mention the production of new branches from the haustorial roots.

Loranthaceae produce as a rule lateral root-like emergences but these do not spread through, or grow inside, the bark of the host plant. They remain on the surface and for that reason are termed „epicortical" roots, also runners. Mostly they are dark brown ond the apex is lighter coloured. At relatively short intervals the runners produce flat, disc-shaped or saucer-shaped outgrowths, called "attachment discs" or "hapters". The lower, flat surface is pressed against the bark and a haustorium penetrates into the bark and part of the wood. At the opposite side the hapters may bear buds which can develop into branches or inflorescences. By this habit a parasite may grow rapidly.

At first the runners are appressed against the bark, they are, as it were, glued to it but after the emergence of the hapters they are lifted from the substrate. The apex, however, continues its growth remaining appressed against the bark. The runners may cover a very considerable distance and may turn and proceed again in the opposite direction. This, in particular, happens if the branch dies off above the place of attachment of the parasite. The runner at first continues its growth along the dead branch until the end is reached then turns, retraces its way downwards along the dead branch and by this means may succeed in regaining the living part of the branch.

Runners of a similar, very slender habit, may also be found in parasite seedlings: they develop endogenously from the base of the hypocotyl. On the other hand, some full-grown plants appear to be without runners. This is in particular the case when a parasite is attached on top of a large knob on the host plant. Why runners may either occur or be absent in specimens of *Loranthus* of the same species I cannot explain

Seedlings of *Loranthaceae*, germinating on the lamina of a leaf, as a rule produce runners. An illustrative picture was given by DUNSELMAN (1939: 77, fig. 7) of a species of *Ginalloa* on the leaf of an *Eugenia*. Just above the hapter two very slender runners emerge from the hypocotyl; these runners also bear some hapters. The runners are directed from the seedling towards the petiole and one already proceeds onto the branch. A seedling on a leaf cannot survive for lack of food. In that case the runners enable the seedling to reach the branch and the seedling may survive. KOERNICKE (1908: 186) claims that lack of food stimulates the parasite to form runners and I am inclined to support that view. A young specimen of *Dendrophthoë pentandra* which had germinated on the stem of a leaf of *Angiopteris evecta* had produced a runner at an early stage of its development. This runner had several hapters but these remained unattached and ineffective and no haustorium was sunk into host plant (see plate VIII A). Evidently the parasite lacked food because the functioning communication with the waterconducting vessels of the host were insufficient. I doubt whether a shortage of food will always be responsible for the presence of runners.

I placed numerous seeds of *Dendrophthoë pentandra* on the petioles of *Carica papaya*. They all germinated. The hypocotyl became attached to the surface of the petiole and the haustorium penetrated into the central parts. The petiole of *Carica* is hollow and the haustorium entering into that cavity filled it by developing a thick white plug. I intended to use this material for an anatomical investigation but the specimens were lost, with a large amount of other material, in the fire of the steamer „Dempo" in the harbour of Tandjong Priok (1932).

The seedlings on *Carica* grew very slowly, produced a few leaves but not a single runner and this absence is hard to understand if starvation should be the sole cause of the appearance of runners. It was a peculiar point that the leaves of *Carica* bearing a seedling remained much longer on the plant than leaves without a parasite. KOERNICKE (1937: 398) observed the same phenomenon. Whether leaves of other species of plants bearing seedling *Loranthaceae* live longer than leaves without parasites I do not know, but it seems quite possible.

As a rule the runners remain comparatively thin, i.e. they thicken but little. Plants which assume the habit if climbers — some were mentioned before — possess very stout runners. In that case the latter obtain a rough bark and their appearance is like that of branches. In spite if this I agree with KOERNICKE (1908 : 187 that the runners are to be seen as roots though some characteristics of roots are absent (e.g. the root cap). KOERNICKE interpretes the runners as sideroots of the first order which through a parasitic habit became modified as to their anatomy and general morphology. I feel that growth in, and exposure to, the air also influenced their morphological characters.

CHAPTER 2.

Dicaeidae, Flower-Peckers or Mistletoe-Birds.

The *Dicaeidae* comprise a few genera of birds which play an important role in the life of various *Loranthaceae*. Their behaviour and the build of some of their organs show clear adaptations to their life-habits. The names "flower-peckers" and "mistletoe-birds" indicate that these birds visit flowers and, in addition, are connected with the life of *Loranthaceae*.

Seven genera containing 54 species form the family of *Dicaeidae*; often the genus *Zosterops*, or white-eyes, is included in the family (MAYR & AMADON, 1947 : 1). Most species occur in Malaysia. Towards the East the family is distributed to the Solomons, towards the South a few species occur in Australia and Tasmania and towards the West and North, these birds are found in S China and NW India. The highest number of species are met with in New Guinea and the Philippines.

In New Guinea occur the primitive genera *Melanocharis* and *Ramphocharis* which suggests that the *Dicaeidae* are originally a Papuan group. From that large island, the birds penetrated into Australia where the genus *Pardalotus* came into being. Towards the West they migrated over the Malayan Archipelago where *Dicaeum* and *Anaimos*, very closely related genera, originated (MAYR & AMADO, 1947 : 3). This distribution proves that arid zones formed serious barriers which will be correlated with the scarcity or absence of trees and parasitic *Loranthaceae*. Trees are the favoured haunts of *Dicaeidae* and they are only rarely seen at any distance away from them. In Australia, situated close to New Guinea but with many arid belts, only few species are met with. The dry regions of NW India also limit their distribution.

In Java 6 species of *Dicaeum* and 1 species of *Anaimos* occur (BARTELS & STRESEMANN, 1929 : 89). They are discussed in the following paragraphs.

1. Dicaeum trochileum trochileum (SPARRM.), syn. *D. flammeum* SPARRM.

A very common bird, especially at low altitudes. BARTELS (1907 : 118) stated that it was seen practically only in the vicinity of human settlements. This is not quite accurate. Actually, the bird is often noticed close to human settlements especially where neglected fruit trees are infested by *Loranthaceae*. On the other hand, they live also in the wilds, if *Loranthaceae* are present. In the hills, they are less frequent, e.g. in the surroundings of Tjibodas, at 1400 m altitude (HOOGERWERF, 1949b : 129).

It is a small lively bird, always flying to and fro. The ♂ is readily noticed on account of its bright colours. It is not very shy, and in captivity easily tamed, and even accepts food from the hand. Head, throat, breast and back are crimson. The belly is grey, wings and tails are bluish black. The ♀ is entirely light grayish, except a dorsal red patch, close to the tail. The species occurs in Java and Bali, another race in Lombok, see pl. I.

2. Dicaeum sanguinolentum sanguinolentum TEMM.

This race occurs in Java and Bali; other races of *D. sanguinolentum* are found in Flores, Timor and Sumba. The ♂ is on the back black-blue with a purple sheen; below white or yellowish and on the breast occurs a bright red patch. The ♀ is grayish to olive-green; the trunk is red. In

Java, the species is largely confined to the mountains, it occurs even in the subalpine regions. More than the preceding species it prefers forests but it is also observed near human settlements, particularly so when these are situated at higher altitudes (HANS DOCTERS VAN LEEUWEN, 1928 : 439). The occurence of *Loranthaceae* is again of first importance.

3. Dicaeum trigonostigma flaviclune HART.

A very widely distributed species, known as occurring in the Philippines, Malaysia, and S. Indochina. The upper parts of the ♂ are black with, besides, a red or orange anterior patch and a yellow patch on the trunk. Throat and breast are grayish and for the rest it is bright yellow, sometimes interspersed with orange. The ♀ is dull grayish. The colours are not conspicuous and it is in the field not easily recognized therefore. I observed the species in the lower mountains. On Krakatau it occurs even on the beach (DAMMERMAN, 1948 : 342).

4. Dicaeum chrysorheum chrysorheum TEMM.

Distributed in N. India, Indochina, and Malaysia. This is one of the few species with striped lower parts. The tail is yellow, the back brigth olive. It is not easily recognized due to its dull colouring. KONINGSBERGER (1911—15 : 530) stated that it was mostly observed in forests. I have never seen it.

5. Dicaeum concolor sollicitans HART.

The ♂ and ♀ are both dull coloured and in the field scarcely to be distinguished from the ♀ specimens of other species. This species occupies a large area of distribution: S. India, Himalaya to Yunnan and Kwantung, Indochina, Formosa, Andamans, Hainan, Malaya, Sumatra, Borneo, Java and Bali. In the two latter islands the race *collicitans* occurs.

6. Dicaeum agile finschii (BART.).

syn. *Piprisoma modestum finschii* BART.

Like the preceding species, this is a dull species, grayish above and whitish below, more or less streaked ventrally. The bill is thicker and slightly shorter than in the species already mentioned; it is also widely spread: Ceylon, India, Malaya, Siam, Indochina, Sumatra, Java, Sumba, Flores, Alor, Timor, N. Natuna Islands, Borneo, Labuan, Palawan, and the Philippine Islands. The race *finschii* occurs in Java but was only rarely collected.

7. Anaimos (Prionochilus) percussus percussus (TEMM.).

The upper parts of the ♂ are slaty blue with a crimson patch. Below yellow with a red pectoral spot. This species occurs in Malaya, Sumatra, Rhio Archipelago, Billiton, Bangka, N. Natuna Islands, Borneo, Batu Islands, and in Java; in the latter island the race *percussus*. KONINGSBERGER stated (1911—15 : 542) that it lived in the mountain forests and even in the subalpine regions and it was said more to feed on insects than *Dicaeum chrysorheum*. I do not know if this conclusion was derived from the examination of numerous stomach contents. I myself never observed this species.

The mistletoe-birds are pollinators as well as seed-dispersers, and few birds are so adequately equipped for these functions. The bill, the tongue, and the intestinal tract demonstrate morphological pecularities in connexion with these life-habits. They are lively birds.

The bill (PORSCH, 1929 : 165) is short and broadly conical, compressed towards the tip, at the base broader than in the middle, slightly curved and sharp-tipped. The edges of the upper bill enclose those of the lower and are, moreover, delicately serrate near the tip. The latter character is also found in some *Nectariniidae*. In the *Zosteropidae*, which are so closely related, the top part of the bill is smooth-edged. The *Dicaeidae* are distinguished from the *Nectariniidae* in having a more squat body and a shorter, thicker bill.

The food of these birds is partly nectar, which is sucked from flowers and the tongue is adapted to this style of feeding. The species of *Dicaeum* and *Anaimos* have the tongue most strikingly adapted to honey-sucking. GARDNER (1926.1) described the tongue of *Dicaeum trigonostigma*. It has a capillary character because the upcurled edges, which are frayed, overlap. The tip is deeply bifurcated forming two equal tubes and the tip of each one of these again is cleft, forming a quadruple tongue and so it ends by 4 capillary tubes.

In other species the build is simpler. With them the tongue is small and flat posteriously, but above the middle becomes abruptly narrower and begins to curl forming a semitube which is deeply cleft at the tips. A tongue of this description is met with in *D. cruentatum, sanguinolentum, trochileum,* and *celebicum*. In *Dicaeum aureolimbatum* the tongue is similarly built but the edges of each tube show a slight notching which might be taken as an attempt at the production of four tips. In *Anaimos* the notches are deeper which results in 4 semitubular fringeless projections. GADOW (1890—99 : 230) pictured the tongue of *Dicaeum trigonostigma*.

It has been demonstrated now that the tongue of these birds is singularly adapted to the uptake of liquid food, i.e. nectar. In some species this adaptation is more striking than in other but it is observed in all species. The name „flower-peckers" indicates that they haunt flowers. It was realized that flowers supplied food but it was believed that this consisted of insects and other small animals. Our knowledge has increased (see e.g. the inspiring studies by PORSCH, 1924 : 553) and at present we know that many birds feed on nectar from the flowers.

In the majority of large-flowered *Loranthaceae*, prior to the arrival of the bird, the flower is entirely closed and only after the flower has been opened by means of the bill the nectar becomes available. Obviously, there live no insects in closed flowers These birds only take nectar; pollen is not eaten though sometimes a few pollen grains may be found in the intestinal tract. The pollen sticks to the feathers near the insertion of the bill, which are often coloured yellow thereby.

The intestinal tract is also peculiarly adapted to the food taken by these birds. In species of *Dicaeum* and *Anaimos* the gizzard appears as a bulge of the intestine, opening only by a narrow pore just between glandular stomach and bowel. This remarkable character was first discovered by the late H. M. BARTELS, the eminent ornithologist of Java. As far as I know, he never published this observation but he told other ornithologists and demonstrated the shape and position of the gizzard. The first printed record concerning this very remarkable characteristic of the intestine is by CAMMERLOHER (1928 : 47). DAMMERMANN discussed this also (1929 : 301) and published a picture. An extensive study by DESSELBERGER (1931) on the build of the intestinal tract in *Dicaeidae* provided me with the following data.

It appeared that three species of *Dicaeum* from Celebes a *Pristorhamphus* and an *Urocharis* from New Guinea had among them two different types of intestinal tract. The species of the two latter genera eat also fruit but the intestinal tract, when compared to that found in *Dicaeum*, seems primitive. The stomach follows directly after the oesophagus and the bowel emerges from the upper part of the stomach. As is usual in fructivores the intestinal tract is comparatively short and its lumen enlarged. In addition, the parietal villi in the bowel are strongly developed.

Species of *Dicaeum* and *Anaimos* show an entirely different kind of intestinal tract. The gizzard is, as it were, set apart from the rest of the intestine and it is attached laterally as a bag-shaped appendix or pouch.

The bowel itself is, as regards length and lumen, like that found in other fructivores. The stomach consists of a glandular stomach and the gizzard. The former is a widened part of the lower end of the oesophagus which, communicates directly with the bowel. On the transition from glandular stomach to bowel is a strong sphincter which may close the glandular stomach and so separate it from the bowel. The gizzard is situated just above the sphincter at the end of the glandular stomach communicating by a narrow pore with it (see fig. 1). When the sphincter is closed, the food moves from the glandular stomach into the gizzard. The communicating pore is narrow and only small objects may enter the gizzard, mainly spiders and insects or their larvae. The bowel itself is clad interiorly by densely placed, long and thin villi, as is usual in other *Dicaeidae*.

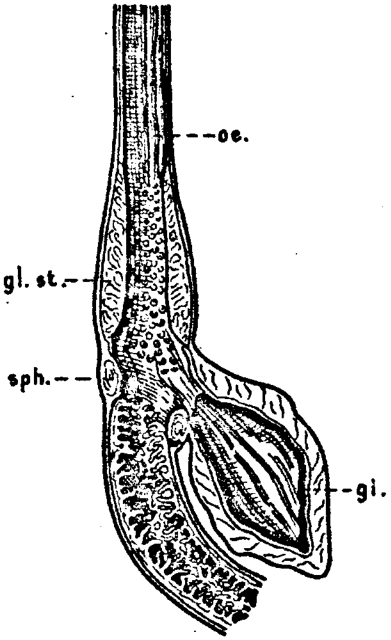


Fig. 1. Longitudinal section of the stomach of *Dicaeum celebicum*; gi = gizzard: gl. st. = glandular stomach; oe = oesophagus and sph = sphincter. (enlarged; after DESSELBERGER, 1931 : 360, fig. 3).

On examination it appears that the gizzard contains nothing but spiders and insects. In the intestinal tract, however, only seeds were found, mainly of *Loranthaceae* but other fruits are occasionally eaten. In the gizzard the digestible parts of the insects turn liquid and the tangled rests, chiefly consisting of chitine remnants, are thrown up as pellets. After the stomach contents have been freed from chitinous rests, they move from the gizzard into the glandular stomach and from there enter into the bowel where digestion and absorption takes place.

The sphincter reacts differently dependent on the kinds of food taken by the birds. If animal food is taken, the sphincter closes and the opening of the gizzard moves slightly forward and extends. If fruits are eaten, the sphincter remains lax and the seeds pass by the pore of the gizzard, which is in any case too small to admit larger objects, and arrive in the bowel where they are digested. The food absorbed in the gizzard consists of proteins or allied substances, the seeds provide carbohydrates and minerals, also some proteins.

The genera *Dicaeum* and *Anaimos*, as we have seen, are specialized and the characters of their intestinal tract and natural food, are correlated. In other genera the intestinal tract is of a simpler nature and more similar to that found in fructivores in other families. There all food, vegetable or animal, passes together through the stomach into the bowel. Probably, the feeding on *Loranthus* seeds has caused that certain parts of the intestinal tract were separated and became adapted to the digestion of proteins and of carbohydrates. Unfortunately I do not know whether *Dicaeidae* having a simpler type of intestinal tract, feed on *Loranthus* seeds or not. Data on this point are required.

The life of these birds has repeatedly been described, more often by zoologists than by botanists and as a rule by collectors who observed their life habits. Ornithological and semi-popular periodicals appearing in the regions inhabited by *Dicaeidae* contain many data on their biology.

These observations and notes often are very short, scattered in numerous periodicals. They appeared in the course of many years. Publications of that nature are liable to become rare, owing to their characters and frequently difficult to obtain while they are, as a rule, not reviewed or referred to in the general scientific press. For these reasons I have probably neglected some recorded data concerning these birds. The following is a review of the facts that came to my knowledge. Although this survey is far from exhaustive it may serve to draw attention to data which deserve to be kept from oblivion.

When studying field observations it appears that many statements are contradictory and it is commonly very difficult to decide whether certain facts are correctly recorded or not. Occasionally an observation in a review seems incorrect and raises justifiable doubt; but then it remains quite difficult to prove the observer to have been entirely in error. A possible source of mistakes influencing the records is the fact that the birds are observed in the field and in the wilds whereas only afterwards, at home or in camp, the observations are put down in writing. Plain fact is, unwittingly as a rule, blended with suggestions or obscured by an interpretive style or terminology and it becomes a hard task to decide where truth ends and imagination begins.

Some mistakes, however, are easily discovered. Brown (1881 : 42) was clearly mistaken when he wrote that a seed of *Macrosolen cochinchinensis*, when deposited on a leaf, fails to establish itself there and moves from its initial station in the direction of the petiole. In this manner, he said, the seed was able to reach the branch and there it was able to attach itself. Ridley (1930 : 466) accepted this statement without comment but its fallacy cannot be doubted. I will refer to Brown's paper again in the chapter 15 dealing with the germination of *Loranthaceae*.

Another mistake was made by Siebers (1927—'36 : 196) in his article on the birds collected by Toxopeus on Buru. Siebers published a coloured plate of the honey-eater, *Myzomela wakoloensis*. These birds, a ♂ and a ♀ specimen, are pictured sitting on a branch of *Dendrophthoë pentandra*. This suggests that these birds in their course of life stand in some relation with this plant. Toxopeus, the collector, says however: "In the interior everywhere in flocks on flowering trees very common". Nothing is said about a *Loranthus*. And to clinch the matter, this species of *Dendrophthoë* does not occur on Buru. Probably the paintress who pictured the birds, picked a branch of the *Dendrophthoë*, which is very commonly found near her residence at Buitenzorg, and used it as a perch and background for the birds in order to portray them in more „natural" surroundings. This again is an example of an easily detected mistake but many other cases are not so evident.

Many observers assert that seeds of *Loranthus* may be deposited on twigs in two different ways. First: they pass the intestinal tract of the birds and are voided together with the excrements. Second: the birds clean the bill by whetting and the sticky seeds are wiped off against the branches. Although I observed very often the depositing of seeds by the birds, in particular by caged birds, I never saw a single instance that a whetting of the bill had this effect. It happens, now and again, that the rind of the fruit which the birds detach from the seeds by means of the bill, sticks to it and, subsequently is rubbed off. The seeds, however, at that moment, have already been swallowed.

The intestine of all species of *Dicaeum* so far investigated invariably appears to contain seeds of *Loranthus*. Salim H. Ali (1931 : 144) stated that *Dicaeum erythrorhynchos* deposited the seeds together with the excrements. On the other hand, according to Ali *Dicaeum agile* disperses the seeds by means of whetting the bill against branches. It is somewhat surprising that two species of closely related birds should disperse the seeds and digest their food in so widely different ways. Unfortunately nothing is known about the morphology of the intestinal tract in these two species of *Dicaeum*. Ali is an excellent observer and it seems presumptious to allege that he is in error. Nevertheless, continued investigation seems very desirable.

Since antiquity it has been known that the seeds of *Viscum* were eaten by birds and spread in their excrements. Concerning the dispersal of tropical *Loranthaceae* I found the earliest description in Rumphius' Herbarium Amboinense (1747 : 61). Rumphius discussed two Ambonese *Loranthaceae, Viscum amboinicum album* and *V. a. rubrum*. The former is now called *Elytranthe triflora* and occurs in Ambon, Flores, Sumbawa, Timor, Ceram and New Guinea. The latter is *Macrosolen amboinensis* and is known with certainty as occuring in Ambon only; possibly it is also found on Sulabesi, an island near Celebes (Danser 1931 : 275).

Rumphius wrote about his own observations and clearly did not accept hearsay from other, less careful observers. His article may be translated as follows: "Both these plants have their origin from the droppings of a tiny bird, being a species of *Regulus*, named in Ambonese "cacopit", at Lubu "sasupite", in Malay "tschui", and never or rarely it comes to rest on the earth; it has a long curved, bill, by which it sucks nectar from several flowers, and equally they say the mistletoe originates in Europe from the dropping of the thrush. The natives deem the excrement of said birds so fertile and vigorous of virtue that they credit it — in their ridiculous fright — with the power of growing a mistletoe on their body if it were incidentally dropt on the head or body, and it were not immediately washed away by water. Though it is more probable that they are affrighted by a presentment of disaster because all branches which bear the mistletoe die, should it grow to profusion. Often large Canari and Capok Trees are seen loaded by these mistletoes, and the trees carry abundant fruit but have few leaves". Further he continued: "It has come to my knowledge that Bauhinus and other authors of the present deny that mistletoes originate from some excrement of the birds and they allege that it grows from the very substance of the trees such as warts and other misgrowths emerge from the human body. This view I am not prepared to support so far, because whenever I took mistletoes from the trees I never found that the mistletoe originated directly from the wood of the trees, but it was always glued to the bark of it at the outside, and however firmly they might appear to be attached, it was invariably possible to separate the two kinds of wood from each other." These accurate observations were recorded about 1680, though they appeared only in 1747 in print.

It is highly interesting that Rumphius already observed that these birds suck honey from flowers, a peculiarity of which the meaning only much later, actually only in our century, became clear.

The tiny bird, similar to *Regulus*, with its curved bill surely is a species of *Dicaeum*. A single species of *Dicaeum* is found on Ambon: *Dicaeum vulneratum*.

The vernacular names referred to by Rumphius are still in use on Ambon. Mr P. N. Ririasso, a student at the University of Amsterdam who was born on Ambon, wrote me that a bird called "tjui" is known to him. He was familiar with its call "tjui-tjui", from which its popular name was derived and a drawing he made, makes it clear that a species of *Dicaeum* is meant. Mr A. M. P. Mollema, an official of the Government Information Bureau („Regeringsvoorlichtingsdienst") at the Hague, wrote me that he was informed from Indonesian sources that in Ambon the name "cacopit" is occasionally heard but that the bird is better known as "tshui".

In a valuable contribution to the knowledge of the germination of the seeds of *Loranthaceae*, Korthals (1839: 226) referred in passing to their dispersal. In a later chapter I will return to Korthals's observations. For the moment I wish to refer to his statement that birds, such as *Turdus, Ixos,* etc. feed on their fruits on account of their soft meat or pith and they void the seeds with the indigestible gluey mass in which they are imbedded. Apparently the birds were not closely observed in their behaviour. The thrushes, indicated as *Turdus,* do not eat fruits in Indonesia. *Ixodidae* consume fruits but take little or no part in the dispersal of *Loranthaceae.*

TEYSMANN, when describing the forests on Mount Wilis (Java) referred (1856 : 144) to "*Loranthus lyndenianus*", which is now known as *Helixanthera setigera.* Its seeds, TEYSMANN said, may attach themselves on other plants only after passing the intestinal tract of certain little birds and after the rind and part of the meat are digested and removed. The seeds being surrounded by a gluey layer stick to any object which happens to catch the dropping of the bird. TEYSMANN overlooked the fact that the rinds are not digested, they are not even swallowed by the birds; the peels are removed before the inner parts of the fruit is eaten.

The results of an important investigation into the life-habits of *Loranthaceae* were published by KEEBLE (1895—1901 : 96). He stated that on Ceylon birds feeding mainly on *Loranthus* fruits are small and belong to the family of *Dicaeidae.* These birds press the seeds from the fruit and throw the rind away. KEEBLE is convinced that they refuse the rind on account of the high amount of tannin. He collected large quantities of rinds under the trees. In addition, in birds he shot and dissected no intact fruits with rind were met with. In the intestine of the *Dicaeums* he examined, he never found more than 3 seeds. It is hard to understand his report that the seeds in the intestine are often corroded by digestive juices and sometimes even completely rotten. His conclusion is that, in all probability, the small *Dicaeums* are scarcely able to swallow the large seeds and that they remove the pulp by means of their bill: they get rid of the sticky seeds by rubbing or whetting the bill. He observed that hundreds of *Loranthus*-seeds stuck to a telegraph wire and he considers it to be improbable that the seeds should have got there as a consequence of being voided but rather that they stuck there having been rubbed from the bill of birds. This conclusion indicates clearly that KEEBLE's view is not founded on actual observation; it is a good instance of biology-at-the-writing-desk.

Telegraph wires are a favoured perch to the birds where they often rest prior to voiding the seeds. KEEBLE is perfectly justified, however, in doubting the statement that seeds might reach branches on account of the fruits dropping from higher positions (ENGLER & KRAUSE, 1935 : 98).

When trying to explain the dispersal of small-seeded species, such as in *Viscum,* KEEBLE experienced some difficulties. The coat of pulp in those fruits is thinner and the digestive juices might be even more harmful than they were thought to be to the large-seeded fruits. He noted that clumps of *Viscum* seeds in the voided excrements of birds were often quite hollewed out. It seems probable, according to KEEBLE, that these small-fruited species are distributed in a similar way, by becoming attached to the bill and subsequently being rubbed off. This again is an unsubstantiated suggestion and therefore of no importance Nevertheless, KEEBLE's investigations on the germination of the seeds are significant and in a later chapter I will refer to them.

RYAN (1899 : 472) is first to describe in an exemplary manner the behaviour of the birds, a record based entirely on the observation of facts. In the field he had noted that *Dicaeums* swallow the seeds and void them in the excrements. A caged bird enabled him to follow the course of events closely. The bird squeezed the seed from the epicarp. It never used its claws but only its bill. Once the bird got hold of the seed it swallows it; the whole act of obtaining and swallowing the seed requires less than 30 seconds. The passage of the seed through the intestinal tract is rapid and takes 8 to 12 minutes. One bird voided 9 seeds in 45 minutes. The removal of the seeds seems to be difficult because the birds jump up and down so as to bring his posterior close up to the branch on which he is seated.

KONINGSBERGER (1911—1915 : 63) says that *Dicaeum* is the disperser of *Loranthaceae*, either because the seeds are deposited on the branches together with the excrements, or by rubbing them off the bill. In an earlier paper (1901 : 31) he also indicated the importance of these birds to the dispersal of noxious *Loranthaceae*.

A species of *Dicaeum* occurs in Australlia, viz *D. hirundinaceum*. The life and behaviour of these birds was often described, usually in short communications by field ornithologists. I am convinced that on perusal of various periodicals (e.g. The Emu) more particulars will prove to have been put on record. The articles I found contained nearly all the same data.

BRITTLEBANK (1908 : 650) wrote that the seeds of *Loranthus* were mainly eaten by honey-suckers (*Meliphagidae*) and the Swallow-Dicaeum. It is not stated whether this was actually observed in the case of *Meliphagidae* nor was it said whether an examination of the stomach was executed. In addition other species of birds, among these even introduced species, which should contribute to the dispersal of *Loranthaceae*, are enumerated by BRITTLEBANK. Sometimes, he said, one sees strings of 3—6 seeds hanging from the twigs, and they germinate all. Larger birds eat the entire seeds and cast them in the manner of the owls, ejecting them orally. These seeds, however, are said not to stick to the branches, though sometimes they may get caught in a forking branch and so these birds mean little, according to BRITTLEBANK, as regards the dispersal of *Loranthaceae*.

The principal seed-distributing agent for *Loranthus* is, CHANDLER stated (1912—13 : 130), *Dicaeum hirundinaceum*. This bird appears to live almost exclusively on the mistletoe-berries, and consume them mixed with nectar and insects. The young are fed by the parents with *Loranthus*-seeds also.

LAWRENCE and LITTLEJOHN (1915—16 : 166) wrote that *Dicaeum* extracts the seed without the berry being first plucked from the parasite. The ripe fruit was taken crosswise in the bird's bill, and the soft case split in halves by pressure. The free portion of the case is then dropped leaving the white berries protruding from the half still attached to the branch. By pressure of this remaining half between the mandibles the seed is forced out sufficiently to allow of its being easily taken by the bill. I have never met with another case of fruit-eating in this manner. The authors add that *Dicaeum* seem to prefer *Loranthus*-fruits to all other kinds. They noted a native cherry full of fruit close of a *Loranthus*, but the birds took no notice.

A detailed survey of the disperal and distribution of *Loranthus* was given by BLAKELY (1922 : 20). He stated e.g. that *Loranthus* makes the most of his host, and sometimes through the favourable position of the first attachment increases by the seeds falling on the lower branches of the host. No mention is made of any actual observation of this strange manner of dispersal. It seems warranted to consider this story as fiction as it seems highly improbable, the seeds never drop from the fruits which, at best, are shed as a whole when overripe. In that event, the seeds are surrounded by the rind and cannot stick. BLAKELY further pointed out that formely it was thought that Dicaeums were the sole agent of distribution of the parasite. There are, however, other species of birds feeding on the fruits. He added numerous observations from older literature which may be consulted in BLAKELY's survey. It has been established that numerous birds eat *Loranthus*-seeds, but whether, and if so how much, they participate in dispersing the seeds, is uncertain. The ingenious way in which *Dicaeum* performed the task to strip the plant of its ripe fruits, is, he said, not without humour. The bird gives the fruit a sharp twist to dislocate it, then, turning the fruit endways in its bill, sucked the seed from the epicarp, letting the latter fall to the ground. Finally he added a list of 20 species of birds he considered to be dispersers, among them even the sparrow and the starling. He made mention of a number of nectar-drinkers, feeding on *Loranthus*, but peculiarly omitted *Dicaeum*.

An interesting statement was made by HEUMANN (1926—27 : 317) who said that the young of *Dicaeum* are first fed with insects and only later with *Loranthus*-berries. The Dicaeums appear to be very particular when picking fruits. They tap many fruits with their bill before selecting a desirable one, which should be neither too young nor too ripe. The berry is then squeezed between the mandibles and after that swallowed as a whole. The seed and its gluey layer are voided and the glue dries quickly. He winds up by stating that the seeds germinate only after passing the intestinal tract of a *Dicaeum*, and this is quite wrong.

In a short but important paper, an accurate description of the behaviour of *Dicaeum* when depositing the seeds, was made by VAN HEURN (1922 : 84). The paper was published in a periodical of limited distribution abroad, and, moreover, was written in Dutch. A translation of the main points may be useful. VAN HEURN stressed the following. "These birds, viz the species of *Dicaeum*, do not rub the gluey seeds off the bill which might make them stick to some substrate, but the seeds pass through the intestine. In the bowel there are always to be seen some rather large seeds which are still embedded in the slimy layer and as a rule these seeds stick together like a string of pearls. It is not without meaning that the seeds are deposited on thin twigs. When defecating the bird suddenly sags visibly in the heels and simultaneously shifts its position with astonishing agility along the twig covering a distance of 20—30 cm while its body rocks horizontally to and fro and this rapidly. The acrobat intends to get rid of the seeds which are no longer wanted in the intestine but are still very sticky and attains this by glueing the superfluous objects to his high seat, to human views a highly inefficient method".

The method may seem inefficient at first sight but on closer consideration it is the best way of getting rid of the sticky seeds which might easily remain stuck to the feathers surrounding the anus.

I have demonstrated by these references that many accurate reports on the behaviour of the Dicaeums are to be found in literature and it might be assumed that later authors would avoid to continue erroneous records concerning the way of life of these birds. By no means, however. Recent authors simply neglect what has been written previously and again and again repeat long rejected statements or add new errors. This led me to go through the literature and to review it briefly.

A striking exemple is found in the statements by SANDS (1924 : 64) who asserted that the flowers of *Loranthus* and *Viscum* are pollinated by insects, possibly with the exception of some species which could be pollinated by sun-birds. He further refers to birds (no species indicated) which feed on the seeds and disperse them locally. These birds, according to SANDS, after removal of the pulp, may rub the seeds off the bill and stick them to a substrate, or the seeds may pass through the intestine. In addition, heavy rains which beat down the fruits, high winds and the natural fall of ripe berries can be agencies of dispersal. It is difficult to conceive how more nonsense could be crammed into one sentence!

According to his own statement, CAMMERLOHER (1928 : 46) had ample opportunity to observe the life-habits of Dicaeums. He wrote: "Bleiben beim Verzehren der Früchten, die wie die Früchten von *Viscum* aussen eine schleimich-klebrige Schlicht führen, die harten Samen seitlich am Schnabel kleben, so wird dieser durch wetzen an einem Aste von dem anhaftenden Samen gereinigt". It may be forwarded that in the first place the seeds are not hard but very soft and the testa is most delicate, and secondly, the record that the birds remove he seeds from the bill by whetting is not founded on observation. He observed at Buitenzorg *Dicaeum trochileum* and that species does not whet the bill so as to remove the seeds. Even without personal observation he might have described accurately had he consulted van HEURN's paper. Admittedly, CAMMERLOHER also refers to the passage of seeds through the intestinal tract. His observations regarding pollination are more important. The bird pricks laterally into the upper part of the closed corolla with its bill. The corolla-lobes suddenly split apart. This has the effect, says CAMMERLOHER, that the nectar, which fills the whole of the cavity in the closed corolla and stands under pressure, squirts out with appreciable force. This is incorrect. Firstly: the nectar only fills the lower half of the corollar cavity. Secondly: the nectar is not under any pressure. It is true that at the moment of the splitting apart of the corolla lobes some substance can be seen to squirt out, but this is no nectar but pollen. Although in CAMMERLOHER's paper, like in so many other, "Wahrheit und Dichtung" are blended, it contains for the first time the record, in what manner the flowers are opened by the birds and that the pollination of *Loranthus*-flowers is effected by *Dicaeum*.

In his valuable book "The Agricultural Zoology of the Malay Archipelago", DAMMERMAN (1929 : 300), discussed the importance of *Dicaeidae* in connection with the dispersal of the seeds of the *Loranthaceae*, the highly noxious parasites on fruit trees. He surveyed the feeding habits of the birds and added a figure of the intestinal canal of *Dicaeum trochileum*. The small stomach is always, he stated, filled with small spiders, the chief food of the birds. This, I think, is a rather one-sided view. The birds take, apart from spiders, also insects and various larvae. In addition, the seeds of *Loranthaceae* are certainly also one of the chief foods. DAMMERMAN stressed the point that the seeds pass the intestine and are then deposited on the twigs and that they do not get stuck to the twigs by whetting the bill, as is often asserted. He quoted HEUMANN's statement, that seeds germinate only after passage through the bird. This is incorrect because ripe and, even almost ripe, seeds germinate very readily when taken fresh and stuck to twigs. DAMMERMAN went on to state that these birds could be instrumental to the pollination of the flowers, which they visit, because they feed on the small spiders living inside. It is to be noted that most *Loranthus*-flowers are closed prior to being opened by the birds and therefore cannot provide shelter to spiders. The spiders are collected in other places. Some Dicaeums I examined had no flower visiting spiders among the stomach contents.

Interesting observations concerning the pollination and dispersal of *Loranthus longiflorus* (now *Dendrophthoë falcata*), a common species in India, were made by SALIM H. ALI (1931 : 144). Two species of *Dicaeum* were involved. The flowers of this *Dendrophthoë* are said to be explosive. At first the corolla lobes are pressed together but when touched by the bird's bill the flower opens all of a sudden. Apart from some species of sun-birds, the pollinators of *Loranthus* flowers are Dicaeums. A shot specimen of *Dicaeum erythrorhynchos* appeared to have pollen stuck to the frontal feathers and its stomach contained a large amount of nectar. Still more important are ALI's observations on the dispersal of the seeds. When the *Loranthus*-fruits have matured, and so are soft, they are taken by the birds. *Dicaeum erythrorhynchos* is the chief disperser of the plant. The bird picks the berries and swallows them. ALI makes no mention of an introductory removal of the rind as was so often observed and described before. Having swallowed 3 or 4 berries the bird quiets down, it remains stationary and squats with the feathers partly puffed out. Then, by a final jerky dipping motion of the posterior part of the body, the seed is passed out. The period between uptake and voiding of the seed is not in excess of 3 to 4 minutes. Exact observations on this point are not given. He also stated that the bird occasionally gnaws the rind and epicarp from the seed and then sticks it to the twig by whetting its bill. This latter point is probably not based on fact.

When describing another species, *Dicaeum agile agile* (TICKELL) which has a stouter bill than the preceding species, ALI said that it takes the fruits quite differently. The fruit is picked and invariably revolved between the mandibles which being thicker and stouter appear better adapted to the process of eating. The pulp is removed from the seed and the seed is rubbed off by the bird whetting its bill. Again, no reference is made to a removal of the rind. It is hard to believe that two so closely related species would feed on the same fruits and act so differently.

Few records from the Philippines have come to my knowledge. SULIT (1931 : 665) refers to fruit-eating birds which consume the berries of *Loranthus*. No closer reference as to the species of these birds is made and there is also no description of the manner in which the seeds are eaten. Again it is asserted, that rains and high winds should be agents of dissemination.

Similarly, SAYEED-UD-DIN and SALAM (1935 : 160) stated that the seeds are stuck to the twigs by the bird, whetting its bill but there is no proof that this statement is supported by personal observation. Finally RIDLEY (1930 : 466) devoted some pages to an account of the role played by *Dicaeum* spp. in the dispersal of *Loranthaceae*. This is largely a review of the records by earlier authors, and not very critical at that.

Noteworthy observations on *Dicaeum trochileum* were made by HETHARIA (1938 : 200). He wrote that the bird defecate with difficulty which is shown by a sudden jerky movement of the posterior part of its body, which is in accordance with the fine description by VAN HEURN, referred to above. HETHARIA never saw with certainty a sticking of the seeds to a twig by purposely whetting its bill.

My own observations concern largely *Dicaeum t. trochileum*, a very common species in cultivated areas where *Loranthus* occurs. This species is readily noticed on account of its bright colours. The other species are generally less brightly coloured and in particular female birds are inconspicuous and, in the field, difficult to tell apart. I failed to establish any difference in their life habits. In addition to my observations in the field, I experimented on the feeding of the birds by keeping them in cages. In captivity the birds soon loose their shyness and are observed easily at a short distance. For these purposes they are much easier to be studied than the sun-birds, and in particular than the species of the genus *Arachnothera*, the spider-hunters.

As was stated before, where *Loranthus* occurs, the birds will be present. The flowers are pollinated in the morning hours though now and again birds may be seen drinking nectar from opened flowers in the afternoon. Throughout the day they are engaged in hunting animal food and *Loranthus*-fruits. They fly rapidly from twig to twig, bob around among the branches and are busily occupied. At certain intervals they emit short sounds, which according to HOOGERWERF (1949a : 96) can be rendered as a loud türr-türr, or trrrrü, or a high pitched tjee-lee...... tjee-lee, or also some such twitter which is often long drawn and repeated. This twittering may be heard while they are sitting or during their flight. The malay name "burung tjabé" alludes to the fiery colour of the feathers, "tjabé" being the red fruit of *Capsicum frutescens*. In Ambon they are called "tjui", because of their song.

Dicaeum spp. are the main pollinators of *Loranthacea*, insofar as species bearing large, coloured flowers are concerned. The flowers of *Viscum* and allied genera, and of *Barathranthes*, are not pollinated by birds. The species of *Scurrula* bear flowers which open in the early morning without external interference, but the flowers of other large-flowered *Loranthaceae* are at that time closed, which means that the corolla lobes are holding together and can be opened only by some pressure from the outside. This pressure is brought about by various birds. I will return to this point in a later chapter on pollination.

There are two ways of effecting the explosive opening of the flowers practised by *Dicaeum*. They either squeeze the top of the closed corolla between the mandibles or they peck into the insertion of the corolla lobes on the corolla tube. The result is the same. The lobes become suddenly detached along their margins, bend outward and curve back. Now the bird introduces its bill into the corolla and sucks the nectar. The feathers round the base of the bill come into touch with the sticky pollen and carry it away. The nectar is sweet and slightly slimy, as is usual in bird-flowers and it contains sugar (glucose) and protein, the latter substance in small amounts. Obviously, in closed flowers no insects or spiders are present.. These are hunted among the twigs and leaves.

To a certain extent their food consists of these spiders and insects, eventually larvae. My son (H. Docters van Leeuwen, 1928—29 : 439) discovered in the stomach of *Dicaeum s. sanguinolentum* besides spiders, red larvae which, though they were largely dissolved, could be recognized as the red larvae of *Chironomidae*, which live in water and mud! It is certainly worthy of notice that these specialized tree-birds should also hunt for food in the mud of ditches or brooks. These insects are digested in the gizzard while the indigestible rests are emitted as pellets. As was described in the first part of this chapter, the gizzard is a pouch, largely separated from the remainder of the intestinal tract and communicating by a narrow pore only. The gizzard is small and only small quantities of spiders and insects can be admitted. Something might be said in favour of the view that nectar and animals are to be seen as accessory foods while the chief fare should be *Loranthus*-berries. The seeds, embedded as they are in a gluey pulp and further surrounded by a juicy rind, do not enter the gizzard but pass directly into the bowel. The gluey layer persists and sticks easily to all sorts of substrate. The fruits provide the birds with much alimentary substance. Carbohydrates are almost completely represented by glucose. One fruit of *Dendrophthoë pentandra* contains c. 20 mg glucose, or 6 per cent of the weight of the fruit. The birds weigh c. 5 g and feeding at a rate of say 100 fruits daily, they consume 2 g glucose in 24 hours, which is 40% of the body-weight.

The fruits are consumed in the following manner. The bird alights on a twig close to a *Loranthus*-inflorescence and pulls off ripe fruits which may be recognized as such by their colour or consistency. The fruit is now revolved between the mandibles until the basal part, viz. the insertion of the stalk, is directed towards the throat. The mandibles squeeze the fruit-wall; the latter gives and the seed is pressed out while, sometimes, the fruit may turn in the process. The seed leapes out and is immediately swallowed. The slimy pulp and the gluey layer pass with the seed through the throat. The remainder of the pulp is still sticking to the rind and the bird presses the rind, squeezes out the pulp and swallows that too. Now the empty rind drops to the ground. Without a single exception, I always observed this manner of feeding both in *Dicaeum trochileum* and in *D. sanguinolentum*. I never saw that the seeds were cleaned with the bill and then stuck to the twigs after whetting. For this reason I consider all statements to that effect as inaccurate. It happens now and again that an empty rind sticks to the bill and is rubbed off by the bird whetting its bill, and it is possible to find these empty rinds glued to the twigs, but their contents, the seed and the juicy pulp, have been swallowed before.

I have observed the way of feeding here described when fruits were taken of *Dendrophtoë pentandra, D. praelonga, Elythranthe albida, Lepeostegeres gemmiflorus. Macrosolen cochinchinensis, Scurrula* spp., and *Viscum* spp. In *Viscum* the uptake is so rapid and the fruits are so small, that observations are less easily carried out. Those small fruits are procured very quickly and the seeds swallowed. Considerable clumps of these seeds can be found in the intestine and often they are voided still sticking together in clumps being mixed with some larger seeds. If these clumps are deposited, they seldomly give raise to seedlings. They are more easily washed away by heavy rains than single seeds and when voided often remain hanging in pendent strings (cf. fig. 2).

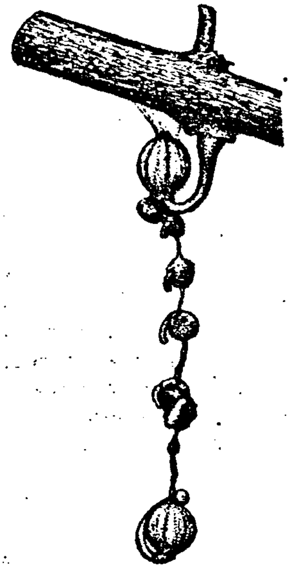


Fig. 2. Seeds of *Macrosolen cochinchinensis and Viscum articulatum* voided simultaneously by a *Dicaeum*. Seeds connected by a slimey strand (× 2).

More or less by accident I was so fortunate as to be able to control the number of *Loranthus*-fruits consumed by a single bird in the course of one day. In my garden a nearly full-grown fledgling sat on a branch. The parents flew to and fro to feed the young bird. The latter was caught, put into a cage and the cage was hung in a tree. The parents continued to bring food. In the cage was a single perch upon which the young bird was sitting and so the seeds which had passed through the intestine could be only deposited on that stick. I saw the young bird continually moving to and fro, in the manner described by VAN HEURN, and finally the stick was covered over its entire length by sticky seeds. The seeds were all of *Dendrophthoë pentandra* and became so numerous that at last the bird was hardly able to move. The cage was hung outdoors from half past six in the morning till 6 o'clock in the evening. The parent birds never abandoned carrying seeds to the young one, having squeezed the seeds from the rind beforehand. At the close of the day, in nearly 12 hours therefore, 75 seeds stuck to the stick in the cage, pl. IVa (REIJNVAAN, 1926 : 27). It is evident from the fact that a single fruit of this species of *Dendrophthoë* contains 20 mg glucose, that the fledgling had consumed 1500 mg glucose, or 1½ g, a third of the body weight of the young bird. I was unable to establish whether in the same period animal nourishment was carried to the young.

The birds consume a number of seeds, according to their size 3 to 6, or in case of small seeds a larger number, and after that remain sitting quietly during a certain period. They suggest being encumbered by the food, like someone who partook somewhat freely of a copious dinner. They may remain perched on the branches of the *Loranthus* or also fly to a neighbouring branch of the host plant, or possibly traverse a slightly larger distance but they never fly far away. In particular telegraph or telephone wires seem to be a most acceptable perch. They now wait for the digestion of the seeds. This process is a quick one. I was able to investigate the time needed in a specimen of *Dicaeum sanguinolentum* kept in a cage. The bird was very tame and readily took berries from a feeding hand. At 14.45 hours 3 fruits were offered of *Macrosolen cochinchinsis* and 3 of *Scurrula atropurpurea*. At 15.07 hour the seeds were voided, one after another, appearing rapidly. At 15.30 hours the bird was given again 3 fruits of *Macrosolen cochinchinensis* and the seeds were voided at 15.42 hours. Some authors found a still shorter period to be sufficient.

On defecating the birds sag and while the legs remain nearly without motion, the posterior part of the body jerks a few times to and fro, the anus rubs the perch and the seed is stuck to the substrate where it remains attached by means of the gluey layer. Now the bird moves sideways, like VAN HEURN described, and the same movements and sagging are repeated until all seeds have been voided. The depositing of the seeds is not always entirely succesfull; occasionally a seed drops to the ground being unsufficiently glued or it remains pendent at the end of a long capillary strand of slime. In the latter case the seeds are lost as regards dispersal. As soon as the last seed has been removed from the intestine, the bird quickly flies away, shows the same busy agility as before, and consumes *Loranthus*-berries as before.

Although *Loranthus*-fruits are the chief fare for these birds, they may take other fruits also. If *Loranthus*-fruits are available they will neglect all other kinds. A caged bird, when *Loranthus*-fruits were withheld, accepted with relish the fruits of *Lantana camara* and the pulp of *Carica papaja* fruits, also banana pulp. *Dicaeum* may live without recourse to *Loranthus*. This was proved by DAMMERMAN (1948 : 156, 342) who found *Dicaeum trigonostigma flaviclune* rather common on Krakatau and the nearby islet of Verlaten Eiland. *Loranthaceae* are not yet found on Krakatau, at least not in 1932, the last time I visited the Krakatau Archipelago. I will further discuss this problem considering the distribution of *Loranthaceae* in general, see chapter 16.

When flying away it may sometimes be noticed that the birds void a drop of white excrement. I have never been able to demonstrate the presence of seeds in these drops. Nevertheless their presence, occasionally, seems probable. It would account for the occurrence of *Loranthus* on the branches of plants growing under a tree carrying the parasite. This way of dissemination certainly is not highly effective because it is pure accident whether a dropping seed will fall on a branch or on the ground, and it is fundamentally different from the efficient dissemination by the sitting bird. In addition, the voiding of seeds at the moment of starting flight seems to occur rarely. The caged *Dicaeum*, referred to above, deposited all seeds on the perch and not a single seed was found on the floor of the cage. On the other hand, the facts that the young bird was a poor flier and had no opportunity to fly in the small cage, have to be brought into account. In all probability flying birds may sometimes void seeds because it seems the only way in which seeds could arrive on slippery, often obliquely pendant leaves. On leaves in that position, birds can hardly gain a hold. Unfortunately I am unable to confirm this supposition by observation. It would be certainly a piece of extraordenary good luck if one happens to observe a seed being dropped on a leaf in this way. Leaves carrying a *Loranthus* seedling are not very frequent but by a methodical search they can be discovered.

Though the birds are noticed easily, and occur in large numbers, it nevertheless is most difficult to find their nest. Often they are not high up in the three. They are hidden near the top of the branches well tucked away among the leaves with which they are more or less interwoven. The nest is about ovoid, closed except for a lateral opening, plate III. A kind of awning above this opening protects the entrance. By means of fibrous ties the nest is very firmly attached. HOOGERWERF (1949b: 129) stated that the nests are constructed of fluffy hairs of fruits or seeds, in particular of capoc, and that they are furnished externally with a rather thick layer of brown fern scales. The hairs occurring on the petioles and young shoots of *Hibiscus macrophyllus* are also used. It seems to depend on the material available in which manner the nest will be constructed. Spiderwebs and mosses are also nesting materials.

A clutch consists of 2 eggs. The eggs of *Diacaeum t. trochileum* measure c. 15 by 11 mm, are white and sometimes slightly dirty, see HOOGERWERF (1949c: 235). The same author recorded the breeding season of this species from January to October. Possibly they nest throughout the year.

CHAPTER 3.

Lepeostegeres gemmiflorus (Bl.) BLUME.

Lepeostegeres gemmiflorus is a relatively small plant. Only few specimens having branches longer than ½ m. DANSER (1931 : 267) referred to "branches rarely over 1 m long". The branches are numerous bushily arranged and runners are common: they creep over the substrate and attach themselves to the host at irregular intervals. Plants with runners and specimens without grow side by side. The place of attachment to the host is often wart-shaped and swollen but the swellings remain rather small.

I came across this species at a few localities in West Java, viz Buitenzorg (Bogor), in the Botanical Gardens, (in some garden plots at short distances from each other), Tjibodas (on the slope of Mt Gedé at c. 1500 m alt.), and near Bandung (at c. 700 m. alt.). *Lepeostegeres gemmiflorus*, actually, seems to be confined to West Java. It seems to be the only species of *Lepeostegeres* indigenous in Java. Even in West Java it is not common and apparently only found locally. DANSER expects (1931 : 268) that in future this species will be discovered in Sumatra and possibly also in Borneo where 7 of the 9 known species of *Lepeostegeres* occur.

Host plants were, according to my notes, *Erythrina*, *Ardisia*, *Fluggea*, *Acalypha*, and *Hibiscus similis*; in the Bogor Botanic Gardens the parasite was mainly present in the section where Rubiaceous shrubs and trees are grown, and in particular species of *Tarenna* and *Pavetta* appeared to be attacked. It might be suggested that *Lepeostegeres gemmiflorus*, in contrast to many other *Loranthaceae*, is less polyphagous than e.g. *Dendrophthoë pentandra*, which seems to be able to grow on practically every Dicot.

The plant is often attached at the underside of a branch and its branches spread in all directions not being pendent in the manner observed in many other species. The entire plant is glabrous. The internodia of the branches are 2—5 mm thick, near the insertion of the branches thicker than near the top; they bear closely arranged, longitudinal ridges. The leaves are opposite, the petioles laterally compressed, canaliculate above and keeled below, 10—20 mm long. The blade is ovate, 5—8 cm long and 3—5 cm wide, the apex and the base as a rule rounded. The blades are dull green on either surface and the midrib is distinctly raised below.

The flowers are aggregate in a capitulum, which is a generic characteristic for *Lepeostegeres* and *Lepidaria*. The aspect of the inflorescence of *Lepeostegeres gemmiflorus* reminds strongly of *Compositae*. These inflorescences are solitary in the axils of the leaves. The receptacle is obconical and when in bud the involucre is nearly globose and 4-keeled. In the open flowers the involucre is elongated, 17—20 mm long and 11—13 mm thick. It consists of 7—9 pairs of thick and hard scales, which are firmly pressed together. These scales are shell-shaped, green, and keeled. In fully developed inflorescences the flowers are surrounded below by the scales and are held as a bundle of firmly appressed corolla-tubes. The projecting part of the flowers protruding from the involucre, curves somewhat outward and so assumes more or less the shape of an open brush. The flowers have very short stalks and are arranged in triads. This distinguishes the inflorescence from that found in *Compositae*. The caliculus is little developed and hidden under the scales. It is only 1½ mm wide and not much longer, its margin is membranaceous and irregularly frilled. The corolla is 6-lobed and c. 25 mm long. The petals are partly connate and the corolla-tube is about 1 mm wide at the base, at the mouth slightly wider (1½ mm). On budding the tip of the corolla splits into 6 lobes, which curve outwards and finally backwards; these lobes are about 8 mm long. There are 6 stamens which consist of a filament and an anther but the anther is not clearly separated from the filament: they merge gradually. SCHAEPPI and STEINDL (1942 : 309) describe a stamen of this aspect as "ungegliedert" or inarticulate. The lower part of the stamens is connate to the petals, the free part being about 5 mm long and obliquely exserted. The style is long and capillary and ends in a small, knob-shaped stigma, which is closely studded by papils.

The flowers are very conspicuous and flaming red, so they stand out clearly against the green involucre. The fruit is globose but, being tightly enclosed by the involucre becomes angular through mutual pression. On top of the fruits is an indistinct caliculus and a style rudiment. When ripening the fruits push apart the scales of the involucre and as the pedicels increase very considerably in length, the fruits emerge finally from the involucre and stand exposed.

The seeds are nearly globose, slightly longer than broad, c. 5 mm long and sometimes barrel-shaped. The gluey layer is not spread over the whole of the seed but covers only the basal part of it. The epical part bears a blunt protuberance, consisting of some narrow excrescences which together cover the base of the hypocotyl. The hypocotyl protrudes slightly from the endosperm and though this protuberance might be regarded as a protective organ, other species are without it.

In a previous paper I described the development of the flower and the seeds (DOCTERS VAN LEEUWEN, 1927 : 123); I am now able to add some observations on the pollination. The flowers are clearly real birdflowers as is evident from their morphology. Their colour is highly conspicuous, bright red, and the corolla-tube filled for about three quarters with very liquid honey. In addition, the flowers are scentless. The flowers do not show any suitable places for the pollinators to alight and get a hold on. On the inside, the corolla-tube is furnished with longitudinal, low and narrow ridges which pass over the transversal walls of the cells. These ridges are formed by the cuticula.

The nectar is conducted upwards and then retained by the capillary action of the ridges. The lower part of the petals in *Helixanthera cylindrica*, though not connate, nevertheless form a tube and the nectar, which fills that tube entirely, overflows and appears like a drop on top of it. This is not seen in *Lepeostegeres*. SCHAEPPI and STEINDL remarked (1942 : 307) that the corolla-lobes bear gland-like papillae, in particular above the insertion of the stamens; they are unable to suggest a function. Similar papillae are often found in bird-flowers in places touched by the bird's bill. These papillae are often provided with a thick wall which certainly contributes to their firmness. The filaments of the stamens also bear these papillar cells. Both filaments and style protrude and are rigid and it seems that this rigidity is solely due to turgescence; I was unable to find any trace of supporting or strengthening tissues. The morphology of these flowers is, apparently, adapted to pollination by birds.

I have made but few observations of birds visiting the flowers in the field. Whether it is necessary to open the closed buds by pressure of the bird's bill, the device commonly found in other *Loranthaceae*, I have been unable to ascertain. Cut branches with open flowers, placed in an aviary where honey-birds were kept, immediately drew attention. Both *Nectarinia jugularis pectoralis* and *Anthreptes m. malacensis* flew to the plants without delay and, alighting on the branch below the inflorescences, dipped the bill into the flowers. The spider-hunters (*Arachnothera*) took no notice of the flowers. In the field I noticed a few times a species of *Diaceum* busily engaged among or in the inflorescences but I could not verify if they inserted the bill actually into the flowers although this seems most probable. I never saw *Zosterops*, a regular visitor of the flowers of *Loranthaceae*, nor any insects.

It has been demonstrated for many species of *Loranthaceae* that fruits may develop even when cross-pollination is prevented. I have not investigated the point in *Lepeostegeres gemmiflorus*. The stigma is usually covered by large quantities of pollen. Self-pollination must be easy, because the anthers and the styles of the flowers are close together and in a position to touch each other. Pollinating birds, however, can be agents to effect cross-pollination.

In a young and closed inflorescence, the flowers are closely pressed together to a narrow bundle. On developing, the flowers push the scales of the involucre aside and the tips of the still closed flowers emerge, the aspect of which suggesting a small wad. At six o'clock on the first day of their emergence, the flowers exert for about 1 mm. After one day they exert for more then 5 mm and this day the flowers open. Flowering lasts two days. The whithered floral parts, as far as they are exerted, shrink and dry out, turning brown in the process; the parts covered by the involucre rot and change to a slimy mess.

The ovaries increase rapidly and the pedicels elongate simultaneously so that the scales of the involucre are still wider apart. When mature, the fruits are placed on long stalks and the scales of the involucre are spread out to nearly horizontal. The ripe fruits are 5—6 mm in diam., nearly globose and very juicy. Although the flowers in a capitulum open simultaneously, the fruits ripen at intervals from 2 to 3 days. In the field only very rarely specimens are seen bearing a full and undamaged set of fruits. As soon as the fruit is edible it is picked by birds, viz Dicaeids.

The birds treat the infructescences roughly and the scales of the involucre are often damaged or disjointed. At Buitenzorg I saw *Dicaeum trochileum* swallow the fruits. I was unable to ascertain whether any other species of bird would take them.

As far as I know, the peculiar elongation of the pedicels, is unique in the family of *Loranthaceae*. The lengthened pedicels carry the fruits out of the involucre and being yellow or sometimes orange, they become very conspicuous and easy to collect for fruit-eating birds. A similar lengthening of the fruit stalks can be seen on other plants e.g. in some saprophytic orchids like *Didymoplexis* and *Gastrodia* spp. Here this elongation is also connected with the dispersal of the seeds, which in these orchids is effected by wind. The fruits, being lifted far above the forest ground are better accessible to air currents.

The seed is globular to depressed barrel-shaped. To the short, blunt protuberances, covering the base of the hypocotyl which emerges from the seed, reference was made above. At the opposite side the gluey layer is found. In many other species of *Loranthaceae*, e.g. *Dendrophthoë* and *Scurrula* spp. the whole surface of the narrower and more elongate seeds is covered by glue; seeds of that description stick to the substrate sidewise. Seeds of *Lepeostegeres gemmiflorus*, however, become attached at one end only. The glue is transparent and often extended to capillary strands. The gluey layer dries slowly and if a heavy rain comes down soon after the deposition of the seed, the glue swells greatly and the seed hangs from the lower side of the branch at the end of a long gluey thread. Seeds in that position often germinate but die, the hypocotyl remaining out of touch with the substrate. If the rain is moderate, the seed slides to the underside of the branch and in its new station, develops normally. This may explain why plants are often seen attached to the underside of a branch (plate IV B). In case the weather remains dry, the glue is, after some hours, sufficiently hardened to keep the seed stationary and rains can no longer change its position.

Delicate striations, running from the base in the apex, are seen on the testa. At the apex they unite in the blunt protuberances mentioned before. Under this protuberances lies the slightly swollen base of the hypocotyl. The rest of the embroy is enveloped by the endosperm. It consists of a thread-like hypocotyl and two cotyls.

Germination is very rapid (see also Ernst, 1942 : 278). I stuck many seeds on the branches of shrubs in order to examine the germination. Here follow the data of the development of one seed (see the figures in Docters van Leeuwen, 1927 : pl. 12).

On January 11, 1927, the seed was stuck to a branch. On Jan. 13 the base of the hypocotyl after pushing apart the strands of the protuberances emerged. It looked like a small, green knob while the remaining part of the hypocotyl was curved, and had lengthened, becoming far exserted from the seed. On Jan. 14 the hypocotyl was greatly lengthened and still strongly curved. On Jan. 15 the knob-shaped base of the hypocotyl had come into touch with the substrate. The curve of the hypocotyl at this stage was so deep that its base nearly pressed against the seed. As soon as the hypocotyl had gained the substrate, the base broadened to a kind of disc and broadening continued day after day. On Jan. 19 the seed was visibly thinner and the hypocotyl began to rise; in the course of rising the cotyls are gradually drawn from the testa. On Jan. 26 one cotyl has been freed, the other one was still attached to the testa by its apex. On Jan. 27 both cotyls were entirely freed. The seeds shrinks more and more but for months sticks to the substrate at the side of the young plant. The two cotyls now develop to the first pair of leaves of the seedling. After one month (Febr. 26) the second pair of leaves became visible and the root had penetrated into the cortex in the meantime. After 4 months a small plant had developed, it had three pairs of leaves. The first pair remains small, the following pairs are gradually larger and obtain the shape of normal leaves. Now the place of attachment is somewhat swollen, like a small cone. This swelling increases later on, but never attains the dimensions observed in other cases of *Loranthaceous* parasitism (the so-called "Holzrosen").

In *Lepeostegeres gemmiflorus* the seed remains stuck to the substrate during germination. It happens but rarely that the seed is detached by the pull of the rising hypocotyl so as to be lifted on top of the stretching hypocotyl into the air. In other *Loranthaceous* species which have the seed stuck at one end to the substrate like in *Lepeostegeres*, the seeds become normally detached (e.g. in *Macrosolen cochinchinensis*). Another striking point in *Lepeostegeres gemmiflorus* is that the cotyls are freed from the seed, being pulled out, and develop to the first functioning leaves of the seedling.

CHAPTER 4.

Macrosolen cochinchinensis (LOUR.) v. TIEGH.

As *Macrosolen cochinchinensis* is a very polymorphic and generally occuring species it is described under various names. In older literature it is often referred to as *Elythranthe globosa*. Of all species visited by birds I examined it had the smallest flowers. They are only 1—1½ cm long. *Macrosolen cochinchinensis* is found as a parasite on very different hosts, it was discovered to be attached even to *Dendrophthoë pentandra* .The area of distribution comprises the Malay Peninsula, Borneo, Java, the Philippines and, on the Asiatic Continent, India (Sikkim), South China, Cochin China and Siam; possibly it occurs also on Celebes (DANSER, 1931 : 285).

Macrosolen cochinchinensis favours low altitudes but, occasionally, penetrates to an altitude of 1500 m. In East Java it is in particular found at that altitude. At Buitenzorg the species is very common in the Botanic Gardens, not only growing on trees but often also on shrubs. The plants are less robust than many other species, but profusely branched and so they acquire a dense and bushy habit. It is entirely glabrous with the possible exceptions of the inflorescence and flowers, which may be pubescent. The terete stems are 2—3 mm thick swollen at the nodes. The usually broadly elliptical sometimes lanceolate, leaves are to 12 cm long and to 7 cm wide, attenuated or rounded at the tip and borne on a petiole which may be up to 7 cm long. The blades are hard and brittle, highly glossy and dark green above, dull on the lower surface. The midrib is raised beneath, the side-nerves run level with the surface. The leaves are alternate, rarely opposite.

The inflorescence is mostly small, and with fairly few flowers. In case of more flowers they are aggregate at the top of the rhachis to a kind af umbel (fig. 3). As a rule the inflorescences are solitary in the leaf axil but they may emerge in small fascicles (fig. 4). The pedicel is short, 3—5 mm, the bracts are small, at most ½—1 mm long. The calyx is little developed and being divided into very slender lobes it forms an inconspicuous collar near the base of the corolla. The corolla is built in a different way from the one described for other flowers in this essay.

The base of the open flower is dilated and, towards the mouth gradually contracts being narrowed slightly below the mouth. On the upper part of the tube 6 flat pouch-like dilatations or wings are present (see fig. 56). These pouches open gradually into the corollar-tube in both directions, upwards and downwards. On the edge of the mouth 6 lobes are seen which are usually spread horizontally, at best somewhat reflexed but never pressed against the corolla-tube. The grown bud shows a similar build but the lobes are at that stage still pressed against each other and thus form a cylindrical tube which is swollen at the top. Pedicel and ovary are dark green, the corolla-tube is lighter green to yellowish. The throat is marked by a violet ring. The top of the bud is at first bright yellow but later on, turns to orange. Sometimes the upper half of the flower is brown or blackish tinged and the tube formed by the lobes, yellow and red near the top.

The thread-like filaments of the 6 stamens are connate with the inner wall of the tube and run like narrow, low ridges over the surface. The anthers are linear and open by introrse slits. The style passes through the centre of the tube and past the stamens the yellowish, knob-shaped stigma being slightly exserted beyond the top of the anthers. One day before the bud opens, the anthers appear to be open and the lower surface of the still dry stigma is covered by pollen. A ring of nectar-producing cells surround the slightly swollen base of the style on top of the ovary. These cells are rounded and distinguished by a thick cuticula, as is often seen in nectar-producing glandular cells. Similar cells occur on the bases of the filamental ridges in the corolla-tube. All these cells secrete nectar; the corolla-tube is, about half filled with it. The nectar is very liquid, slimy and without scent.

At sunrise all flowers are still closed, but the lobes are under high tension and only wait some external agency to be released. If the top of the bud is pressed the 6 lobes jerk apart and turn backwards. This pressure has no result in flowers which are 24 hours younger but the lobes become detached on pressure in the afternoon preceding the day of natural flowering. The cells of the lobe-tissue are thin walled, the epidermis cells bear a thickened cuticula and the marginal cells of the epidermis are furnished with protruding teeth, which have a much thickened cell-wall.

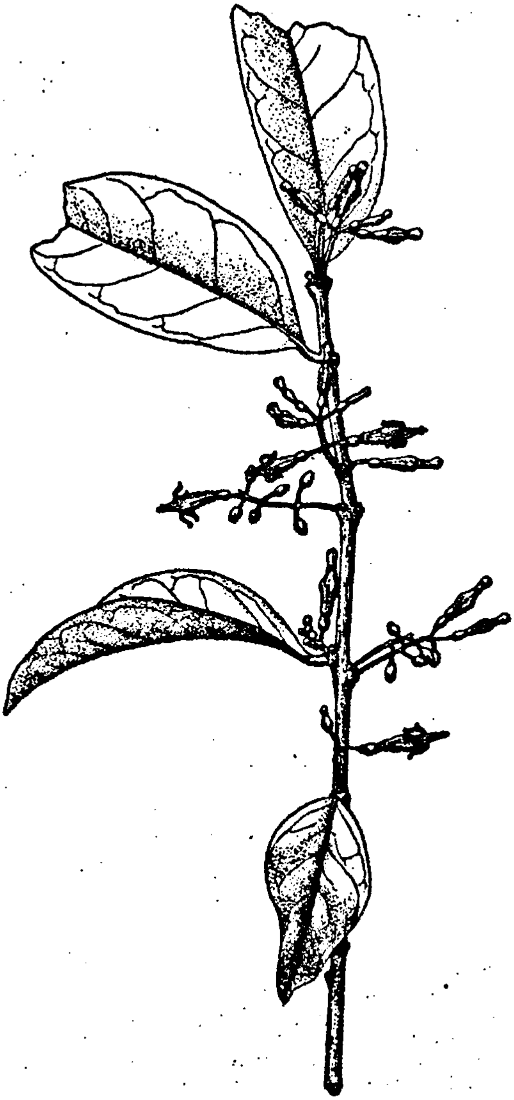


Fig. 3. *Macrosolen cochinchinensis*, branch bearing closed buds, open flowers and young fruits (× 2/3).

The protruding triangular papils or teeth of one lobe grip with the teeth of the next lobe and so the two tightly hold each other. The cells situated below the inner or axial epidermis, which forms the inner wall, one day before the flowers opens, are filled with starch grains. These grains, in the course of the morning, less than 24 hours before the actual bursting of the bud therefore, are converted into sugar. This results in a high turgescence at the inner side of the lobes whereas the outer side remains unchanged. As soon as the lock between the lobes is sprung, the inner walls stretch suddenly and as a result the lobes burst apart and spread backwards. The flower may be made to open not only by pressure or pricking but also by putting fully grown buds in a 4% aqueous solution of potassium nitrate or in ethyl alcohol 96%. Probably the resulting desiccation increases the tension to such an extent that the lobes lose their grip. In nature the flower can be opened only by birds.

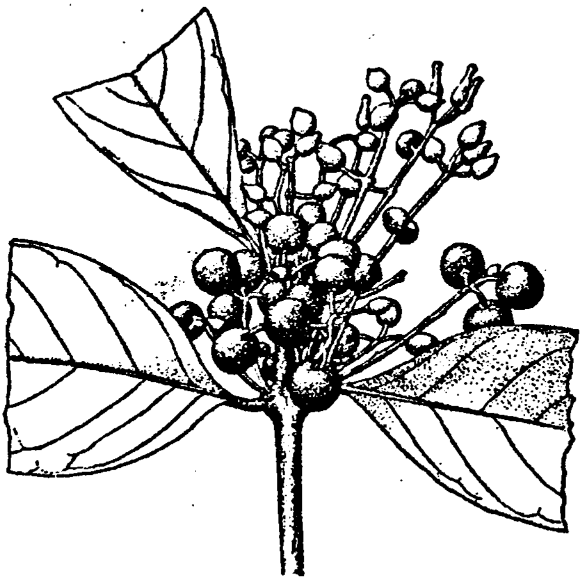


Fig. 4. *Macrosolen cochinchinensis*, young and ripe fruits (× 2/3).

In case the flowers are left untouched and birds are prevented to reach them, they remain closed and drop unopened.

At daybreak various birds may be observed to fly towards the flowers. First of all *Dicaeum*, however, I also noticed, *Nectarinia jugularis pectoralis* and *Anthreptes m. malacensis* as visitors to and openers of the flowers. I saw no other species but most probably more species will come and drink nectar from the flowers. The presence of nectar, the absence of scent, the colours, and the absence of organs or appendices suitable as a hold for insects in search for nectar, mark this flower as a real bird-flower. Admittedly the flowers are rather small but the birds seem to experience no difficulty in finding them. Cross-pollination can be effect regularly.

On the other hand, self-pollination might easily occur. This takes place already in a full-grown bud because the anthers are pressed against the lower surface of the stigma. When the flower is shed, the anthers rub against the moist stigma and self-pollination at this moment is also possible. If a branch with flowers or the whole of a plant is covered by a gauze pouch and so birds are prevented to visit the flowers, they remain all closed but all produce fruit containing fertile seeds. By this simple experiment it was demonstrated that the flowers are self-fertile.

The fruits are globose to slightly ovoid, 6—7 mm long and equally thick. At first the basal part of the style persists on top of the fruit together with the calyx-lobes. The calyx-lobes curve inwards. Soon the style remnant is shed. At first the fruits are green and hard, they soften and become yellow, finally they are shining and dark red. Under the rind is a tissue of cells containing glucose and under this the gluey layer is observed. This gluey layer is most developed at the area opposite the point of emergence of the hypocotyl. For this reason the seeds, when deposited, do not stick lengthwise and over their full length, but they are attached with one end only which keeps them more or less erect, the hypocotyl pointing upwards. The hold of the seed to the substrate is less firm than that found in e.g. *Dendrophthoë pentandra* and many other species, in which the seed is stuck over the whole of its length to the substrate. Heavy rains may rather easily wash it away or make it slide, in particular soon after the seed is deposited.

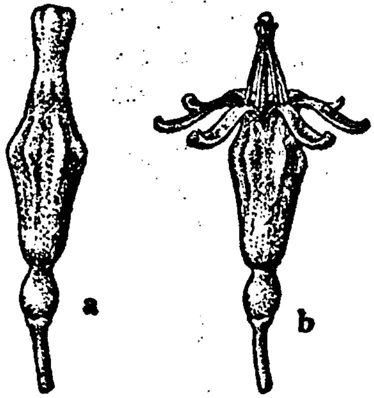


Fig. 5. *Macrosolen cochinchinensis*, a. fully grown flower bud, and b. open flower (X 3).

The seed is ellipsoid. The embryo is surrounded by the endosperm and consists of a hypocotyl and two long and thin seed-lobes. The base of the hypocotyl is swollen, conical and protrudes slightly from the endosperm. When germinating, the hypocotyl lengthens considerably and curves in the direction of the substrate. As soon as the substrate is reached it attaches itself by means of the conical, swelling with its flattened base. The hypocotyl stretches and the seed is loosened from its substrate (fig. 21). Both seed-lobes become free and function as the first pair of leaves of the plant. This is a characteristic of the genus, and of a few related genera, and sets these taxa apart from all other *Loranthaceae*. In general, *Loranchaceae* when germinating leave the cotyls inside the seed and these do not function as primary leaves of the growing plant.

The small size of the flowers of this species made it desirable to examine a second species of *Macrosolen*, which had larger flowers.

Chapter 5.

Macrosolen formosus (Bl.) Miq.

Macrosolen formosus occurs in Java, Sumatra, and the Malay Peninsula, in the latter area it is apparently more common. In Java it is locally found in mountainous regions at medium altitude, as a rule above 1000 m. I came across this species at Tjibodas (at 1450 m alt.), near the Puntjak Pass (at 1200 m alt.), and on the slope of Mt Guntur (at 1500 m alt.); all localities therefore situated in West Java.

It is a very much larger plant than the *Macrosolen cochinchinensis*. The branches may attain a length of 3 metres or more. The leaves are generally ovate, more rarely lanceolate, 10—35 cm long and 3—15 cm wide. They are widest below the middle and the apex is, as a rule, acute. Their upper surface is shiny but the lower is dull. The nerves are distinctly raised on the lower surface, only slightly so on the upper.

The inflorescence is 1—4-flowered, often nearly umbellate. Only rarely they occur solitary in leaf-axils or along runners but, as a rule, they emerge in aggregates from older nodes. The pedicels are 3—7 mm long and bear near the top a bract and two smaller bracteoles. The calyx-tube is cylindrical, 3—6 mm long and 1½—2½ mm wide. The corolla is strongly developed, 5—9 cm long. The basal part is cylindrical, about 3 mm across at the base and gradually widening up to 6—9 mm through. Where it is widest, six pouch-shaped, flat wings are present. Above these wings the tube contracts again to c. 4 mm through. The full-grown bud shows, on top of this contraction, an angulate or six-edged, clavately swollen top, with a rounded tip and formed by six appressed lobes. The ovary is often obliquely erect, the corolla is also erect or nearly so.

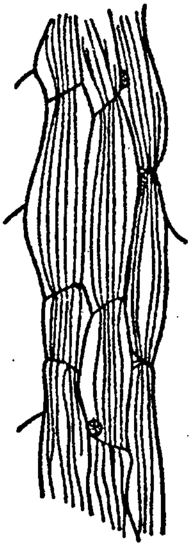


Fig. 6. *Macrosolen formosus*, cuticular ridges on the epidermis cells of the filamental ribs inside the corolla-tube (enlarged).

The flowers are beautifully and brightly coloured. The ovary is green, the corolla-tube orange-red and towards the top darker red. The light-red wings stand out strikingly against the darker surrounding colour. Above the wings the tube is often golden yellow. The contracted part is black. The clavate ending of the bud is green and shows 6 black stripes running over the zone of attachment of the lobes. A coloured picture only may convey the beauty of this magnificent flower.

After their release, the lobes are green, and black margined. Abaxially they are appressed against the corolla, being reflexed and often more or less spirally contorted. Near the base the 6 filaments are connate with the corolla-tube and run on the inner surface like narrow, low ridges. The free part of the stamens projects from the corolla; the filament is green and bears the yellow anther wich splits lengthwise. The style is green and ends in an orange, depressed spherical stigma which is borne slightly above the anthers. The epidermis of the anthers bears conical to clavate pappillae, the cell-walls being thickened at the surface. The stigma is studded with white pappillae.

The epidermis cells of the outer wall of the corolla have a thickened wall but the cuticula is not grooved or ribbed. Part of the epidermis cells have developed to many celled, branched hairs. The epidermis cells of the filamental ribs inside the corolla-tube are furnished with a thick closely rugose or grooved cuticula. The cuticular grooves are longitudinal and pass over the transversal walls of the cels. A continuous open system of capillary canals results which both conducts and retains the honey (fig. 6). Systems of capillary canals of a similar pattern have been observed in many bird-flowers. The epidermis cells between the filamentary ridges on the inner wall of the corolla-tube also bear a thick cuticula. This is also furrowed but less thoroughly than the cuticula on the ridge cells (fig. 7). The cells along the margin of the corolla mouth, and on the base of the corolla-lobes bear conical papillae with thickened walls (fig. 8). In those places where the flower is to withstand the main impact of the bird's bill, strenghtening tissue is found.

On the margins of the lobes which are connate in the bud, conical cells with thickened walls occur. The teeth of one margin fit exactly into the depressions between the teeth of the opposite margin of the next lobe. As described for the preceding species, the cells of the layer under the epidermis cells are, one day prior to the opening of the flower, filled with starch grains. This starch is converted in the course of that day into sugar. In the same way as was described above, the turgor of the inner side of the lobes is greatly increased and so the lobe is conditioned to spread and curve back when it loses its grip.

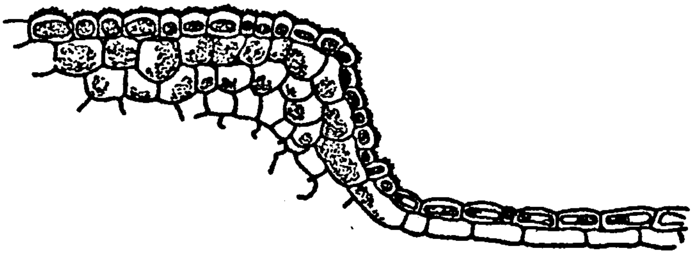


Fig. 7. *Macrosolen formosus*, left: epidermis cells of the staminal ridge showing the folds in the cuticula; right: epidermis of the corolla-tube (enlarged).

A thick ring of nectar producing cells surrounds the base of the style; its epidermal cells again are furnished by a thick cuticula. This ring secretes profusely very liquid, slightly slimy and sentless nectar, which fills the corolla-tube for about one third.

The flower is a classical example of a bird-flower. All functional characteristics indicating pollination by birds are present, bright orange contrasting with green and black, large quantities of very liquid, scentless nectar, strengthening of the areas touched by the bird's bill, and a system of capillary canals on the inner wall of the corolla-tube conducting and retaining the honey.

Regarding pollination I have only few data. Being located in remote places the plants were hard to observe at leisure. I was struck, however, by the small number of opened flowers. Most corollas appear to be shed unopened. *Dicaeum* and the small honey-birds may open the flower by pressure but their bill is too short to reach the nectar in the lower part of the corolla-tube. The long-billed spider-hunters may be able to reach it: in particular *Arachnothera robusta armata* has a very long, slightly curved bill. This subspecies and *Arachnothera a. affinis* occur in the forests of the lower mountains, but I was unable to establish their presence in the neighbourhood of the flowers. On the other hand, nearly all flowers had, close to the base of the corolla, a small round hole, bordered by a black margin. There is a bird, therefore, which cannot reach the nectar in the usual manner but forces its way, an occurrence repeatedly observed in bird-flowers. I suspect *Aethopyga eximea*, a common honey-bird in the mountain forests.

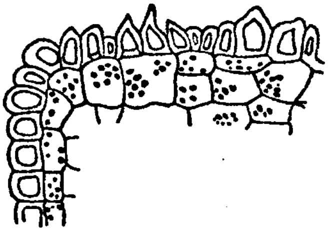


Fig. 8. *Macrosolen formosus*, epidermis cells in the zone of curving of the corolla-lobes, bearing papillae (enlarged).

In my aviary at Buitenzorg, birds behaved in a very peculiar manner when these flowers were offered to them. On March 2, 1930, I took a well grown specimen from the Puntjak Pass home and early next morning put it in the aviary. The aviary was a few meters long, high and wide, and some shrubs planted inside gave a fair suggestion of natural surroundings. At first all birds were highly interested, and immediately flew towards the flowers. The white-eyes, *Zosterops palpebrosa buxtoni*, alighted on the branches, pottered around among the flowers, but not a single effort was made to open them. After some time, the birds flew away. The honey-birds *Nectarinia jugularis pectoralis* and *Anthreptes m. malacensis*,stayed for a longer period and examined the flowers from all sides, but made no further efforts. I was in particularly interested in the behaviour of *Arachnothera longirostris prillwitzi* with its long curved bill, but this bird also made a brief survey and then left the flowers alone. It was an extraordinary situation: a true bird-flower and no natural reaction from pollinating birds whatsoever.

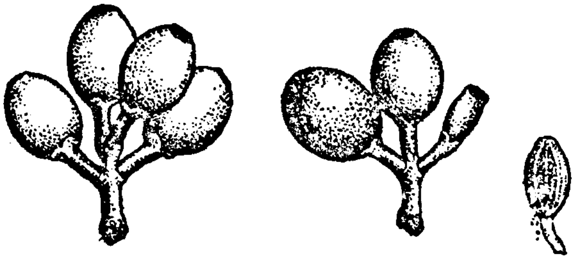


Fig. 9. *Macrosolen formosus*, fully grown fruits and germinating seed (nat. size).

All the birds in my aviary have been caught in the neighbourhood of the Botanic Gardens at Buitenzorg and the loranthaceous species of the district have smaller flowers. Obviously, the birds were at a loss what to do. Numerous true bird-flowers from the New World, which are pollinated in their homeland by kolibri's, are found in gardens in Java. Here native honey-birds are seen collecting their nectar. It is an open question whether these Javanese birds recognized the foreign flowers immediately as sources of food or whether they had to learn by experience. The answer is hard to give.

One might expect that they might have found their way to the nectar of the flowers of *Macrosolen formosus* after they had become familiar with their peculiar build. There is no evidence in support of this suggestion.

Apparently, a regular pollination by the birds does not occur; nevertheless, fruit is borne in abundance. The anthers are mature before the opening of the flowers, moreover, the stigma is covered by pollen when rising from the flower. Self-pollination, therefore, is normal.

The fruits are at first green, later they turn yellow and finally they become dark or blackish and shining. The shape of the fruits, (see figure 9) and their build is similar to that of the preceding species and germination proceeds like in the seeds of *Macrosolen cochinchinensis*.

CHAPTER 6.

Elytranthe albida (BL) BLUME

Only few data concerning *Elytranthe albida* are at my disposal, but its remarkble biology is sufficient reason to include a summary of the life of this species. It may assume proportions quite unusual in parasitic plants. Thick branches exceeding 4 m in length are commonly observed and, being not pendent but pointing towards all directions, they form a dense and tangled shrub of more than 6 m in diam. DANSER pointed out (1931 : 306) that *Elytranthe albida* had been found so far only on *Quercus* and *Castanea* and the connection between host and parasite appears to be extremely strong. The wood is hard and its anatomy shows several similarities to that of the host tree. One might think that the parasite was grafted on the host.

Elythranthe albida is known as occurring in the Malay Peninsula, Sumatra, Borneo, and Java, also from India to Siam. In Java it occurs between 600 and 1500 m alt.

The plant is entirely glabrous, its branches are rough and may be 12 cm thick. The leaves are large and coarse, up to 15 cm long and 8 cm wide, usually ovate, the top gradually narrowing to an obtuse apex. Both surfaces of the leaves are dull and the nerves are manifestly raised. Rarely inflorescences are found in the axils of leaves; as a rule they appear singly or in bundles on the old, leafless nodes. They bear one to three flowers. The bract is well developed, 12 mm long and 2 mm wide, more or less shell-shaped and appressed to the pedicel. The bracteoles are inserted just above them and are equally long as the bracts and are likewise pressed to the pedicel at their concave side. The calyx-tube is short, up to 1½ mm long and the limb is slightly wider, campanulate, and up to 3 mm long. In the full-grown bud the corolla measures ca 60 mm, the corolla-tube is at its base ca 3 mm wide. This narrow part contracts and as a result the basal part of the corolla-tube is nearly closed by the bases of the filaments which are connate with the inner wall and there somewhat raised. Above this contraction the tube widens gradually, attaining a width of ca 6 mm which another contraction of the corolla-tube follows. The apex of the bud is conical.

The corolla-lobes split apart down to the widest part of the tube which, after the flower has opened, can be termed as the throat of the flower. The 6 lobes become reflexed and finally touch the outer wall of the corolla-tube. The 6 capillary filaments of the stamens are connate with the corolla-tube at their base, and protrude like small ridges there. The anthers are ca 3 mm long. The style is capillary, somewhat increasing upwards. The knob-shaped stigma is slightly exserted from the anthers.

The corolla is white or yellow-white and with blue markings, sometimes the lobes are green-violet or tending towards red, especially near the top. The globose fruits are 2—2½ mm through and when mature, are black.

I saw very large specimens of *Elythranthe albida* in primary forest on the slopes of Mt Guntur in West Java. The plants were high up in the trees and this prevented observations of pollinating agents. The fruits contain a single albuminous seed; the embryo consists of a hypocotyl and two, well developed cotyls. The germination is similar to that described for the preceding species and the two cotyls become the first functional leaves of the young plant.

CHAPTER 7.

Helixanthera cylindrica (JACK) DANS.

Helixanthera cylindrica is a robust plant. Runners are often observed which advance over the bark of the host-plant and become at various intervals attached by means of a haustorium. The result is that several bundles of branches, closely placed together, hang from the branches of the host-plant. As a rule specimens occur high up in forest trees which makes it difficult to collect them and more difficult to investigate their biology. Flowering specimens are very conspicuous by the orange or red colour of the inflorescences and flowers.

Helixanthera cylindrica is known to occur in the Malay Peninsula, Sumatra, Borneo, Java, Celebes, and also in Cochin China and Birma (cf. DANSER, 1931 : 379). In Borneo, it has often been collected at sea-level but generally it is found in the lower mountains, at ca. 1000 m alt. KOORDERS collected it on Mt. Ardjuno (E. Java) above 2000 m alt. Personally I came across this species in the Pateunteung and Kemondjon districts near Garut (West Java). In that area they occurred in large numbers between 1400 and 1500 m alt., usually high up in the trees. A few specimens, growing on trees with low-inserted crowns in the margin of the forest, were accessible and offered an opportunity for some observations.

The branches of this parasite may exceed 3 m in length and are pendent from the branches of the host-plant: the top of the branches of the parasite is pointing upwards and bears the inflorescence. The leaves are large, up to 15 cm long and 6 cm wide, but usually smaller. The upper surface is shiny, the lower dull green, the stout midrib is evident on both surfaces and the lateral nerves are indistinct. The leaves are spirally arranged, sometimes they happen to be opposite and, rarely, three may be found together.

The inflorescence is an axillary raceme, emerging near the top of the branch; sometimes the branch carries a terminal inflorescence.

These racemes are, usually, rather few-flowered. In the specimens I collected they are mostly 5—10-flowered, but sometimes the number of flowers in an inflorescence may increase to 25. The flowering axis is angular irregular, yellow to orange and the surface turned to the light is often red-orange to red. The pedicels are well developed, in my specimens 5—8 mm long, angular like the main axis and thickened near the bases and tops. Like the axis the pedicels are yellow-red to deep orange. The flower is subtended by a scale on top of the pedicel. The scale is semi-circular to almost round and semi-amplexicaul, it is 1—2 mm in length and the apex is rounded. On the upper edge of the ovary a short cylindrical calyculus is present, which is entire, crenate or also lacerate. The ovary is red-orange, the calyculus greenish. The pentamerous corolla consists of linear petals. The petals are adnate in the bud by dentate sutures. The bud of the flower is orange, the apex red, the whole being 15—25 mm long and ca 2 mm through. The base of the corolla and its curved, beaked top are slightly dilated. After anthesis the base of the corolla is a ca 2 mm long tube, formed by the adherant basal parts of the petals. The rest of the petals spread to a star-shaped corolla while the petal tips are often recurved. The inner wall of the petals, which is turned upwards after anthesis, is red. The filaments of the stamens are connate in the lower part but not coherent with the petals. They are ca 8 mm long, capillary, very rigidly erect and deep red. The filaments change in anthers, which are linear and split by introrse length-slits. The pollen is yellow. In the open flower the stamens are widely spreading though, occasionally, an anther may remain stuck against the stigma.

The ovary is cylindrical and orange coloured, the style is capillary, rigid, red, and ca 15 mm long. On top is the small, knob-shaped stigma, which is densely studded by papillae. A ringwall, round the base of the style, secretes nectar. The short, tubular bottom of the opened flower is entirely filled by nectar and this protrudes like a globular drop from the centre of the staminal whorl.

The fruit is cylindrical though more or less rounded, about 8 mm long and just above the rounded base half as wide; towards the top the fruit tapers and is conical. Young fruits are green, becoming pink at maturity. The seed is pink and bears some soft. white appendices surrounding the base of the hypocotyl which is sligthly exerted from the endosperm.

SCHAEPPI and STEINDL (1942 : 338ff) did not examine *Helixanthera cylindrica*, but *H. hookeriana*, specimens of which had been collected in Ceylon. The flowers of the latter species are 4-merous, not 5-merous, but are in general very similar to those of *H. cylindrica* (SCHAEPPI & STEINDL, l.c., fig. 37). It is to be noted that the ovary is thicker and shorter in the Ceylonese species. These investigators found that the style-canal and the cavity of the ovary is, in the early stages of development, only a narrow slit. At the base of this slit the embryosacs are formed from subepidermal cells and no true placenta develops. Ovules are not noticed.

The embryosacs of all *Loranthaceae* grow and extend into the tissue of the style. SCHAEPPI & STEINDL (1942 : 342, fig. 41) found an extreme development in *Helixanthera hookeriana*. In the flower the top of the embryosacs reaches the top of the style and it curves as it extends under the epidermis cells of the stigma. The ovular cell and its synergids are found here. Whether the embryosac is equally extended in *H. cylindrica* is unknown.

The general build of the flowers is similar to that in *Barathranthus axanthus*. In both *H. cylindrica* and *H. hookeriana* the petals are free and in open flowers their bases remain connate, forming a short tube while the upper part of the petals spread star-like. On the other hand, in *Barathranthus* nectar is almost absent and the flower of the latter is for that reason not to be regarded as a bird-flower. Probably, insects are the pollinating agents. The flowers of *Barathranthus axanthus* are white or pink, though in few cases somewhat brighter coloured flowers were observed. The flower of *H. cylindrica* is, in all details a true bird-flower. Nevertheless, DANSER (1931 : 485) suggested that the flowers in this genus were pollinated by insects. A reason for this suggestion is not given.

The flowers of *H. cylindrica* are conspicuously coloured, bright orange to red and even the flowering axis and pedicels are steeped with this striking coulour. The nectar is secreted in profusion, very liquid and scentless. The flowers have no suitable area for insects to alight on. These are all characteristics for bird-pollinated flowers. On the other hand, the general build of the flower is different from that found in many other *Loranthaceae*. In those species the petals are connate and form a long tube which is about half filled by nectar. In *H. cylindrica* the bases of the free petals remain firmly attached by dentate sutures forming a short tube, which is entirely filled by nectar and this even appears on top of the tube as a drop between stamens and style. In these flowers, when still in bud, the margins of the petals are firmly connected by protruding and mutually fitting epidermis cells. As soon as this connection is interrupted, the upper parts of the petals recurve and the corolla becomes star-shaped. Whether this spreading is started spontaneously, or like in numerous *Loranthaceae* only after a bird released their hold through pressure by its bill, I have been unable to establish. In species of *Scurrula* the corolla-lobes are released without interference of birds.

The petals, filaments, and stigma are rigid and this rigidity is caused by a high turgescence. Lignified tissue I was unable to find. In the area where the petals curve back, the epidermis bears numerous papillae and these raised parts have a firm thickened wall. This reinforcement is firstly useful because it is at the point where the birds's bill penetrates into the flower and secondly, the papillae form a system of capillary canals which retains the honey easily. In that same area the filaments of the stamens and the style bear also papillae. Lower inside the flower the epidermis cells are delicately striped on account of low ridges on the cuticula which serve to retain the nectar and to conduct it upwards. This is a common characteristic of bird-flowers.

Regarding pollination only few data are at my disposal. I remained near the plants only a short time and only once I observed the very common *Nectarinia jugularis pectoralis* drink from a flower. The little bird had gripped with its toes the lower part of the inflorescence and could thus reach the flowers. Its head touched the anthers and the stigma. But, actually, I did not observe that it was necessary for the bird to open the flower first by pricking in to the bud with its bill or by pressing it. I also saw a few specimens of *Zosterops* sp. among the flowers but it was impossible to establish whether they drank from the flowers.

Self-pollination seems improbable, because the stigma is far removed from the anthers. However, in bud the anthers are pressed against the stigma and in *Loranthaceae* the stigma is often sticky before the flower opens. I already referred to the fact that occasionally, in an open flower, an anther appeared not to be exserted and spreading but to remain sticking against the stigma. Self-pollination cannot be excluded entirely therefore.

The fruits are taken by birds, viz Dicaeids, and the seeds are deposited on the branches of the host-plant by rubbing the anus against the bark. I collected fruits deposited in this manner several times. The seeds stick over their entire length. The hypocotyl is slightly exserted from the endosperm and surrounded by a few soft appendices which whither and shrink soon after germination and appear to be without meaning as regards the further development of the young plant. The edge of the hypocotyl turns towards the substrate, grows in that direction and becomes attached. Further development is similar to that found in *Dendrophthoë* and *Scurrula*, see there. The cotyledons remain inside the endosperm and the first leaves are real leaves.

CHAPTER 8.

Barathranthus axanthus (KORTH.) MIQ.

In the course of time *Barathranthus axanthus* develops to large specimens with long, often curved or pendent branches. A strong runner proceeds over the bark of the trunk of the host plant and at rather wide intervals it becomes attached, a root penetrating in the bark. At these points of penetration a new bunch of branches originates. As a result large specimens by their appearance may suggest to be a climber. The twigs are terete or angular; the leaves large and firm. I came across this species only in the Tjibodas district, on the slopes of Mt. Gedé (West Java). It is particularly found on *Villebrunnea rubescens* but also occurs on other trees. It is worthy of notice that though this parasite can be found on the branches of the host plants it shows a preference for growing on the trunk and even in dense forest, specimens are found to be attached fairly close to the ground. This species is known in Java only from the slopes of Mts Salak and Gedé, and it seems to be confined to the Western part of that island. It has been recorded from Borneo and Sumatra and the islands of the Rhio Archipelago; it is also found on the Malay Peninsula. DANSER referred to its occurrence on Ceylon (1931 : 393).

Barathranthus axanthus is highly exceptional being the only dioecious species in *Loranthaceae-Loranthoideae* in Malaysia (DANSER, 1931 : : 395). Male and female specimens are similar in habit but in the neighbourhood of the Tjibodas Mountain Gardens male specimens are rare, and female common. It might be possible that female specimens occur mostly nearer to the base of the host plants than the male which might prefer growing stations in the crowns and escape notice for that reason. On the other hand this is improbable, because seed dispersing birds could hardly be suspected to deposit the seeds producing male plants in another region than female seeds. The fact remains that numerous female plants are often found to grow gregariously while male plants appear to be rare. Plate VII is a picture of the branch of a male plant.

Young parts of the plants are covered by a dense ferrugineous tomentum of stellate hairs which proves to be fugacious. Older parts are glabrous. As a rule the leaves are opposite and occur in two kinds. There are, firstly, leaves of normal size and shape, and these alternate with one to five pairs of smaller, sometimes strongly reduced leaves. The normal leaves are short or long petioled (petiole 3—17 mm), the lamina is ovate or lanceolate, 5—15 cm long and 2—8 cm wide. At first they are covered by a brown tomentum of short, stellate hairs but soon they become glabrous and shiny. The midrib is strongly raised on the lower surface and the side-nerves are scarcely visible or indistinguishable. The small leaves are often reduced to a petiole which has a flattened top, is 5—7 mm long and clothed by a ferrugineous tomentum. The reduced leaves are often caducous. On older branches normal leaves may be seen at small or wide intervals. The function of these reduced leaves is unknown.

Inflorescences emerge from the axils of both kinds of leaves, often even on the lowermost internodia of the branches. As a rule a pair of inflorescences develops on each node, on older branches a small number may appear together. The female flowers are in sessile capitula; the foot of the flowers is surrounded by small, ca ½ mm long and wide scales which are covered by a ferrugineous tomentum. Each flower is placed in a scale which more or less envelops the ovary. The ovary is cylindric and bears on top a hardly visible calyx-ring. The corolla is choripetalous and consists of four, sometimes 5 petals. These petals together form a small tube. In the full grown bud the corolla is 4-angular and 2½ to 4 mm long. In open flowers, the petals in their lower half persists in forming a tube but the apical parts spread, becoming finally slightly recurved. The corolla is therefore star-shaped. Each petal is strap-shaped, ca ½ mm wide and the top is sulcate. The tip has a little tooth, directed inwards. DANSER (1931 : 395) stated "without appendage inside at the tip". In the flowers I examined, the teeth were small but clearly noticeable. Somewhat downwards the rudimentary stamens are inserted on the petals. These consist of a very short filament and a red, rudimentary anther. The style is 2—3 mm long, capillary, 4-angular, at base slightly thicker than on top and it ends in a very small stigma. The flowers are white or yellowish pink and very little nectar is produced.

The male flowers are also sessile and similarly arranged in axillary capitula. They are tetramerous and white or pink. The buds though thicker than those of female flowers, are equally long (2½—4 mm). The petals are wider (up to 1½ mm) and fleshier and in open flowers their tops spread less widely. The appendage which is directed inwards and occurs at the tip, is still smaller. The filaments of the stamens are 4 mm long and almost entirely connate with the petals. The anther is ovoid, obtuse at the base and at the apex, ca 1 mm long and it opens by 4 slits. The pollen is white and the grains are tripterous and so are of the same build as found in other *Loranthoideae*. Nectar is secreted in limited quantity. The ovary is still present but the style lacks. The scales at the foot of the flowers are sturdier than in female flowers.

The fruit is ellipsoid, 4—5 mm long and ca 3 mm thick, being crowned by a very little calyx. The fruit is white to light pink. The epidermis shows numerous papillae which contain vacuoles filled by a red sap. The exocarp is fleshy and the slime cells are large being filled with thick drops of gluey matter. The endocarp is connected to the fruit stalk by a short woodened stipe. This character is also found in Scurrula (see fig. 23) where the woodened stipe is strongly developed. The fruit is ca 2 mm long and 1 mm wide.

Barathranthus axanthus is very variable. Specimens from Java and Sumatra have narrower and generally more scattered leaves than Bornean and Malay Peninsular specimens which have wider and usually opposite leaves. According to DANSER (1931: 395) these differences are not consistent. The colour of the flowers varies still more. The plants from Tjibodas I examined had white, pallid yellow of light pink flowers. In the Malay Peninsula specimens were colleted bearing white waxy, light yellow, pale green, bright yellow, yellow, and even orange or red flowers. DANSER admits that this species is rether polymorphous but "it seems impossible to see more than a single species in it".

SCHAEPPI and STEINDL (1942 : 343) investigated this species also. They had only female flowers at their disposal. They described the 4-merous flower and refer to 4 staminodes. The gynoecium consists of 4 carpels alternating with the petals. The limb of the very short calyculus is irregularly frilled. According to these investigators (1942 : 344) the staminodes emerge in the axil of the perianth and apical meristem of the flower. The devolopment of the free parts soon ceases and there is no differentiation between anther and filament. The conclusion may be drawn from my description of the flower that I established occasionally a distinct differentiation between the filament and the red coloured anther. SCHAEPPI and STEINDL found the stigma slightly thickened and bearing a few papillae. The base of the style is surrounded by a ring wall which is undoubtedly the site of nectar secretion. Neither the style, nor the ovary show any cavity but in the centre of the ovary a series of cells was observed containing abundant protoplasm. In very young ovaries, however, a cavity is present and below that cavity embryosacs orginate without the development of a placenta or ovules. At an early stage the cavity fills. Concerning the subsequent development of the embryosacs little is known.

Regarding the floral biology of *Barathranthus* few data are at my disposal. The flowers are obviously no bird-flowers being comparatively small, containing very little nectar and being inconspicuously coloured. The build of the heavy and sticky pollen, the sessile flowers, which are massed in the axils of the leaves and the small stigma indicate that also the wind is unlikely to effect pollination. Though the flowers are but weakly, somewhat sweetly scented, insects are most likely to be pollinators. On the other hand, I never saw any insect in the flowers and I often examined them. I never saw pollen on the stigma. A few times I noticed in older flowers dead, brown discoloured epidermis cells of the stigma. These data are all negative and hardly fit to support any definitive view. In the Tjibodas forest where this species is rather common, the number of female plants is strikingly large. Selfpollination, which has been demonstrated to be successful in numerous *Loranthaceae*, is impossible in this dioecious species. Perhaps these fragmentary data indicate that no pollination at all is necessary to cause fruit production. All flowers yield fruit. An investigation on this point seems very desirable.

The build of the fruit is similar to that commonly found in *Loranthaceae*, especially like in *Dendrophthoë* and *Scurrula*. A prodigiously developed gluey layer covers the whole surface of the seed with the result that it may stick to the substrate over its entire length. On germination the base of the hypocotyl, which protrudes from the endosperm, continues growth and the part turned towards the substrate lengthens in that direction and becomes attached. Shortly after, the first two leaves of the young plant appear while the cotyledons are left behind inside the endosperm.

CHAPTER 9.

Dendrophthoë pentandra (LINN.) MIQ.

Dendrophthoë pentandra is a very common species and in Java generally seen in areas under cultivation. In the dry season dense, green bushes representing this species may be seen hanging from the bare capoc trees. It prefers low altitudes but it has also been collected in the mountain gardens at Tjibodas, up to an altitude of 1600 m. I collected it at the same altitude on the slopes of Mt Tankuban Prahu near Bandung. In the mountains it is never common, however.

As regards the species of host plant the parasite seems to be indifferent. It may be found on practically every Dicotyledonous tree or shrub. It occurs less frequently on Monocotyledons. I came across a single case of its parasitizing on the thick petiole of *Angiopteris evecta*. This specimen of *Dendrophthoë pentandra* proved to be short-lived. It was in possession of long runners, which crept along the petiole and had formed numerous haustoria, pl. VIII A. Only part of these had been able to fasten themselves and to penetrate into the host. It suggested some difficulty met with when effecting a communication with the vascular system of the host, see DOCTERS VAN LEEUWEN (1936b : 24).

The shape and size of the leaves is very variable. The flowers also very in appearance and the species has been given many different names in consequence, see DANSER (1931 : 417). It is, nevertheless, clearly distinguished from the other species in the genus by the short corolla, which is swollen at the base. In a few instances *Dendrophthoë falcata*, also a highly polymorphic species, resembles it.

Dendrophthoë pentandra is widely distributed. It is found in India, Siam, Cochin China, and the Malay Peninsula. It is rare in the Philippines but very common in western Malaysia. No record exists of its occurrence east of Borneo and Java, (DANSER, 1931 : 422).

The plants grow very rapidly and in time develop to large bushes consisting partly of ascending, but more generally descending or pendent branches. At the place of attachment a large ligneous protuberance develops, as a rule, a so-called wood-rose ("Holzrose"). On the other hand, this wood-rose may also be absent. Probably the precence or absence of the knobs depends not on the parasite but on the host-plant. (cf. *Korthalsella opuntia*, chapter 11). Runners often ermerge from the base of the plant and grow in all directions over the bark of the host. The runners are comparatively slender, red-brown or lighter coloured and at short intervals produce haustoria, which press themselves against the bark of the host. From the centre of a haustorium a boring root penetrates and subsequently a new communication with the wood of the host plant is brought about. On the upper surface of the haustoria buds are formed which develop into branches with leaves and flowers. As a result the plant expands quickly and an infested tree is soon overgrown by the parasite.

The stems of this species of *Dendrophthoë* are often over 1 m long, sometimes even much longer and it branches profusely. The stems, leaves, and inflorescenses are densely hirsute only when young; finally the plant is glabrous. The branches are 2—5 mm in diam. though often swollen at the nodes.

As a rule the leaves are spirally arranged, only on short branches they may be opposite. The leaves are highly polymorphous, sometimes lanceolate, but also ovate and not much longer than wide. Their length is 5—20 cm, their width 2—15 mm, the top is acute or rounded, and usually the lamina is decurrent along both sides of the petiole, which measures 5—20 mm. The lamina is thick and brittle, and the nerves are sometimes evident, but often hardly visible. The variability of the leaves caused the error of proposing new species which proved to be identical on closer study; the flowers are less variable.

The inflorescences are solitary or few together and placed in the leaf-axils. Leafless branches may bear a larger number in a single spot. The flowers are arranged in racemes, which are usually few-flowered although sometimes up to 20 flowers may appear to be present. The axis is 10—30 mm long and incrassate at the insertion of the 1—4 mm long pedicels. The intervals between flowers are irregular, sometimes the flowers are opposite. A 1—2 mm long scale is on top of the pedicel; it is appressed against the base of the ovary and more or less cup-shaped. The calyx-tube is only short, at most 2 mm long, and ends in some irregular lobes.

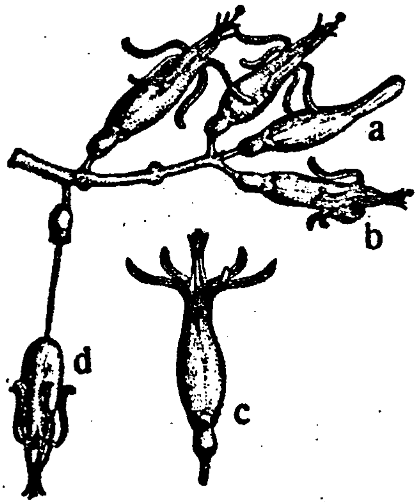


Fig. 10. *Dendrophthoë pentandra*. a: closed flowering bud; b: open bud; c: newly opened flower; d: shed flower. (a, b, and d × 1½; c × 2).

In a young bud the corolla is cylindrical and rounded at the top but the base soon swells and the mature bud is, for this reason obclavate, fig. 10a. The basal swelling ends rather suddenly and the tube continues in the cylindrical upper part. The surface is, in the bud, covered by tomentose hairs, and looks like being pruinose but after anthesis becomes soon glabrous. The base is greenish, the tip is more yellowish but buds developing in the shadow are entirely green; on the other hand, the bud may be yellow or even reddish. The corolla is 5-petaled. The petals connate at the base; the free top-lobes are in the bud firmly attached. Pressure or squeezing do not effect detachment. Tooth-shaped papillae on the epidermis of the margins of the petal-lobes fit interse and are also connected by a gluey substance. The manner in which the corolla-lobes are fitted together may be compared to that seen in the bones of the skull of the mammal, a dentate suture. This suture holds even when sections are made.

On the day prior to the opening of the bud, the cells bordering the inner epidermis, in particular near the base of the lobes, are full of amylum grains which are converted into sugar during the day. As a result the turgescense in the inner side of the lobes is much increased whereas the turgescence of the outer layers remains stable. Considerable tension from the inside comes into being and it seems that the gluey mass between the papillae of the epidermal cells disappears. On the day of anthesis the corolla-lobes are still attached to each other but through some mechanical stimulus are released easily. On squeezing the tip of the corolla, the connection between the slips is broken; they spring their hold and bend backwards with a jerk. At first their position is horizontal but finally they recurve until the outer surface touches the corolla-tube. In nature birds provide the stimulus to release the corolla-lobes.

The epidermis on the zone of bending, close to the mouth of the corolla-tube, is of a peculiar structure. The cells are furnished with a papil-shaped excrescence and on top of that a cell with a much thickened wall is present. The part of the corolla touched by the bird's bill is in this way protected against damage. This phenomenon has been observed in many bird-flowers.

The lower part of the filaments of the 5 stamens is connate with the inner wall of the corolla-tube. Their upper half is straight and protrudes from the corolla, the anthers are situated close to the style and the stigma is slightly exserted above the anthers.

The anthers open by two introrse slits, the evening before the day of flowering, but the stigma is not moist at that time. The flowers are protandrous therefore. The lower side of the stigma is covered by pollen prior to the opening of the bud. Self-pollination is for this reason easy. The epidermis cells on the adaxial surface on the filaments, in the zone where they emerge from the corolla-tube, are provided with a thick cuticula which is delicately grooved. These grooves are longitudinal and continuous, irrespective of the limits of the underlying cells, see fig. 11. These delicate flutings in the cuticula are even more strongly developed in the lower part of the filaments where these are connate with the corolla-tube. The epidermis cells of the inner wall of the corolla-tube between the filaments bear a similar grooved cuticula but mainly near the base. This results in a cuticular system of delicate capillary canals suited to holding and conducting the nectar upwards.

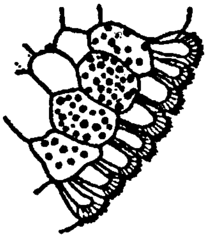


Fig. 11. *Dendrophthoë pentandra*. Epidermis-cells of the staminal filament in the corolla-tube showing folds in the cuticula (enlarged).

The long filamentous style protrudes from the whorl of anthers and terminates in a green knob-shaped stigma. The base of the style is inserted on the centre of the ovary and surrounded by a ring-wall, the nectary.

This gland secretes a large amount of very liquid, slightly slimy nectar, which is very sweet and present already before the flower opens. The corolla-tube is about half-filled. CAMMERLOHER (1928 : 49) alleges that the corolla-tube is entirely filled and that the nectar is cast out forcefully when the corolla-lobes separate suddenly. This statement is inacurate. Moreover, it would seem a highly unusual situation if the anthers were submered in nectar in the bud. The pollen would be moistened and possibly geminate in the sugary solution.

Very early in the morning many species of birds visit the flowers and these are highly skilled at opening the corolla. Usually only the smaller birds open the flowers, larger kinds generally arrive later, only after the flowers are open. Bright and early *Dicaeum* potter about among the flowers; they are able to open the flowers in two ways. Firstly they transversely squeeze the top of the bud with the bill, secondly they prick the corolla-tube pecking exactly in the place where two lobes are connected. The result is the same. The sudden jerk often casts part of the pollen into the air. Now the birds dip the bill into the flower and drink the nectar. The front of the head comes into touch with the pollen and the base of the bill is soon coloured yellow. The moist stigma, which protrudes above the anthers is easily pollinated. Various sun-birds also are early visitors. At Buitenzorg I observed *Nectarinia jugularis pectoralis* repeatedly. (In literature on floral biology this bird is better knawn as *Cinnurus pectoralis*). A common species is *Anthreptes m. malaccensis*. More rarely I noticed *Aethopyga m. mysticalis*, which appears to prefer the high trees (HOOGERWERF, 1949a : 103). *Arachnothera longirostris prillwitzi* is common in the Botanic Gardens, but I found that it visits the flowers only occasionally; the bird is a spider-hunter. Its bill is much longer than the length of the corolla-tube and the pollen would be deposited about the middle of the smooth bill. Whether this actually takes place I do not know. The bill in the other kinds of honey-birds is about as long as the corolla-tube and the base of the bill is also smeared by the yellow pollen. These birds all open the flowers in the same way viz by a transverse pressure of the slender top of the bud exerted by the bill. I have been unable to establish whether *Arachnothera* acts in a similar way or if it only visits opened flowers. This spider-hunter is even in captivity extremely shy and for that reason difficult to observe.

A white-eye, *Zosterops palpebrosa buxtoni* is also common in the Buitenzorg Botanic Gardens. This very lively bird also visits the *Loranthus* shrubs but they are less regular visitors than the species mentioned above. The white-eyes open the flowers by squeezing at the basis of the corolla-lobes. Much later, the Bul-buls, *Pycnonotus cafer aurigaster* pay a visit. Presumably there are more species of birds drinking from the *Loranthus* flowers. CAMMERLOHER (1928 : 49) observed that the bill of a shot leaf-bird, *Chloropsis cochinchinensis nigricollis* was smeared by *Loranthus*-pollen and I myself once saw this bird near Palabuan Ratu, on the South coast of Java, drinking from the flowers.

My observations on the opening of the flowers were conducted partly in nature but mostly in an aviary where I kept the majority of the above mentioned species during several years. Most of them became accustomed to my presence and were easily observed in their habits. It was always a striking sight when a branch bearing *Dendrophthoë* flowers was hung in the cage. The birds reacted immediately, alighted on the plant, and opened the flowers and drank.

I never noticed any insects on the flowers. The presence of an abundance of very liquid, slightly slimy honey, the absence of scent, the peculiarly reinforced build of the epidermis, where the bird's bill touches the corolla, and the exceptional way in which these birds open the flowers, indicate that they are bird-flowers. The capillary system of conducting and retaining the nectar also supports this view.

The period of flowering is brief; the corolla is shed in the evening of the day of opening or also during the following night. The corolla slides along the style together with the connate stamens. The style remains attached and so the corolla and stamens are often seen hanging from the top of the style (see fig. 10 d). When being shed, the stamens and anthers touch the stigma in passing and pollination may be effected. There is, it seems, ample opportunity for self-pollination but the frequent visits of the birds also effects cross-pollination.

The flowers are highly sensitive as regards a high amount of moisture in the air. During the rainy monsoon a large amount of the flowers fail to set fruit though having been visited by the birds. This susceptibility against moisture may be the cause that all buds are shed when the branches are protected against the visits of the birds by a pouch of gauze. I have been unable therefore, to prove that self-pollination may produce fruits, as appeared to occur in other species. A communication by RAUCH (1936 : 49) is to be noted. He wrote that Prof. A. ERNST had told him that he had cut the buds, shortly before opening, below the stigma and nevertheless the flowers had produced fruit, cf. also ERNST (1942 : 296). This leads to the conclusion that pollination had taken place in that stage of development and that the pollen-tubes had penetrated already. It would prove effective self-pollination.

The fruits are more or less conical and are crowned by the calyx-lobes, see fig. 12. When ripe the fruits are orange-yellow. The rind is very tough and covers the pulp which contains a high amount of glucose. The pulp covers a greenish layer of slimely cells which is very sticky. The layer surrounds the whole of the seed and for that reason the seed sticks over its entire length to the substrate. .

Fig. 12. *Dendrophthoë pentandra*. a : full-grown fruits; b : branch with young fruits ; c : stem-gall caused by a lepidopteron (× ½).

Among all fruits those of *Dendrophthoë pentandrus* are preferred by the birds (cf. Chapter 16). The hypocotyl, which protrudes somewhat from the endosperm, swells and grows towards the substrate from the side turned towards it. Once the substrate is reached the hypocotyl attaches itself. Soon after, a penetrating root develops in the centre of the base of the hypocotyl. The cotyledons remain surrounded by the endosperm and the hypocotyl is drawn from the seed until the bases of the cotyledons protrude slightly. The first leaves develop from the end-bud between the cotyledons (fig. 22).

CHAPTER 10.

Scurrula atropurpurea (BL.) DANS.

DANSER (1931 : 427) accepted 8 species in the genus *Scurrula* as represented in Java. These species of *Scurrula* are easily distinguished from other genera by the tetramerous corolla which is zysomorphous. On the other hand, it is very difficult to distinguish them among each other. I selected *Scurrula atropurpurea* for investigation as it is comparatively stable in its characters. BLUME recognized *Sc. fusca, Sc. repanda,* and *Sc. schultesii* as distinct species but DANSER reduced these all to *Sc. atropurpurea.*

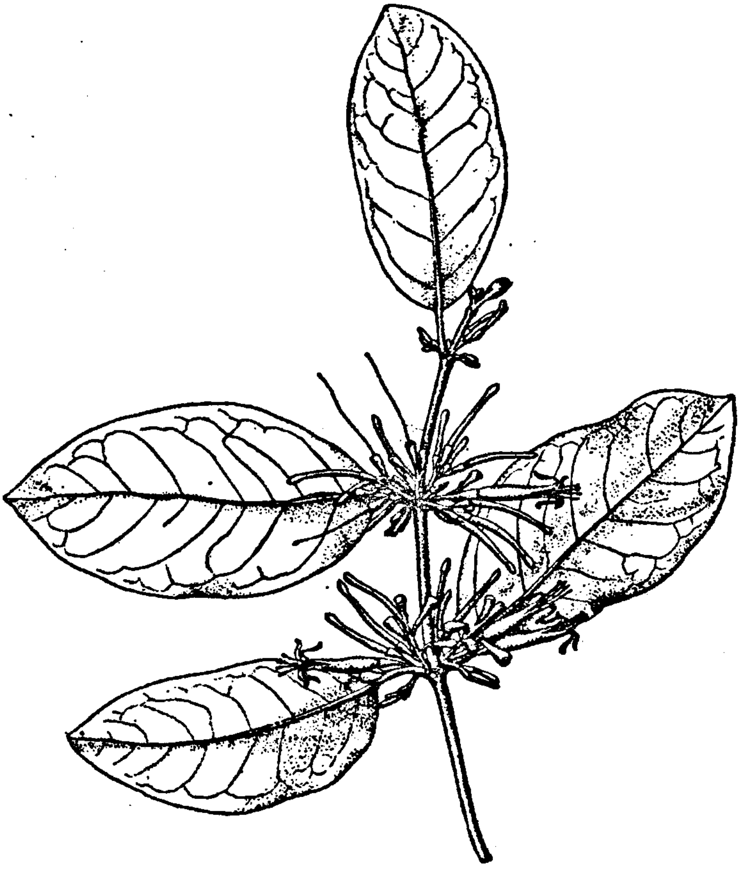


Fig. 13. *Scurrula atropurpurea.* Branch with buds and open flowers $(\times\ ^2/_3)$.

However, DANSER suggested a possibility that *Sc. atropurpurea* was only a local variety, if generally occurring in Java. of *Sc. fusca* or *Sc. parasitica.* It is not for me to decide in this matter.

Sc. atropupurea occurs commonly in the Botanic Gardens at Buitenzorg which made it easy to collect material. I also investigated allied species of *Scurrula* but, from a biological point of view, found them not different from *Sc. atropurpurea.*

Scurrulas are less stout and of smaller dimensions as are often seen in *Loranthoideae.* They are frequently attached to the slender branches of shrubs, see pl. IX. The specimens are profusely branched and the twigs are often pendent. Usually they are densely bushy, bear rich foliage and flower abundantly. As a rule they fruit freely. Scurrula's are rather indifferent as regards the host plant. They may be found on almost all Dicots; as far as I know, they were never met with on Monocots. Occasionally a *Scurrula* was seen to parasitize on a *Dendrophthoë pentandra.* Most specimens also produce numerous runners.

In contrast to the majority of *Loranthaceae, Scurrula's* are densely or even very densely pilose or hirsute. Young organs of *Sc. atropurpurea* are covered by a dense indument of grey or grey-brown hairs, which are short and stellate. The upper surface of the leaves soon becomes glabrous, the lower surface often also, but there are exceptions. The branches are relatively slender, 1—3 mm in diam., and bear opposite leaves. The leaves are mostly elliptic or obovate, sometimes oval, rarely lanceolate. Usually the top is rounded. As a rule the inflorescenses are aggregate in the axils of the leaf. They are arranged in sham whorls and bear normally 1—4 flowers, fig. 13. The pedicels are slender and short, 2—3 mm long and have a small, inconspicuous scale on top. The calyx is small, the tube being 2½ mm long and the limb is short. In bud, the corolla-tube is cylindrical and only the top is inflated to a blunt, more or less conical distension, fig. 14. This part comprises the 4 lobes which are closely pressed together. Later on the base of the corolla-tube distends also, becomes pouch-shaped but laterally it is slightly compressed. The lobes are tightly connected by teethed margins which fit in the way as was described before. The occurrence of a large amount of starch in the cells underlying the epidermus of the inner surface of the lobes, one day before anthesis, is also observed in these flowers. The starch is converted into sugar and as a result the inner surface of the lobes acquires a high turgescence. All this is similar to what has been described in the preceding species. In those cases, however, the lobes were only released after being squeezed or pressed by a bird's bill. In *Scurrula* the tension appears to be sufficient to overcome the resistance of the attached margins of the corolla-lobes because they are released and spread before sunrise. No visit by birds is required.

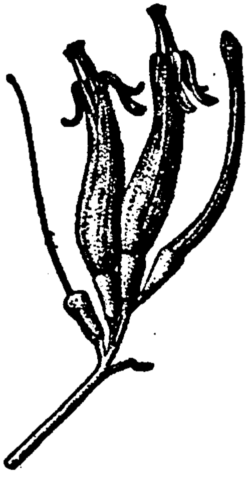


Fig. 14. *Scurrula atropurpurea.* Full-grown bud, open flowers and young fruit (× 2).

The lobes bend, but rarely so far as to become pressed against the corolla and remain more or less in a single plane. The opened corolla is zygomorph and slightly curved. The lobes are about 3 mm long, rather short therefore, but the two outer lobes are widely interspaced while a deep rift appears in the corolla, exactly between these lobes. The rift may lenghten to ½ or ⅔ of the corolla-tube. The flower has, in that stage, the appearance of a labiate flower though without a lower lip. The cells along the edge of the rift are not teethed. This implies that the rift is not originally present but results in consequence of the tension following the opening of the flower when the lobes turn and assume a position in a single plane.

The thread-like filaments are slightly exserted from the corolla-mouth and end in about 2 mm long anthers. At their base the filaments are adnate to the inner surface of the corolla but hardly any ridges result. The stigma is green and knob-shaped and scarcely protrudes from the stamens. One day before anthesis, the anthers are open and the stigma is pollinated, though not yet moist. This species is, for this reason, protandrous also.

A well developed ringshaped nectar-gland surrounds the base of the style. This ring consists of cells filled by starch and their epidermis, on the abaxial side, is made up by rounded cells. The outer wall is strongly incrassate, fig. 15. This ring produces nectar which is found as a large drop in the base of the corolla shortly after the flower has opened. Although the amount of nectar is not particularly large, it is apparently sufficient to attract nectar drinking birds. I observed visits by *Dicaeum t. trochilium*. *Anthreptes m. malacensis*, and *Nectarinia jugularis pectoralis*. The birds in my aviary immediately approached and drank from the flowers.

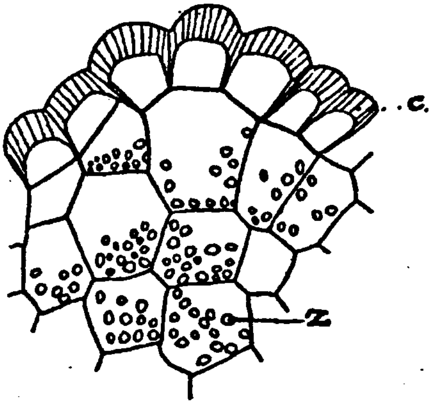


Fig. 15. *Scurrula atropurpurea*. Part of nectary; c : cuticula; z : starch, enlarged.

The epidermis on the inner wall of the corolla, close to the corolla-mouth bears numerous papillae showing a much thickened outer wall; the filaments are also covered by this kind of cells. Apparently, the places where the bill of visiting birds touches and enters the corolla, are reinforced. The reinforcements are absent along the margins of the rift and it seems likely that the rift is lengthened when the birds push the bill into the corolla. I found that older flowers were deeper torn open than young ones but I was unable to ascertain whether tearing progresses on account of tension in the corolla or as a result of damage by the bill.

After removal of all open flowers and fruits, a specimen was covered by a gauze bag. All buds open and the flowers produce fruit without exception. This proves that pollination by birds is not required and that self-pollination occurs. Cross-pollinating by birds may be the rule if the flowers are not interfered with. After anthesis the corolla dries and is shed, the style remains somewhat longer and the pedicel curves with the result that the fruit points downwards finally, fig. 16.

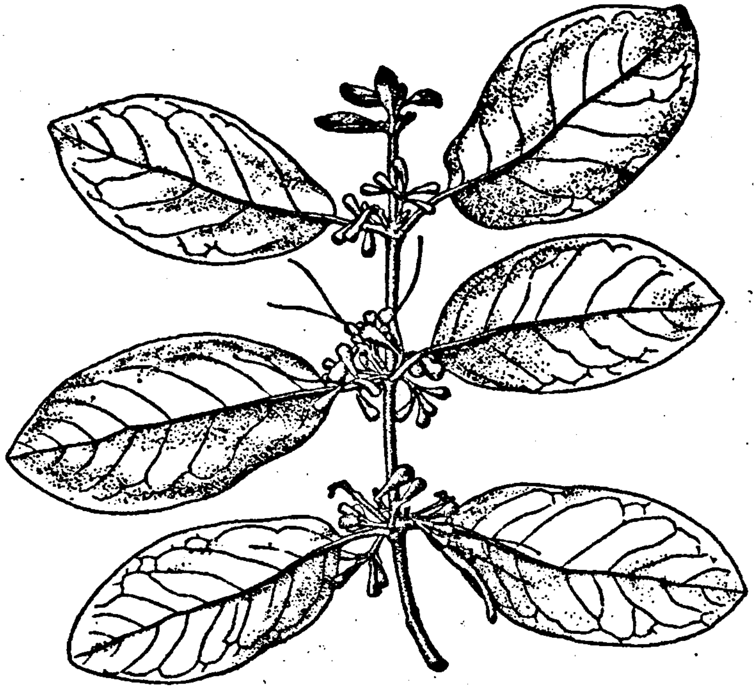


Fig. 16. *Scurrula atropurpurea*. Branch with young and mature fruits (× $^{2}/_{3}$).

The fruit is 7—9 mm long and 2—3 mm wide; it is cylindrical. When ripe, the fruit is soft and dark yellow. In *Scurrula* the seed is square and when being deposited bears a small white stalk at the distal end, fig. 23. This little stalk consists of lignified parts of the pedicel. This is a characteristic of *Scurrula* seeds, not found in other *Loranthaceae*, except in *Baranthranthus* (see there). The gluey layer is highly developed; the glue is very sticky, dark green and occurs over the whole of the surface of the seed. The seed sticks to the substrate over its whole length for that reason. The cotyledons remain within the endosperm during germination and the first leaves of the seedling are true leaves.

All species of *Scurrula* show the same built of flower, and a similar pollination and germination.

Scurrula atropurpurea is mainly found in West Java. It has been collected in East Java and there is a single specimen collected in Bali.

CHAPTER 11.

Korthalsella opuntia (THUNB.) MERR.

The genus *Korthalsella* was described by VAN TIECHEM in 1896. *Korthalsella ramayana* was the type species; it was indigenous in the Hawayan Archipelago. Afterwards, a number of additional species were referred to *Korthalsella*, many of them had been placed in *Viscum* originally in 1937 a revision of *Korthalsella* was published by DANSER (1937: 115), he added a Supplement (1940: 329). Both papers contain exhaustive descriptions of many species and valuable remarks on their distribution. By the absence of bracts and, usually, the presence of hairs among the flowers *Korthalsella*'s are easily distinguished from leafless *Viscums*. The flowers of *Korthalsella* are tri-merous, not tetra-merous as in *Viscum*. Most species of *Korthalsella* have all internodia flattened in one plane, which is never seen in *Viscum*.

Korthalsella is widely distributed: Abyssinia, Madagascar, Comores, Mascarenes, Continenntal SE Asia, Ceylon, Japan, Formosa, the Philippines, Borneo, Java, the southern parts of the Australian Continent. New Caledonia, the Archipelago eastwards of Henderson Island, the Hawayan Islands, and New Zealand. In the Hawayan Islands 5 species are found but as a rule a single, or only a few in one island. Some species are known from one finding locality only, others are widely distributed. In considering the area of distribution it is necessary to remember that many *Korthalsella*'s are very small plants and, on a trip, difficult to find. Only incidentally they are discovered and, on a trip, to secure a specimen is always considered good luck. The minute *K. dacridii* occurs in the tops of high trees, especially *Podocarpus imbricata* It is only possible to obtain them on a fallen branch and even there they are only discovered after a close search.

Korthalsella opuntia is spread over a large area. This species is found in Abyssinia, the Asiatic and Australian Continents, Ceylon, Japan, the Malayan Archipelago, and Lord Howes Island. Not only are these areas far distanced from each other, but the collecting localities in these regions are few and wide apart. DANSER (1940: 333) is of the opinion, however, that this species may be expected to grow on all high volcanoes in the Malayan Archipelago. In Malaysia the most recent collections were made by VAN STEENIS on his trip to the high volcanoes in N. Sumatra. The plant was found to occur there above 2000 m on various arboreous *Ericaceae (Vaccinium, Diplycosia,* and *Rododendron* spp.) and also on *Ternstroemia* and *Symplocos*. In India *Korthalsella opuntia* was collected on *Quercus*, in Siam on *Symplocos*, in Queensland on *Lycium*, on Lord Howes Island on *Elaeodendron*, and on Mauritius on *Eugenia*. In the Philippines it was collected, parasitizing on another *Loranthacea (Amyema verticillata)*, in Ceylon on *Olea*, in China and Japan on *Quercus*, in Java on *Symplocos, Schima,* and *Altingia* (DANSER, 1937: 134 etc.) This proves the plant to be rather polyphagous. In Java it has been collected in three localities. In 1911 I found it in Central Java, at an altitude of about 1400 m in the Gilipitung Mountains, parasitizing on *Symplocos spicata*. Later, in 1932, I discovered it in the Mountain Gardens of Tjibodas, on the slopes of Mt. Gedé, where it infested *Altingia excelsa* in large numbers. This finding locality is in the Mountain Gardens, which have been visited by dozens of botanists and it occurred on a grove of *Altingia*'s bordering a commonly used path. This may illustrate how easily the plant is overlooked if no particular attention is paid. The third finding locality is on Mt. Telaga, not far from the second locality, at about 1600 m alt.; VAN STEENIS found it there on *Shima noronhae*. At Tjibodas my attention was drawn to it because the presence of the parasite provokes the development of gall-like warts at the place of attachment (plate X). VAN STEENIS (1933: 112), when picturing a specimen from the last locality, observed that the knob-shaped protuberance on the host was absent and concluded, that the protuberances originate only after the parasite has been present a considerable period of time. This certainly is not the case. Immediately after germination, the branch swells at the place of attachment, as will be described below. The specimen pictured by VAN STEENIS is either an exceptional one or it is a *Viscum* and not a *Korthalsella* at all which cannot be ascertained from the photograph.

Korthalsella opuntia is a small plant consisting of one or a few branches. Its branches seldom exceed 10 cm in length, rarely they attain a length of 15 cm, they are simple or branched. The leaves are replaced by small scales arranged in di-merous „superponierte" whorls (SCHAEPPI, 1945: 75). The pair of scales forming a whorl are largely connate along the edges and protect the flower buds. The stem is always flattened. The long axis of a cross-section is perpendicular to the plane of the main narrowed, the nodes are small. The long axis of the flattened internode, in a transverse direction lies in the same plane as the pair of sessile scales and as the whorls of scales do not alternate, all internodes are flattened in a single plane. The result is a kind of platycladium. The side-branches are less wide than the main branch but are similarly flattened. The long axis of a cross-section is perpendicular to the plane of the main stem. The basis of a scale is decurrent along the margin of the internode. In the axils of the scales, on top of the internodia, the flowers are inserted.

On the branches of its host at Tjibodas, *Altingia excelsa*, the parasite gave rise to knobs measuring up to 4 cm in diam. (plate X). The knobs are slightly depressed and more or less pear-shaped being much wider on top than at base, where they merge gradually with the branch. On the higher and broader part, one or more green secundary knobs develop and on top of these the parasite is attached. After a crop of fruit the branches of the parasite are shed and adjacent to the bases of the shed branches small green knobs emerge which develop afterwards to new branches. Whether the branches develop periodically, I do not know; it seems improbable seeing that simultaneously specimens with and without branches and with branches of various ages may be present. DANSER (1937: 118) also refers to this manner of growth.

The flowers are crowded in the axils of the scales and all internodes bear flowers except the lowest. On both sides of an internode a group of flowers arises; on wide internodes they remain separate on narrow the groups merge. At first 3 flowers develop, a central ♂ one and two lateral ♀ (RUTISHAUSER, 1937: 8). More pairs of ♀ flowers originate and finally each cluster of flowers consists of a single ♂ and 7 to 9 ♀ flowers, the latter being arranged below and beside the solitary ♂ flower.

The male flower consists of 3 perianth scales. In the centre is a synandrium containing 6 pollen pouches. No anatomical evidence is available indicating the number of anthers composing the synandrium. RUTISHAUSER (1937: 9) suggests that there are probably 3. The female flowers comprise 3 perianth scales and probably 2 carpels; the stigma is bilobed. The two carpels are only partly connate; there remains an open slit-shaped stigmatal canal. The canal widens near the base of the ovary. The placenta is shaped like a truncate cone and there are no ovules. The gamethophyte originates in the tissue of the placenta.

The fruit (LECOMPTE, 1916: 125) is more or less ovoid, somewhat cylindrical, and is crowned by 3 persistent small lobes which are c. 2 mm in length. The ripe fruit is green-white, slightly glassy. Its build is similar to that observed in other *Loranthaceae*. A gluey layer is present and appears to be thickest at the side where the hypocotyl of the embryo protrudes slightly from the endosperm.

The manner in which pollination is effected, is unknown. I kept watch many times but never observed any visitor eligible to effect pollination. It is unknown whether the wind takes a part. The pollen is sticky and anemophily seems unlikely, cf. also the small number of male flowers in an inflorescence. The dispersal of the seeds is better known SAHNI (1933: 96) found that the seeds are expelled from the fruit with some vigour. He covered cut twigs with a handkerchief and found the seeds sticking to the tissue the next morning. The force by which the seeds are expelled may be judged from the fact that seeds may travel over a distance of 60 cm or even further. SAHNI (1933: 98) expressed his view that possibly the expulsion of seeds occurs in more *Loranthaceae*, in particular in *Viscum articulatum*. This certainly is not the case because the fruit of the latter species is avidly eaten by various birds. There is no question of the seeds being expelled.

I have no observations on the explosion of the seeds of *Korthalsella opuntia*. In the immediate surroundings of the fruiting specimens I found indeed seeds sticking everywhere: on the twigs and leaves of the host as well as on the twigs of the parasite. The seeds germinate easily and rapidly, but it is noteworthy that the germinated seeds only then develop further, when the seeds get lodged in the place where the lower side of a petiole emerges from the twig (fig. 17). Seeds alighting in other places soon die. I cannot say wether the same holds good for other hosts than *Altingia*. I found this parasite also on a *Symplocos* in Central Java, and remember that the plants were arranged in rows against the branches; the seeds can apparently also germinate and develop in this case on the internodia of the host. This statement, however, must be considered a surmise, until it has been examined in the habitat.

A similar expulsion of the seeds from the fruits is also known and more extensively examined for *Arceuthobium oxycedri*, by HEINRICHER (1915a : 181) and JOHNSON (1888: 137) and for *Arceuthobium occidentale* by PIERCE (1905: 99). Here too the seeds are expelled with vigour, so that the seeds may fly over a distance of one meter. According to HEINRICHER (1915a: 224) the viscous layer causes the tension and at the same time it functions as a lubricant. The wall of the fruit is elastic owing to a layer of collenchyma. Owing to a strong extension of this collenchyma longitudinally and diagonally the tissue is torn and the releasing tension expells the seed. According to HEINRICHER it should not be compared to shooting a gun or a cartridge. The function of the collenchyma is similar to that of a strap of a cross-bow. WANGERIN (1937 : 1191) discusses the problem extensively.

In Java occurs another *Korthalsella*, which is also found in Malakka: *K. dacridii*. This is a wee plant compared to *K. opuntia*. Various investigators, MEKEL (1935 : 312), RUTISHAUSER (1935 : 389), SCHAEPPI (1945: 59), and SCHAEPPI and STEINDL (1942: 301) have examined this plant. Little is known about its biology, nor about that of other *Korthalsella* species, with exception of three species occurring in New Zealand: *K. clavata*, *K. lindsayi*, and *K. salicornoides*. Miss G. B. STEVENSON (1934: 175) points out the following details: "there is a strong reduction of the ♀ flowers, just like in other cases. The reduction has gone further than in *Viscum* species. The ♂ flowers too show this extensive reduction. The embryo is situated in the top of the endosperm, and when the fruit matures the top of the hypocotyl projects from the endosperm."

The seed consists of endosperm, embryo, a number of cells of the parenchymatous cap, surrounded by a viscous tissue. It is an unprotected structure, lacking a true seed-coat. According to Miss STEVENSON the seed is very small and quite unadapted to bird attraction. I do not agree with her: the seeds expelled from the fruits and sticking to branches or leaves are not very inviting to birds, which make for the food within the fruit-wall, not for the seed. She states that the seeds drop near the motherplant, many even sticking to her. This utterly insufficient distribution of the seeds make the plant incapable for dispersal over greater distances, says Miss STEVENSON. Below I will discuss the faults of this argumentation.

During the germination of the seed there arises a distinct radicle, or rather hypocotyl, adhering against the surface of the host. This is a common phenomenon of the *Loranthaceae*. Miss STEVENSON also states that during the further development of the young plant the growing point of the stalk in the endosperm grows into a cotyledonary collar, by means of which the young plant takes the food from the endosperm, (1934 : fig. 15).

As regards the fact that in case of *K. opuntia* the young plants are only then found developing when the seeds adhere to the lower edge of the petiole it is important to note her statement: "Commonly in *K. lindsaya* the seeds become lodged in the angles of the stems."

The discussion begins on page 186. The plants are greatly reduced, which is shown by the general habit, the small measurements of all parts and the build of the flower, the absence of leaves and particularly so by the completely undifferentiated embryo. This reduction and the small measurements of the fruits explain why the plants are not easily dispersed and occur only locally. Where the plants do occur, however, they may be common. It is Miss STEVENSON's opinion that the reduction of the plants has gone so far that they are on the road to extinction. The plants do not die out through competition, but through their own inefficiency. *Korthasella* in New Zealand parasitize on *Leptospermum* and where this plant is crowded out by others, there is an additional factor for the extinction of *Korthalsella*.

These statements are too much based on guess-work and not on observations. We know of organisms with an even stronger reduction with a very wide distribution, which do not make the impression of dying out, such as many parasites of animals. With them too dispersal is often very difficult and intricate. It may be true that *Korthalsella* disperse over great distances with great difficulty and even if the branches of the trees do not intertwine move hardly from one tree to another, they yet have the faculty to do so, although we do not know how they travel over long distances. After all many species have a large area of distribution and occur in islands, nearer or farther apart. I will discuss this question of the distribution in chapter 16.

In New Zealand *Korthalsella* may disappear when the host-plant *Leptospermum* is ousted by other plants, but this will probably be due to human interference with the original vegetation. It does not prove that the plants would not continue to grow under the original circumstances.

The *Korthalsella* species I observed did not make the impression of getting extinct at all. One of the tiniest species, *K. dacridii*, is often found with many hundreds of specimens in the high crown of the full-grown *Podocarpus imbricata*. This very small and delicate parasite, the flowers of which are reduced to the same amount as those described by Miss STEVENSON, is very difficult to find. The plant is only known in two habitats, very far apart, viz. in Malakka and Java. Where it occurs, however, it is common and well developed. *Korthalsella* species are just as well adapted to their special life habits as other *Loranthaceae*.

I will now tell my own observations on *K. opuntia*. As stated above I found the plant for the first time on the slopes of Mt. Gilipitung in Central Java at an altitude of 1400 m above sea-level in 1911. The parasite grew in rows along the stems of a *Symplocos*. I was then of the opinion to have found a common species of *Viscum*, that is. *V. articulatum*, and as such it was inserted in the herbarium at Buitenzorg. It was years afterwards that DANSER found the real name. At the time I did not realize to have found a valuable acquisition, did not pay much attention to the plant, and just took a few specimens for my collection. In 1930 I visited the place again in order to collect more material and observe the plant in the habitat, but the plant was no longer there. Cultivation had completely altered the vegetation.

A short time before I left Java in 1932 I found the plant again in the mountain garden of Tjibodas. The knob-shaped protuberances where the parasite was affixed to the branches of *Altingia excelsa* were very pronounced. *Korthalsella* grew on three nodes of a branch (plate X B) and there were three protuberances on top of one another, the lowest and oldest being the biggest, the top one and youngest being the smallest. From this one a branch has developed from the axil bud of the leaf, where the seed was lodged up against the base of the petiole. The protuberances did not show twigs of the parasite, but on the upper half were green excrescences, to which the dropped twigs had been affixed. Near these excrescences were small rounded knobs from which in the course of time new twigs will develop. Another specimen (plate X A), had caused a firm protuberance on the branch of the host-plant, and the parasite had 7 branches. These branches are fully developed, there are no more flowers and a great number of fruits has already disappeared. The tops of the first and third branch are broken off and the same is the case with the side-branch of the third branch. At the same time there were specimens with open flowers and also specimens with still growing branches. One would be apt to say that there is no periodicity, although an investigation in the dry monsoon between May and September might lead to a better insight. At that time, however, I had already left Java.

A longitidunal section shows that the dark green tissue of the parasite extends as far as the wood of the branch. The knob is the infested wood-tissue of the host surrounded by bark.

The flowers are crowded on the upperside of an internode: one ♂ flower surrounded by several ♀ flowers. The ♂ flower opens prior to the ♀ flowers. The small stigma exudes a viscid fluid which often holds some germinating pollen-grains (see also RUTISHAUSER, 1935: 407). RUTISHAUSER assumes that *Korthalsella opuntia* has wind-fertilized flowers. I am not so sure of that. When blowing in the open ♂ flowers one does not see any pollen come out, although the grains are glabrous. The studies of *Viscum album* have not completely cleared up the question of its pollination either, although the flowers of this plant are visited by honey-bees and other insects and there is a secretion of nectar. The flowers of *Korthalsella opuntia* have a small nectar-ring producing a very small quantity of nectar. I never saw any insects in the flowers, although this is not conclusive, the observation of the plants being extremely difficult, as the parasite is often situated high up in the trees. The small size of the flowers too makes examination difficult.

Fig. 17. *Korthalsella opuntia*. Freshly deposited seed on branch of *Altingia excelsa*. × 3.

The seeds are expelled from the fruits and just chance to drop on the branches, yes even on the leaves of the host, or on the branches of the parasite itself. The seed is about 1 mm long and wide and flattened, see fig. 17. The top of the hypocotyl slightly projects from the endosperm, just as is the case with the other *Loranthaceae*. The seeds stick to the substratum with their flat sides and when he weather is not very moist and it does not rain hard they are soon firmly attached. The hypocotyl starts to grow immediately and one day after attachment the top of the hypocotyl has already fixed on the surface of the substratum; simultaneously the seed is somewhat lifted on that side, fig. 18. Two days later the seed is completely detached from the substratum, the hypocotyl is stretched, is more or less erect, with at the top the seed, fig. 19. The place where the hypocotyl presses against the substratum gets more or less disc-shaped and from the centre emerges a root which penetrates the bark of the host. Immediately after the penetration of this root the surrounding tissues of the host incrassates, fig. 19, and this is the beginning of the knob-shaped protuberance on the branch of the host and which may develop to a striking size.

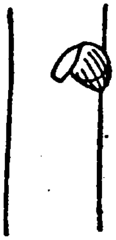


Fig. 18. *Korthalsella opuntia*. Young seedling, left: hypocotyl. × 5.

In the seed is a hypocotyl passing into a short stalk which is surrounded by the endosperm. Seed-lobes such are found in other *Loranthaceae* are not developed here. The endosperm is sucked out through a kind of cotyledonary collar, a thickening round the end of the stalk. I cannot say whether this can be compaired with scales. The reduction of *Korthalsella* has at any rate gone so far as to the absence of cotyledons.

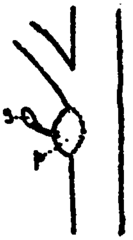


Fig. 19. *Korthalsella opuntia*. Young seedling
s: seed; p: protuberance. × 2.

After some time the testa is empty, dry, and drops, and in its place arises a short stalk, the first internode of the stalk of the parasite. At the top it produces constantly more internodes. While the plant is still very young and no more than a few cm long, green excrescences develop at the base, from which branches will develop, fig. 20.

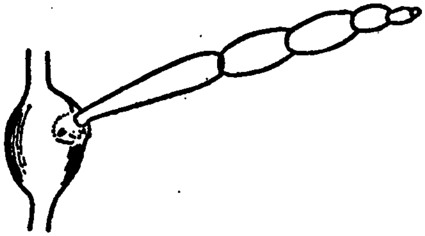


Fig. 20. *Korthalsella opuntia*. Young shoot and buds on wart of *Altingia excelsa*. × 1½.

In the surroundings of the mother-plant young seedlings can be found in great numbers, but the only plants which develop as far as I could state were those the seed of which lodged against the underside of the petiole where it emerges from the branch, fig. 17. There may be exceptions but I never saw them.

I do not know how the plant is dispersed over greater distances. I never saw any bird eating the fruits. But then a negative observation has little conclusive evidence in these matters. Even though the fruits are small, the fruit-wall contains a small amount of food which might be advantageous to small fruit-eating birds. I will discuss the subject of the dispersal again in chapter 16.

CHAPTER 12.

Viscum, species diverses.

In Java there are three species of *Viscum*: 1. *Viscum articulatum*, 2. *V. ovalifolium*, and 3. *V. liquidambaricolum*. 1 and 3 have no leaves, 2 has well-developed leaves. *V. articulatum* is the most common species. This plant forms irregular bunches of thin twigs, mostly pendent, especially so when older. The internodes are at the base more or less quadrangular, but the tops are mostly flattened. The internodes alternate. The number of hosts mentioned for this species is great. DANSER (1931 : 462) points out that many of them have been mentioned by mistake, because it was not noticed that the *Viscum* parasitised on other *Loranthaceae*. *V. articulatum* is a typical hyperparasite growing on many species of the genera *Dendropthoë*, *Elytranthe*, *Lepeostegeres*, *Macrosolen*, *Scurrula*, and many others. It is found parasitizing on *Viscum ovalifolium* and *liquidambaricolum* and even on *V. articulatum* itself. It is found on few plants other than *Loranthaceae*. It is fairly common on *Evodia*. In the Botanic Gardens at Buitenzorg it was often seen growing on *Calotropis gigantea* and especially on *Fluggea virosa*. VAN STEENIS (1930 : 103) too mentions *Fluggea*. These *Fluggea's* were also infested by other *Loranthaceae*, but the *Viscum* infested only those *Fluggea's*. The conclusion might seem evident that they prefer *Fluggea*, but this is not probable. WENT found *V. articulatum* in the mountain garden of Tjibodas on the slopes of Mt Gedé in West Java parasitizing on the epiphytic *Henslowia umbellata* (see VAN STEENIS, 1931 b : 177). KOERNICKE (1910 : 693) found the plant on *Lagunaria patersoni*. BURKILL (1906 :299) states that this *Viscum* is a parasite on *Taxillus vestitus* in the Himalaya, and also mentions other hosts such as *Acer*, *Eurya*, *Prunus*, *Rhus*, etc. FOREST collected this species in Yunnan and mentions as hosts: *Pinus*, *Quercus*, *Populus*, *Alnus* and other trees. DANSER (1936 :56) points to the fact that FOREST never found the plant on *Loranthaceae*. See also EZEKIEL (1935 : 162).

Other species too are known to infest *Loranthaceae*: *Viscum loranthi* parasitizes on *Scurrula philippinensis* and *Taxillus estipitatus* in the Philippine Islands, and on *Scurrula ferruginea* in Sumatra (DANSER, 1931 : 466). KIRK (1875 : 329) found *Tupeia antarctica* on *Paraxilla decussata* in New Zeeland.

It is not clear why this *Viscum* prefers *Loranthaceae* as hosts. The seeds are deposited by the birds in all kinds of places and certainly not only on *Loranthaceae*. I even found them on telephone-wires. I have stuck hundreds of seeds to numerous hosts. They germinate easily and quickly. They adhere firmly to the branches of *Loranthaceae*, practically all plants develop normaly; if, however, stuck on the branches of other plants they germinate almost as easily, the hypocotyl attaches itself to the bark, but in the course of time the seedlings die. The root apparently cannot bore the bark of these plants while this is easily performed in case of the *Loranthaceae*. I do not know the reason for this phenomenon.

Viscum articulatum is common in Malaysia; from Malakka as far as the Molukkas where it was found once. It also occurs in tropical Southeast Asia and tropical Australia. Closely related forms also in tropical Africa (DANSER, 1931 : 464).

Viscum ovalifolium is fairly common, but not to such an extent as the former species. It is occasionally found on other *Loranthaceae*, but mostly on other plants. It infests many hosts. An infested host is often loden with this parasite, while neighbouring trees remain uninfected. I saw the plant repeatedly in beach-groves of the islands above Batavia, amongst others on mangrove-plants.

As late as 1938 the plant was called *Viscum orientale*. DANSER (1938 : 50) examined authentic material in the Herbarium in Berlin-Dahlem and found that *Viscum orientale* is confined to the continent of Asia and that the species found from tropical Asia as far as New Guinea should be called *V. ovalifolium*. The plant also occurs in the Philippine Islands. This species is easily distinguishable by the well developed leaves from the two other javanese *Viscum* species.

Viscum liquidambaricolum has not yet been known so very long in Java. It was present in the herbarium at Buitenzorg, but was classed as *V. articulatum.* In 1929 DANSER (1929 : 49) discovered that the fruits of this species differ from those of *V. articulatum.* They are oblong and yellowish, those of *V. articulatum* being rounder and white. He described this plant as a new species (DANSER 1929 : 119 and 1931 : 469) viz. *Viscum stenocarpum.* Afterwards DANSER (1938 : 57) combined it with *V. liquidambaricolum* found by HAYATA in Formosa.

The species is fairly common in Western Java where the giants of the forest *Altingia excelsa* are found. The plants hang down from the branches of the host in enormous, yellowish bunches; because this tree usually emerges above the other trees of the forest, these bunches are very conspicuous, plate V and VI. KORTHALS (1839 : 258) mentioned the plant under the name of *Viscum angulatum* as infesting *Quercus.* This species occurs in Western Java, in Tonkin, Annam, Southern China, and Formosa. It displays a disjunct dispersal, such as is common with many plants of the higher mountains. It may some day be collected in Sumatra because here the javanese host *Altingia excelsa* also occurs. It may also be found on *Quercus.*

According to DANSER (1938 : 57) the internodes of this species in Java are narrower and less flattened than is the case in *V. articulatum.* DANSER (1941 : 28) also mentions it as occurring in India where it parsitizes on *Cornus capitata, Terminalia chabula, Pinus, Alnus* and many other species of trees. Neither this nor *V. articulatum* form big protruberances on the branches of the host, but *V. ovalifolium* often does. This latter species often causes the death of the top part of the infested branch ,so that the pasasite crowns the top of a truncated incrassate branch, (plate VIII).

I mostly examined *Viscum articulatum,* but also investigated the germination of the seeds of the two other species.

Viscum articulatum is monoecious. The inflorescences are situated opposite each other at the upper end of the internodes. At first there is a ♀ flower surrounded at its base by two radially placed bracteoles which are connate so as to form a small cup. Below them are a number of decussate pairs of bracteoles (DANSER, 1931 : 462). In these cup-shaped bracteoles new flowers emerge, partly ♀, partly ♂. Each flower is enclosed in two connate bracteoles. More flowers are rare. Occasionally there are inflorescences which have grown to an irregular mass at the top of the old internodes. The bracts are hardly ½ mm long, the bracteoles even smaller. The ♂ flowers are hardly ¼ mm long, the tepals very short and the anthers flat. The ♀ flowers are slightly bigger, up to ½ mm long. The lower part consists of 4 incrassate tepals opening but slightly and surrounding the style. The build and development of the flowers is discussed extensively by STEINDL (1935 : 370) and by SCHAEPPI and STEINDL (1942 : 301). In case of the ♂ flowers there are 4, rarely 3, perigone leaves, the anthers being attached to the adaxial wall. The tops of the anthers stand loose from the perigone leaves. All the anthers contain 2 to 12 pollen-pouches. The pollen grains are small, much more so than those of *Viscum album.* They measure only 17—18 μ. The pollen grains of *Viscum album* are delicately echinate, those of *V. articulatum* are glabrous. TREUB (1883 : 11) described that the ♀ flowers were strongly reduced. The flowers are very small and green. There are no nectar glands. The ovary consists of two carpels, which are so completely connate as effecting a homogeneous tissue without inner cavity. The upper cells of the carpellum are papillose. After anthesis they are darker green and form a kind of elevation reaching up to the middle of the perigone leaves. This is the style, but there is no style-canal. Placenta, nucellus, and intugement are completely absent. The embryo-sacs are free within the parenchymatous tissue so that there are no ovules.

Little is known about the pollination of the flowers. STEINDL (1935 : 374) thinks that the small size of the flowers, the inconspicuous colour, and the absence of nectar glands as well as the glabrous exine of the pollen grains prove that the flowers of this are wind-fertilized. When keeping the particularities of *Viscum album* in mind one is, however, hardly justified in pronouncing such a judgment.

There have been many controversies about the pollination of *Viscum album.* The subject is extensively discussed by WANGERIN (1937 : 1132). The investigations of POHL (1931 : 378) revealed pollination by insects. He stated that warm days effected a more ample secretion of nectar. Drops of nectar come forth from between the perianth and the pistil so that the secreting gland must be situated either at the bottom of the flower or on the inside of the periant. Further investigations showed that the disc secreted the nectar. The nectar is tough and viscous and when exposed to the air it gets tougher all the time. The honey contains little sugar. Apart from the viscous liquid and the sugar the nectar also contains a small amount of an oily material. The disc of *Viscum album* secreting the nectar is small. It is present in all *Loranthaceae* which have been examined. POHL never found nectar in the male flowers neither any places containing sugar.

POHL points out that the proofs of HEINRICHER showing that berries developed even when insects were prevented visiting the flowers by a gauze envelopping them are no conclusive proof of anemophily. When the gauze is so fine that no insects can slip through, the pollen-grains cannot slip through either. When on the other hand the gauze is permeable to pollen-grains small insects, such as thripses and small diptera and also mites can get through. Therefore only an investigation of the build of the flower can give conclusive evidence. The pollen of wind-flowers is very fine. The exine is glabrous and therefore the grains do not stick together. According to POHL the pollen of *Viscum album* do not have these characteristics. The pollen adheres in small clumps, the exine is echinate, and between the grains is an oily substance, characteristic of insect-fertilized flowers, and this substance gets stickier as the grains are exposed to the air. Wind-flowers are hardly ever conspicuous by their colour or smell. The ♂ flowers of *Viscum album* have a very conspicuous yellow colour. The ♀ flowers are less striking. It is only their drops of nectar which stand out glistening in the sunlight. The flowers also spread a fine scent. The above shows that the flowers of *Viscum album* are insect-flowers. It is remarkable that the honey-bee mainly visits the ♂ flowers but rarely the ♀. There are, however, small flies visiting both flowers, also thripses and mites.

The various *Viscum* species I examined in Java have even less conspicuous flowers than those of *Viscum album*. It was but rarely that I saw insects in the flowers; just occasionally thripses and mites and sometimes small, black flies. Small stingless bees, species of *Melipoma* are occasionally seen visiting the flowers. Unfortunately all my notes regarding Javanese *Viscum* species got lost during transport, so that I have to go by memory. The flowers of the Javanese species also smell nicely, although very faintly, the pollen is forming small clumps and therefore I think we are justified in calling these flowers insect-flowers. Further investigations seems, however, desirable.

However this may be there is regular pollination; there is ample fructification. The fruits are round, have a light colour, with a glabrous exine in case of *V. articulatum* and *liquidambaricolum*, and a granulate exine of *V. ovalifolium*. The fruits of *V. articulatum* and *ovalifolium* are globular, those of *V. liquidambaricolum* more oval, their colour is white to yellowish and transparent and glassy. The berry contains a small, flat seed, surrounded by a viscous layer, which is best developed opposite the place where the hypocotyl emerges.

The fruits are readily eaten by *Dicaeum*, mostly the birds eat several fruits at a time so that sometimes more than one seed is excreted simultaneously, although one is more common. Figure 2 shows such a string of *Viscum* seeds together with seeds of *Macrosolen cochinchinensis*. Seeds are rarely voided in such a way, it is after all not very efficient; the seeds cannot adhere to the substratum and are lost.

Soon after the seed is deposited, sometimes within 24 hours, the hypocotyl grows out rapidly and turns the base towards the substratum. The swollen end adheres to the host, the top of the hypocotyl withdrawing as it were from the clinging seed. The seed rarely comes off so that it crowns the top of the erect hypocotyl. In case of *Viscum* the cotyledons remain in the seed, see fig. 22a.

Chapter 13.

Insects and fungi.

Insects do not play a part in the pollination of the larger-flowered *Loranthaceae*. I did not even see the common stingless bee of the genus *Melipoma* or *Trigona* collecting pollen in these flowers. This is all the more remarkable because these small bees are present where ever pollen can be found. They are even found collecting the pollen in the dropped masses under the sugar palms. They may visit the flowers of the *Viscoideae* which must be fertilized by insects, but I failed to find sufficient data. I found thripses and mites in the flowers of *Viscum articulatum*, but I have no particulars about the other species.

Although insects do not play an important part in the fertilization there are various insects living on those plants. At Buitenzorg I found a green, glassy, slug-like caterpillar on *Dendrophtoë pentandra* which was regularly visited by ants. The caterpillar pupated and gave a blue, a *Lycaenide: Tajuria cippus pseudolonginus*, see Roepke (1933: 108). The ♂ ♂ have silvery, light blue wings with a black front edge and top part of the fore wings, the undersurface is grayish brown with a transverse crenated line. The ♀ ♀ have fainter and paler colours.

There is a genus of *Rhopalocera* some species of which are known to be dependent on the presence of *Loranthaceae*, because the caterpillars only feed on the leaves of these plants. Therefore they are also known as *Loranthus* butterflies. We do not know anything about the life-habits of most species, nor about the food eaten by their caterpillars. This genus is *Delias*, partaining to the family of the whites or *Pieridae*. Roepke (1935: 46 and 1942: 393) describes 7 species of this genus for Java. Some of them belong in the higher mountains, upwards of 1500 m, others live in the plains. Most common of them is *Delias b. belisama* which can be seen flying about in villages and towns where *Loranthaceae* occur. It is found up to 1500 m above sea-level, and is only collected in Java and Bali. It is the biggest species. The ♂ is white with a black border and top of the fore wing and a black border of the hind wing. The colour of the ♀ is more yellowish. The underwing view shows a red spot at the base of the hind wings. There are several subspecies of *belisama*. Most striking is the sp *D. belisama aurantia* in Eastern Java where the white colour is replaced by a beautiful golden yellow which is orange in case of the ♂. The nominate form is a butterfly of the plains and the lower mountains, *aurantia* replaces it in the mountains of Eastern Java.

The yellow eggs are placed in small groops on the underside of the leaves of *Loranthaceae*. The caterpillars move to the edge of the leaf and sitting close together they rapidly devour the leaf. The full-grown caterpillars are plain greenish yellow to brownish with white or yellow hairs. Full-grown they measure about 3 cm. When the *Loranthus* is not too big the leaves are soon devoured and the caterpillars are seen creeping to and fro. When there is nothing more to be got the caterpillars spread over and along the branches of the host of the parasite in search of food. The parasites can be seriously damaged in this way, but when the destruction has not gone too far they soon sprout out again. If food is exhausted the caterpillars sometimes remain quite small, but they pupate nevertheless and the butterflies hatching from these pupae are also very small. The pupae are pale yellow to yellowish brown with black dots and black spines on the dorsal side. They mostly hang in groops from the branches of the *Loranthaceae* or their hosts.

Delias h. hyparete too is common from the plains up to the lower mountains. The same holds good for *D. p. periboea*, which, however, is restricted to the plains. *D.c. crithoë* is a common butterfly of the mountains, between 1500 and 1800 m above sea-level. *D.m. momea* is here and there common in the mountains of Western Java. *D.d. doryglaea* is rare in Java, the other subspecies more common in Eastern Malesia, the Moluccas, and New Guinea. Another species of Java is *D. aglaja egialea*, which has also been collected in the island of Bawean. The latter species is among those insects which are sometimes seen in great numbers, only to be absent again for years at a stretch. It has been collected all over Java. OVERBEEK (1938 : 19) found the caterpillars on a small *Loranthus* parasitizing on a *Punica granatum*. They could not find sufficient food; after devouring all the leaves of the *Loranthus* they looked for food on the host of the parasite and finally returned to the *Loranthus*, where they ate all the young shoots; they pupated before being full-grown, and gave very small butterflies.

The greatest number of species of the genus *Delias* lives in New Guinea. Professor ROEPKE at Wageningen told me that L. J. TOXOPEUS collected more than 3000 specimina of many species in the higher mountain regions between 3000 and 4000 m above sea-level. One wonders where the caterpillars of these butterflies live on. The *Loranthaceae* should then be very common at these altitudes. DANSER (1931 : 233) mentions 44 species of New Guinea. Most of them have been collected in the lower regions. Only 18 species have been found upwards of 1000 m as far as 2400 m above sea-level, only few of them between 2000 and 2400 m. Two species: *Amyema miraculosa* and *A. wichmanni* were collected between 3000 and 3900 m above sea-level. This leads to the conclusion that *Loranthaceae* get rarer as the regions get higher. I experienced the same when I collected plants in New Guinea for 6 months in 1926. I did not see a single specimen upwards of 1500 m. Further investigations will have to prove whether those *Delias* in the higher mountain regions of New Guinea live ecxlusively on *Loranthaceae* or on other plants.

There are other species of *Lepidoptera* the caterpillars of which live on the leaves of *Loranthaceae*. *Dasychira (Lymantria) mendosa*, a tussock-moth has been found on these parasites, but it is a polyphagous insect living on many plants. Another *Lymantriidae* too, *Euproctis cataba*, is polyphagous and has also been collected on *Loranthus*.

KALSHOVEN (1951 : 1031) mentions some mining, webbing and boring caterpillars living on *Loranthaceae*: *Epermonia parasitica*, *Phyllocnistis voûtei*, *Anarsia autacta*, and *Ptochoryctis loranthivora*. The young leaves may also be covered by an aphis secreting wax: *Oregma loranthi*. When young leaves are completely covered with the lice they get rolled up thus forming simple galls. Scale insects too occur. The species *Chionaspis vitis*, *Pseudococcus citri* and *P. lilacinus* are very polyphagous and can live also on *Loranthaceae*.

Many galls have been found on these plants, but not a single one caused by a gall-mite. Gall-mite galls are very common in Java. They make out even 25 % of the galls. Of the 43 galls collected on *Loranthaceae* (DOCTERS VAN LEEUWEN-REIJNVAAN, 1926 : 167 and 1941 : 146) 12 are caused by gall-midges or *Cecidomyidae*. 9 by *Hymenoptera*, 6 by *Lepidoptera*, 4 by *Aphidae*, 3 by *Coleoptera*, 3 by *Thysanoptera*, 3 by *Phyllidae*, 2 by *Coccidae*, 1 by an *Aleurodide*. The names of the gall causers are still unknown with the exception or those of 2 *Thripsidae*. These thrips-galls are rollings of both leaf halves towards the upper surface. The walls of the galls are swollen and brittle. The gall on *Dendrophthoë pentandra* is caused by *Eothrips crassicornis* and *Eothrips annulicornis* lives inside as an inquiline. The indentical gall of *Dendrophthoë praelonga* is formed, according to KARNY (1913 : 84, 87) by *E. annulicornis* with *E. crassicornis* living inside as an inquiline. This seems very queer and further investigations are desirable. The third thrips-gall is a leaf-rolling on *Scurrula junghuhnii*; the gall-causer is unknown.

The aphid-galls are found on *Macrosolen cochinchinensis*, *M. tetragonum*, *Scurrula junghuhnii*. and *Dendrophthoë pentandra*. The first three are upward rollings of both leaf halves, the last plant has downward rollings. Of all plants the leaves are torsive. A small coccid lives on the leaves of *Dendrophthoë pentandra*. The insects live in shallow hollows of the lower surface of the leaves. The upper surface shows small, flat, and yellow bladders. Another coccid lives on the twigs of *Viscum articulatum* and there it causes small witches' brooms. It is remarkable that in Europe only one gall is known on *Viscum album* also caused by a coccid: *Diaspis visci*. This insect forms small galls on the leaves and young twigs.

Another very simple gall is caused on the leaves of *Dendrophthoë pentandra* by an *Aleurodide*. Hundreds of the insects are grouped on the lower surface of the leaves. Each larva is situated in a small hole about 1 mm across; on the upper surface of the leaf is a corresponding small, flat, and yellow swelling, so that the infected leaves are spotted with yellow dots.

Scurrula junghuhnii has two psyllid-galls. One is a narrow rolling upwards of the leaf edge; the other one forms a circular depression on the upper surface of the leaves surrounded by a low, circular wall. In case of *Scurrula parasitica* a psyllid deforms the axil buds into cylindrical or pear-shaped galls. Each gall contains a longitudinal larval chamber connecting with the outerworld through a narrow opening in the top.

There is a beetle-gall on three *Loranthaceae*. They are caused by a weevil. These galls cause globular swellings of the nodes on *Lepeostegeres gemmiflorus* and *Macrosolen cochinchinensis*. In case of *Dendrophthoë pentandra* these swellings are more. lopsidedly developed, about 6 mm across, with a roomy larval chamber.

There are 6 galls caused by *Lepidoptera*. One originates from the ovary of *Macrosolen cochinchinensis*, which, is somewhat swollen and contains a roomy larval chamber. The other galls are formed on the branches. In case of *Dendrophthoë pentandra* the gall is a spindle-shaped swelling of the branch and inflorescence, see fig. 12 c. A similar gall is found on *Scurrula atropurpurea*, and on *S. junghuhnii* the gall is a somewhat more oval swelling which is lopsidedly developed. Finally there is on *Scurrula oortiana* a sessile or pedunculate globular gall in the axils of the leaves or in those of the bracts of the inflorescences. This gall is 5 mm across, the surface is closely covered with long, brown, multicellular hairs.

From the flowers of *Scurrula oortiana* originates a wasp-gall. The ovary is swollen to a dark-brown hirsute gall. The other wasp-galls develop on the leaves or on the stalks. On *Dendrophthoë pentandra* there is a long spindle-shaped swelling of the branches. Inside there are many small spacious gall-chambers in a perpendicular row. Species of *Scurrula* have large leaf-galls. Sometimes they comprise the whole leaf so that only the leaf-edges project outside the gall. Inside is a small gall-chamber, surrounded by a thick, spongey wall. The wasp bred out of this gall belongs to the *Braconidae*. But it is not very probable that this wasp is the gall-causer, since *Braconidae* are parasites. Further investigations are desirable.

Finally the galls caused by gall-midges. *Macrosolen cochinchinensis* has globular galls on the upper surface of the leaves, spindle-shaped swellings along the midrib, and balloon-shaped galls originating in the corolla. *Scurrula lepidota* has globular bud-galls. *S. atropurpurea* bears on its leaves semi-spherical galls, the lower part of which is conical with an opening in the top. *Barathranthus axanthus* has many galls. The buds may be swollen and globular. A swelling of the branches is also caused by a gall-midge. The leaves have lenticular swellings, developed on both sides and 2 mm across. On the upper-side of the leaf are also pointed coniform galls, up to 6 mm long and at the base 1½ mm across. In the base is a very small larval chamber. The surface is green or red and glabrous.

A parasitic fungus can sometimes completely cover the leaves of some *Loranthaceae* with black streaks and dots. This fungus has a curious history. Blume (1825 : 662) thought that these black-dotted leaves occurred on one special species of *Loranthus* which he called *Loranthus maculatus*. Léveillé (1845 : 57) was the first to discover that the spots were caused by a fungus. He called it *Dothidea sordidula*. After him the fungus has been described several times, see Boedijn (1935 : 497). Boedijn called the fungus *Polystomella sordidula*. Still more confusion was caused by the fact that picnidia of a parasite on this fungus were described as belonging to *Polystomella*. According to Boedijn the spots and streaks are caused by numerous scutella; bundles of brown hyphae pass through the stomata in the leaf-tissue. The black layer consists of the above-mentioned scutella with below a subhyaline tissue. There are many locules slightly lifting and boring the black layer. At their bases they contain many asci with 8 spores.

Sometimes the leaves of an infected plant are covered with these black spots. Such a plant makes indeed a remarkable impression, see plate VII. Up till now the parasite has been found on *Macrosolen cochinchinensis*, *Dendrophthoë pentandra*, and *Barathranthus axanthus*, in the plains as well as in the lower mountain regions. Boedijn mentions it on *Amyema celebica* in the Talaud islands north of Celebes.

CHAPTER 14.

Pollination.

Although only a small part of the *Loranthaceae* have been examined as to their pollination one is justified to say that the flowers of these plants are pollinated by animals. It is practically surely the case with the representatives of the *Loranthoideae*, which in general have bigger and brighter flowers. Some doubt is justified as to the species of the *Viscoideae*. It has even been a point of long controversies whether the often examined *Viscum album* is pollinated by wind or by insects. The investigation of POHL (1932 : 378) has finally shown that the flowers of this plant are entomophilous. Very little is known about the pollination of the tropical *Viscoideae*. They have rarely been examined. The structure of the flowers of the Javanese species of *Viscum*, similar in many respects to *Viscum album*, makes entomophily most probable, although little is known about the pollinators. The colour of the flowers, their fragrance though slight, the formation of pollen clumps, and the very poor development of the stigmas imply that anemophily is not probable here. It should, however, not be concluded that anemophily does not play any part whatsoever.

Even less is known about the pollination of the far smaller flowers of the *Korthalsella* species. The flowers are unisexual; pollination must therefore take place, but it is not known in what way. Nor is anything known about the pollination of *Arceuthobium oxycedri*. As to the small size of the flowers this plant may be compared to *Korthalsella dacridii*. Apparently the flowers are not suitable for anemophily. The pollen is not smooth and dust-like, but the pollen grains, stuck together by a viscous material, fall from the anthers in clumps (HEINRICHER, 1915 : 489). There is some secretion of drips of fat, but none of nectar. Pollinators have not been observed. Yet it will now be clear that the structure of the flowers of *Viscoideae* notwithstanding their small size is not made for anemophily, nor has this ever been proved.

The representatives of the *Loranthoideae* have mostly large to very large flowers, generally bisexual. There are exceptions, for instance *Hyphear europaeum*. This plant has small unisexual flowers, which, however, secrete nectar. Although the flower by itself it not very conspicuous they yet stand out clearly against the foliage of the host, when they are grouped together in great numbers. CAMMERLOHER (1921 : 64) examined he biology of the flowers of this plant. They did not have any scent. The pollen is lumpy and the quantity of pollen per flower is small, which is in striking contrast with the enormous quantities of pollen of anemophilous plants. The number of male flowers is not much greater than of the female ones. This is too mostly quite different in case of anemophilous plants. CAMMERLOHER detected some pollinators: some species of flies, a red ant, a species of *Aphanogaster*, and two small bees, a *Halictus* and a *Colletus*. The latter was rare, the former quite common, and these bees visited one flower after another. The exposed nectar may be an indication that still other insects act as pollinators.

One of the Javanese *Loranthoideae* I examined has small flowers. This is *Barathranthus axanthus;* the flowers are unisexual and the plants dioecious. Little is known about pollination (see chapter 8). The flowers have a faint but distinct scent, the pollen is triangular, as with other species. These details point to entomophily, although insects have not been found on the flowers. As far as I was able to certify, all flowers had fructified, although I did not find any pollen on the stigmas. A further investigation is desirable.

THOMSON (1881 : 274) mentions another species with small flowers in New Zealand: *Iteostilus micranthus.* The flowers are bisexual and have a strong sweet scent. THOMSON mentions *Diptera* as probable visitors. He also discusses *Tupeia antarctica.* This species has small incospicuous flowers. The plant is dioecious. The flowers secrete much sweet scenting nectar which attracts great numbers of small *Diptera.* There will be more small-flowered species with pollination by insects. Nevertheless most species of *Loranthoideae* have large flowers often with conspicuous colours. All species examined had their pollination brought about by birds; the flowers are often avoided by insects or not even noticed, at any rate not visited.

The first man to observe birds visiting flowers in order to drink is the famous RUMPHIUS (1747 : 61). He states in his Herbarium Amboinense that a small bird, called "cacopit" or „tshui" (*Dicaeum vulneratum*) sucks nectar from the flowers. In those days nothing was as yet known about the pollination. Afterwards birds were repeatedly observed visiting the flowers, but it was a common opinion that they examined the flowers hunting for insects. Even KONINGSBERGER (1915 : 63) a perfect field biologist, who for years had the opportunity to examine flowers and birds in the tropics, writes in discussing *Leptocoma jugularis pectoralis* that the examination of numerous stomacks of these birds has shown that the name "honey-bird" was wrong. The stomacks contained small spiders or insects which is completely in accordance with the structure of the bill, the upper and lower part of which join as a fine pair of tweezers. The sun-birds undoubtedly eat insects and spiders, but they also drink nectar, which can be seen when observed composedly, for the deglutitious movements are very distinct. Moreover, the tongue of these birds is built for sucking liquids. It stands to reason that the flowers of many *Loranthus,* which are first closed cannot contain any insects prior to being opened by the birds. The visits to the flowers are only meant for the nectar. The inhabitants of Java knew that the birds drink the nectar; the Malay name is "burung madu" which is laterally honey-bird. The Sundanese name (the language spoken in Western Java), see MÜLLER and SCHLEGEL (1839—44 : 54) is "manuk manjesep". Manuk is bird and manjesep is derived from sesep which means to suck or sip. It is the opinion of MÜLLER that these birds with their long narrow tongues at the tip frayed like a brush and which can be projected far beyond the bill, can lap or suck pollen from deep down in the flowers and catch smaller insects. MÜLLER does not mention nectar. He states that these sun-birds often make for the flowers of *Loranthus* and those of *Erythrina indica.* He also mentions *Ficus,* but it is hard to understand what these birds could profit by visiting the inflorescences of these trees with their very narrow openings. MÜLLER, however, is the first to mention these birds as visitors of *Loranthus* flowers in Java.

From the middle of last century it has been known that birds can be pollinators. Articles about this subject have been published by DELPINO (1868: 1875), SCHNARFF (1913), and WERTH (1915: 314), and others. Much has been published about the characteristics of bird-flowers, but some doubt remained whether the birds visited the flowers for the insects or for the nectar. It was a well-known fact that many birds, such as humming-birds, sun-birds, and honey-suckers drink the nectar, but most writers believed the spiders and insects to be the main reason of the visits. In this case, however, it is not a question of adaptation of the flower and the bird, because insects and spiders can be found in all open flowers. When the birds make for the flowers only because of the nectar, there might be just as well bird-flowers as bee-flowers or butterfly-flowers. One might state the characteristics of bird-flowers, just as has been done for insect-flowers. A quarter of a century ago the subject of bird-flowers was still a matter of discussion. Then PORSCH published well documented and enthusiastic reports showing that there are real bird-flowers and that the numbers are definitely underestimated. It was 30 years ago that PORSCH (1924 : 553) published his first more extensive discussion of bird-flowers thus opening a new field in the study of the interrelationship of birds and flowers. Almost every year he published new articles. His „Methodik der Blütenbiologie" (1922), chapter „Die Vogelblumen" on page 464 gives valuable indications for investigations into this subject. PORSCH did also very useful work in looking up articles on flower visiting birds in Zoological literature. It was published as „Kritische Quellenstudien ueber Blumenbesuch durch Vögel" This zoological literature contains many observations of collectors, hunters, and naturalists, who observe the habits of birds with an open mind. In looking through volumes of the Australian periodical „The Emu", a publication of the Royal Australian Ornithologists Union, I found many contributions on the biology of flower-birds, particularly so about a bird which is very important to the *Loranthaceae: Dicaeum hirundinaceum*, see chapter 2.

In an extensive study MELIN (1935) has tried to demonstrate that there is no real adaptation between flowers and birds; that the food of the flower-birds consists of insects and other animals and that nectar is only a kind of luxury. Nobody will deny that these birds eat insects, but it does not mean to say that the nectar does not stand for an essential part of their food. At any rate the birds drink the nectar and pollinate the flowers. Sometimes the birds reach the nectar by boring a hole in the tube of the flower. This, however, is also known of insects.

MELIN's work contains an extensive study of the literature, but he is not always sufficiently critical. Everything which is in favour of adaptation is carefully criticized, everything against it is cited without comment.

There is no proof that the birds visit the flowers only for the insects, as is asserted by many and copied by MELIN. Therefore bird-flowers should first be proved to contain many insects. This is definitely not the case in the Old World. Inflorescences such as those of *Umbelliferae, Araliacea,* etc. which are often crowded with insects are not visited by sun-birds. In the real bird-flowers the bird comes for the nectar.

At any rate insects cannot be present in the flowers of many *Loranthaceae* because they first have to be opened by the birds when they want to get at the nectar. A clearer proof of the adaptation of flowers and birds can hardly be wanted

Porsch (1924 : 581 and 617) writes: „Die Vogelblume verdankt ihre Entstehung dem Drange des Vogels, seine Flüssigkeitsbedürfniss zu stillen. Zur Weiterentwicklung der beiderseitigen Umbildung trugen der vom Vogel durch sein Abtrinken auf die Blume ausgeübte Reiz und die gesteigerte Zuckeraufnahme wesentlich bei" and „Die Blume erscheint mithin als ein Kompromissreaktion der Pflanze auf die ständige bestimmt gerichtete Beeinflussung durch die Tierwelt"; in my opinion this is stretching the point and I do not endorse this view.

Melin's work is useful for its criticism, but on the other hand it is too negative to help us penetrating any further in the difficult subject of the interrelation between birds and flowers. Many more investigations should be carried out in the field to solve the problem of the relationship between bird-flowers and flower-birds.

I observed the habits of the birds as regards the flowers of the *Loranthoideae* at my numerous walks in the fields. Besides I possessed in my garden a roomy aviary, planted with shrubs and low plants where sun-birds, white-eyes, and mistletoe-birds could be kept alive for a long time. The birds were fed with diluted bee-honey and with milk with dissolved sugar. The proteins they could find in the shrubs where many spiders and insects lived. An insect which had entered the aviary through the meshes of the wire-netting was hunted immediately by the birds. The liquid food was offered in small, narrow tubes, about 5 cm high and 1½ cm across. It was very difficult that the *Nectariniidae* are often very intolerant towards other birds. When a tube containing the food was hung in the aviary one of the sun-birds sat down near it, chasing away every other party interested. When a second tube was hung in the aviary a second bird took possession of the source, keeping all the others at bay. We solved the problem by putting many tubes in the cage. The white-eyes and the Dicaeums were less intolerable than the sun-birds.

This intolerance of the *Nectariniidae* was also observed in the fields, not only towards congeners or other birds, but particularly so towards flower-visiting insects, most of all the bigger forms such as bees and bumble-bees. At the top of Mt. Pangrango in West Java I once noticed a *Bombus rufipes* visiting the flowers of *Rhododendron retusum*. An *Aethopyga eximea* came towards the flowers, but seeing the bumble-bee chased it away and, not content yet, hunted the *Bombus* over some distance, only then to return to the *Rhododendron* (Docters van Leeuwen, 1933 : 103). The birds are not equally hostile to the big carpenter bees, *Xylocopa*, but this may depend upon the fact that these big insects visit other flowers than sun-birds. Could the restless urge of the birds to keep all other animals at a distance explain the reason why *Loranthus* flowers are not visited by insects?

Wallace (1889 : 320) states that in Australia and in New-Zealand the flowers of *Loranthus* are cross-fertilized by birds. Hart (1885: 443) writes that in Palestine the flowers of *Tapinostemma acaciae* are visited by *Nectarinia osea*. "This species of *Loranthus* may be dependent on the visits of the sun-birds for the fertilization of its flowers. Specimens of this bird were obtained with their bills covered with the pollen of the tubular flowers which the bill is well fitted to probe".

As far as I know EVANS (1895: 235) was the first to describe the structure and fertilization of the flowers of African *Loranthaceae*. With *Tapinanthus kraussianus* the flowers when in bud have the lobes strongly pressed together. There are five slits, about half-way up the upright tube of the corolla, and these slits are about one quarter the length of the tube. The anthers are pressed together in the unopened top of the corolla. When the bill of a bird enters one of the slits it causes the top of the corolla to split with some force, and the anthers fly downwards violently, scattering practically all the pollen they contain by the movement, and at the same time the style, from being upright, springs to an angle of 40 degrees on one side clear of the now split corolla. By this movement the stigma is not fertilized by its own pollen. The flowers are frequently visited by *Nectarinia olivacea*, which gets head and bill covered with pollen. EVANS writes that he never saw a flower splitting open spontaneously. When he envelopped a branch with a net-bag, the flowers remained closed, although the slits were there. The flowers seem to be quite sterile without outside help. At first EVANS did not find any bees in the flowers, but afterwards he saw them in good numbers; they seemed simply to follow the birds. The above-mentioned *Nectarinia* is the real pollinator. Another sun-bird *Nectarinia verreauxi* also visited the flowers of this plant.

The flowers of *Erianthemum dregei* also have slits in the corolla. With this species, however, instead of the anthers remaining still attached to filaments, when the flower jerks open, they are all broken sharp off, and fly off into space with great violence, parting with their pollen as they go. In this manner too the pollen gets lodged on the head and bill of the visitor. Not a single insect visits the flowers of this species. The host-plant of the *Loranthus*, a species of *Acacia*, had its flowers constantly visited by bees, but these skipped the flowers of the parasite. In this species too the pollination is brought about by the above-mentioned sun-birds.

VOLKENS (1899: 251) examined the flowers of several species of *Loranthus* on Mt. Kilimandjara. The flowers of *Tapinanthus ehlersii* are purple, the buds have the shape of long-necked bottles. On maturing the bud gets 4 slits in the upper half of the corolla, that is the lower part of the lobes while the upper parts remain connate. I never observed a similar opening as described by EVANS and VOLKENS in any of the species in Java. In a letter of July 2nd, 1938 B. H. DANSER wrote to me that several species of *Lepeostegeres* in Borneo had the same slits, and some species of *Dactyliophora* in New Guinea opened in the same way. It is shown in figure 14f for *Dactyliophora nova-guineae*, see DANSER (1931: 359).

VOLKENS explains this opening with slits as a consequence of the fact that the lobes are more strongly connate at the top than at the base. The flower opens fully under mechanical influence, that is by the introduction of the bill of a bird. When a bill enters the slit the tops of the corolla jerk open with violence. During this process the filaments coil suddenly and are flung away. The pollen gets lodged on the head of the visiting bird. VOLKENS calls this way of opening the "explosion type" He saw *Nectariniidae* visiting the flowers.

The flowers of *Tapinanthus laciniatus* also first have slits, while the tops of the lobes are released by the bird inserting the bill in the slits. But with these flowers the stamens do not jerk apart, there is only one slit in the corolla and the tops of the lobes remain connate opposite the slit. According to VOLKENS the anthers now brush the breast of the bird and this type he calls the "Einsalbetypus". The flower bud of *Plicosepalus sagittofolius* is bent and the base swollen. These flowers have no slits, the lobes release and turn back and downwards. The stamen and the stigma remain unaltered, the former turning the pollencovered side downwards, so that the flowers remind of those of *Labiatae*. VOLKENS saw both species visited by sun-birds.

JOHOW (1900: 242) described the flowers and the pollination of species of *Phrygilanthus* in Chile. *P. tetrandus* and *P. aphyllus* have flowers which during anthesis have the same slits in the corolla as described above. JOHOW does not mention the bill of the bird as a mechanical impetus, but states that the lobes finally open and bend outwards. The anthers and the stigma project free from the opening of the corolla. The pollen is spread by the mobility of the anthers. JOHOW observed some species of humming-birds pollinating the flowers. He in his turn is not quite sure about the fact whether the birds visit the flowers for the nectar or for the insects. It stands to reason that the closed bud cannot contain any insects.

Several articles have been published about Asiatic *Loranthaceae*. HART (1885: 443) writes that traveling through Palestine he saw many specimens of *Tapinostemma acaciae*. He does not mention the structure of the flower, but says that this species may be dependent on the visits of the sun-birds for the fertilization of its flowers.

KEEBLE (1895—1901: 91) gives more particulars about Indian *Loranthaceae*. He mentions the slits in the corolla, such as described above for the African species, for two species: *Dendrophthoë falcata* and *D. neelgherrensis*. He also gives pictures of such flowers in fig. 1c and 11 on plate X. He mentions that the sun-birds insert their bills in the slits thus releasing the top of the corolla. It is remarkable that he saw these slits in the flowers of 2 species of *Dendropthoë*. *D. pentandra*, which I examined in Java has definitely not got the slits, nor does ALI mention them (see below). KEEBLE states that the flowers of *Elytranthe parasitica* are punctured at their bases by birds.

It is KEEBLE's opinion that the fact that the buds remain closed prior to the visit of the birds has the highly important function of protecting the pollen from the rain; besides that the slits in the corolla are meant to allow small insects access to the nectar. This seems very queer for what would the flowers profit by pollen-eating and nectar-drinking insects which do not bring about pollination? If insects could really penetrate into the flowers through the slits one could at best state that the slits do not always work profitable. The birds visit the flowers very early, for, says KEEBLE, even in the tropics it is at that hour relatively cool. All this needs extensive investigation.

FRIES (1903—04: 429) gives an outline of ornithology in South America, and describes the pollination of some *Loranthoideae*. In Northern Argentine he examined *Phrygilanthus cuneifolius*. The 6-merous corolla is red, the flower-bud is cylindrical with a thicker top. This species has no slits as described by JOHOW, but the lobes open immediately. FRIES states that the flowers are scentless and contain much nectar. He saw humming-birds regurlarly visiting the flowers, but he does not state whether they first had to open the flower or not. Is is remarkable that he also mentions a big, black bumble-bee visiting the flowers.

WERTH (1900: 244 and 1915: 334) gives a detailed description of the build of the flowers of *Erianthemum dregei*, the same plant as described by EVANS, see above. WERTH too describes how the flower suddenly jerks open, the stamens being flung out over a considerable distance. He looks upon the triangular shape of the pollen grains as a special adaptation to this function. It can, however, hardly be called an adaptation since the pollen grains of all examined *Loranthoideae* are triangular. The flowers of *Oncella poecilobotrys*, which in Sansibar are visited by sun-birds, are according to WERTH opened in the same way as described for *Erianthemum dregei*.

PORSCH collected many details from the ample zoological literature, which otherwise would have been kept hidden for botanists. These data have been published in five articles: "Kritische Quellenstudien ueber Blumenbesuch durch Vögel", I-V. In part III (PORSCH, 1929: 511 and 535) we read that MAC-GILLAVRY saw nectar-feeding birds on the Barrier Range in Australia also visiting the flowers of *Loranthus* and that HOWE observed *Phylidonyris pyrrhoptera* feeding its young with nectar of *Loranthus* flowers. More important to our study is what PORSCH (1929: 168 ff) writes in volume IV about the Australian *Dicaeum hirundinaceum* and about the structure of the flowers of some Australian *Loranthoideae*. As interesting particulars PORSCH mentions the bent of the corolla, explosing flower-buds, capillary systems in the tube of the corolla, build of the stamens, coloration, shape of the pollen grains, and the mechanical tissues in the flowers. With *Amyema pendula* he found a vigorous development of the collenchyma below thick-walled epidermis-cells. *Amyema linophylla* has a uniseriate or biseriate layer of stone-cells in the wall of the corolla. Under the top of the perianth-lobes these stone-cells take about half of the section. With *Amyema sanguinea* these stone-cells are even more strongly developed, forming a close cylindre in the corolla *Amyema quandang* also has stone-cells but not so well developed. The same holds good for *Phrygilanthus celastroides*. See the coloured plates VIII and IX.

Stone-cells do not strengthen the flowers of the species examined in Java. The rigidity of the tissues depends on turgidity. Other plants of the moist territories of the tropics also have this turgescence of the tissues. Even the elastic stamens, but which feel like stiff copper-wire, of *Erythrina indica* (DOCTERS VAN LEEUWEN, 1931 : 5), get this firmness only through turgidity. There might be a relation between the drier climate of Australia and the presence of these mechanical tissues. It might be worthwhile to examine *Amyema* species growing in the moist part of New Guinea for this detail.

The above mentioned articles only give sun-birds as visitors. In 1928 CAMMERLOHER (1928: 46), who was carrying out observations in the surroundings of Buitenzorg found also other pollinators. He describes the structure and the anthesis of the flowers of *Dendrophthoë pentandra* and mentions as pollinators: *Zosterops palpebrosa buxtoni*, *Nectarinia* *jugularis pectoralis, Dicaeum concolor sollicitans* and *D. t. trochileum* and the leaf-bird *Chloropsis cochinchinensis nigricollis.* The last bird was not seen visiting the flowers but a shot specimen had *Loranthus* pollen round the base of the bill. The Dicaeums probe with their bills sideways into the top of the flower-bud, the corolla jerks open, the liquid nectar which completely fills it shooting out. This is definitely not correct; it is not the nectar but the pollen shooting out and the corolla is only half filled with the nectar. This article also contains the first description of the build of the digestive organs of the *Dicaeums.* CAMMERLOHER writes that these species of *Dicaeum* are not only the seed dispersers but are among the most important pollinators of these plants.

BLAKELY (1922: 23) mentions some visitors of *Loranthus* flowers in Australia. All these birds look for nectar and many flowers are found with small punctures at the base and sometimes the swollen part near the attachment of the filaments. BLAKELY observed that *Acanthorynchus tenuirostris, Gliciphila melanops,* and *Pardalotus punctatus xanthopygius* bored a hole in the base of the flowers with their sharp bill. Other nectar-drinking birds are: *Myzomela sanguinolenta, Meliphaga virescens,* and *Meliornis novaehollandiae.* He mentions that SARGENT saw *Zosterops australasiae* drinking from the flowers of *Amyema linophila.*

ALI (1931: 144) gives a more extensive description of the birds. He discusses *Dendrophthoë falcata.* While with this plant KEEBLE describes that there are slits in the corolla and later the top of the bud jerks open, giving pictures of these slits, ALI does not mention them, nor does he show them in his drawings. The lower narrow part of the corolla tube contains some drops of colourless, watery and sweet nectar. The anthers and the style projects from the corolla, so that when a bird probes its bill into the opening, the pollen gets attached to the feathers round the base of the bill. The stigma is somewhat elevated above the anthers and gets pollinated by a bird which has previously visited another flower. The flowers remain closed when not opened by a bird and belong to the so-called explosive flowers of VOLKENS.

The birds visit one flower after an other. ALI saw one sun-bird visiting 8 to 10 flowers within one minute and the birds are about and busy all day long, so that it is easy to understand their importance to the pollination of the *Loranthaceae.* In this case it is sure that the birds are looking for nectar, for the closed flowers do not contain any insects.

The birds visiting the flowers in Western India are: *Nectarinia lotenia, N. asiatica,* and *N. zeylonica,* and apart from them there is *Dicaeum erythrorynchos* mainly eating the ripe fruits. ALI saw shot specimens of these birds with pollen sticking to their foreheads. The stomacks contained much nectar which dripped from their bills. ALI kept the visitors away from the flowers by covering the latter with a 12 × 12 mesh-wire. All the flowers dropped without fructifying, which leads him to believe that the agency of flower-birds is indispensable for fertilization. All flowers of *Dendrophthoë pentandra* in Buitenzorg also fell off without fructifying after being envelopped in mesh-wire; it is my opinion, however, that this is due to the greater amount of moisture in this space which the flowers are not proof against.

ALI (1932 : 598) mentions other *Loranthoideae* he examined in his next article. They are: *Tolypanthus lagenifer, Elytranthe parasitica, Scurrula* *parasitica, S. obovata,* and *S. rhopalocarpa.* All these species have the same particulars as regards the pollination as described in his previous article for *Dendrophthoë falcata.* The buds have to be opened by birds and as regards their pollination they are therefore dependent upon these animals. As I observed *Scurrula* and found that the corolla opens spontaneously, that is without the help of the birds, ALI's statement about the Indian *Scurrulas* seems highly improbable to me. ALI mentions still other sun-birds as visitors: *Nectarinia asiatica, N. minima,* and *Aethopyga vigorsi,* the latter in wooded country. Also two birds other than sunbirds: *Zosterops palpebrosa* and *Pycnonotus cafer.*

The above summary of the literature shows that the flowers of some *Loranthoideae* must be classed with the bird-flowers and that several species of birds have been proved to be pollinators. What then are the characteristics of flowers which belong to the flower-biological class of bird-flowers ? On the whole one is too much inclined to take as the main characteristic the coloration. One holds the red and orange colour to be the most striking feature. But one characteristic should not be overestimated. Many insect-flowers also have a beautiful red or orange colour. The colour is indeed a means of luring the birds to the flowers, and red is supposed to be the best colour for alluring birds, because edible fruits are very often red too. Many fruits eaten by birds are indeed red, as can easily be observed in autumn, but is it the colour alone which allures the birds ? In my garden there are three big shrubs of *Symplocos paniculata* the berries of which are dark blue and these berries are greedily eaten by the thrushes. The red berries of *Cotoneaster salicifolia* var. *floccosa* on the other hand remain on the shrubs all through the winter. The red berries of *Viburnum opulus,* which have a scent of valerian are despised by the birds and only eaten when nothing else is left. I do not know whether there are birds who pick out these berries, but in my garden it is not the case. The blue berries of *Symplocos* are preferred to many red ones. In the tropics there are many red fruits too, but by their side also white, blue, or black ones which are all readily eaten by the birds.

Loranthaceae have many species with red or orange berries, but there are others with white, yellowish, or black ones. There are even species with red berries where the unripe yellow or greenish specimens when soft are picked out. It is the taste which allures the birds more than the colour.

PORSCH (1924 : 636) writes that apart from their colour bird-flowers have the following characteristics. 1. The presence in the flower of a large quantity of very liquid, more or less slimy nectar; 2. The absence of scent. There may be a very weak scent occasionally, but this is of no importance to the birds as they are no scent-animals. Humming-birds do not even possess the first pair of cerebral nerves connected with the scent-organ; 3. The absence in the flowers of a proper perch which are so common in insect-flowers. The birds, particularly so the humming-birds, hover in front of the flower while the other birds sit down between the flowers on a neighbouring twig; 4. The flowers are strengthened in those places where the bird inserts its bill. This strengthening is mostly formed by papillae and thickening of the walls of the epidermis-cells; 5. The capillary system in the flowers of conducting or holding the nectar.

The size of the flower is not so important; bird-flowers range from small to very large.

What about these characteristics with the flowers of *Loranthoideae* ? There are many species with very big, brightly coloured flowers, but the colours of most of the flowers I examined were less conspicuous, with the exception of *Macrosolen formosus* and *Lepeostegeres gemmiflorus;* the former has orange, the latter red flowers. *Elytranthe albida* has big, but white flowers; *Macrosolen cochinchinensis* small, light green to yellow flowers, only the top of which is orange. The flowers of *Dendrophthoë pentandra* and of species of *Scurrula* are also relatively small.

In the Sandwich Islands grow a great number of *Lobeliaceae* which are pollinated by birds: *Drepanididae*. PORSCH (1924 : 629) mentions as their colours. white, light and dark purple, blue, lilac, green, yellow, and scarlet, almost all the colours of the rainbow; and the remarkable thing about it is that 31.6% of the flowers are white and only 2.2% red ! That fact sets one thinking. PORSCH, however, states that bird-flowers often have spectral colours and that they are mostly found in certain combinations called parrot-colours; these colours also occur in the feathers of flower-birds in very effective contrasts. In my aviary the birds were not in the least interested in the colour of the tubes containing their food. They found the sweet liquid immediately, apart from the fact whether they were given them in white, brown, or green tubes. Birds have a very strong sight and can find food in the flowers even when the latter are inconspicuous and small.

An important characteristic of bird-flowers is the presence of an ample quantity of very liquid, sometimes somewhat slimy nectar. There are birds which take the pollen, such as representatives of the *Trichoglossidae; Loranthus,* however, only offers nectar. The corolla tube of most flowers is filled for one third or even one half with the nectar. This nectar mostly remains in the basal part of the corolla tube, but sometimes it is conducted to the edge of the flower where it stands exposed as a glistening drop. This happens in case of *Helixanthera cylindrica*.

Important too is the absence of scent. Birds have a strong sight, but their smell is often poorly developed, for instance with the humming-birds. It is not that a flower-bird would skip a scenting flower, they do not notice the scent, which has no importance for them. One is justified to assume that scenting flowers from which birds drink the nectar, are actually insect-flowers or are descended from them. The flowers of all the *Loranthoideae* I examined with the exception of *Barathranthus axanthus* have scentless flowers. The other strongly smelling flowers described by others are visited by insects, see THOMSON, mentioned above.

Another characteristic of bird-flowers is the absence of a landing-place which on the other hand is particularly well-developed in case of insect-flowers. With humming-birds flowers where the birds suck the nectar while hovering in front of the flower the absence of a landing place is easily understood; the landing-places, however, are also absent in flowers visited by other birds which not or rarely feed while on the wing. There are exceptions. The flowers of *Erythrina indica* (DOCTERS VAN LEEUWEN, 1931a : 1), have standards arranged like a fan serving as landing-place. It is remarkable that the flowers of the insect-pollinated species of *Salvia* have a well-developed lower lip while the species visited by birds for instance *Salvia splendens* have no or a reduced lower lip. Another *Labiata*: *Leonotis nepetifolia* has the lower lip withered and these flowers are visited by sun-birds in their original habitat Africa as well as in Java (Docters van Leeuwen, 1925 : 66). The bird sits down on the stalk in the neighbourhood of the flowers, and takes the most remarkable attitudes in order to reach the entrance of the flowers. The flower-birds give the same kind of acrobatic performance as our titmouse. All *Loranthoideae* examined by me lacked landing-places for birds.

Insects on the whole are frailer than birds and it stands to reason that the flowers visited by birds must be stronger and more resistant than those visited by insects. Those places are particularly strengthened which are touched by the bird's bill. With the *Loranthoideae* I examined these places are the edge of the corolla and the wall of the filaments. Here the epidermis-cells have developed to papillae with a thick cuticula. Even bigger birds can drink from the flowers; I saw a crow and even a squirrel drinking nectar from the flowers of *Erythrina indica* without damaging them.

Finally the capillary systems. Porsch (1924 : 646) has given extensive descriptions of them with various bird-flowers. They either consist of papillose excrescences of the epidermis or of fine grooves in the cuticula of the cells which pass uninterrupted over the interjacent walls, thus forming long open canals. With the *Loranthoideae* I examined these canals in the cuticula are very common, particularly so in the corollar tube, and especially on the ridges formed by the lower half of the filaments in the corollar tube. The very liquid nectar which is secreted in the base of the corolla must not only be conducted but also retained, because the opening of the flowers does not always point upwards; they may point in just every direction, even downwards. Porsch (1924 : 656) describes the flowers of a *Verbenacea*: *Holmskjoldia sanguinea* with which the nectar is conducted towards the mouth of the corolla and is there retained. A similar thing happens in the flowers of *Helixanthera cylindrica*. The nectar is formed in the base of the corollar tube, conducted upwards where it remains as a glistening drop in the opening, whatever the attitude of the flower. The edge of the corolla opening is very papillose here and this holds the nectar. The adaxial wall of the corollar tube is provided with a great number of canals in the cuticula of the epidermis, which conducts the nectar.

The above shows that the flowers of most *Loranthoideae* are real bird-flowers and that the birds are the real pollinators.

In chapter 5, discussing *Macrosolen formosus*, I mentioned that the birds in my aviary did not know what to do with the flowers of this mountain-plant. In the locality where the plants are found, however, only few flowers were opened; most of them had small openings in the base pierced by a bird's bill, a short cut to the nectar. The birds in Buitenzorg, used to smaller flowers, neglected these flowers after a short visit. It is a well-known fact that flowers of the plants introduced from the New World are regularly visited for the nectar by the birds of the Old World. Whether the birds have immediately recognized the new source of nectar or first had to get used to the strange flowers I cannot say. The flowers are mostly adapted to pollination by humming-birds which hover before the flowers while drinking. Van der Pijl (1939 : 17) explains that the flowers must offer difficulties to birds originated elsewhere. There often is a disharmony between the flowers from America and the Asiatic flower-birds The Asiatic birds rarely hover before the flowers and try to get at the nectar in a different way. This is one of the reasons why these flowers are often punctured at their bases; the birds bore a hole in the corolla-tube and are no good pollinators. VAN DER PIJL (1934 : 179) gives numerous examples. He explains that there is a better harmony between indigenous plants and the birds of the neighbourhood. It would be worthwhile to examine the pollination of plants introduced from the Old World into the New World.

The following pollinators of *Loranthoideae* have been observed in Java. 1. *Dicaeum t. trochileum*, 2. *Dicaeum s. sanguinolentum*, 3. *Dicaeum concolor sollicitans*, 4. *Zosterops palpebrosa buxtoni*, 5. *Apoia* (*Zosterops*) *javanica frontalis* (DOCTERS VAN LEEUWEN, 1933 : 113), 6. *Anthreptes m. malacensis*, 7. *Nectarinia jugularis pectoralis*, 8. *Aethopyga eximea*, 9. *Aethopyga m. mysticalis* (SPENNEMANN, 1932 : 37), 10 *Arachnothera longirostris prillwitzi*, 11. *Chloropsis cochinchinensis nigricollis*, and 12. *Pycnonotus cafer aurigaster*.

CHAPTER 15.

Germination.

With most Phanerogams it is easy to discern which is the fruit and which the seed. In the flower is an ovary and inside a placenta with the ovules. The ovary develops into the fruit, the ovules into the seeds. With the *Loranthaceae* it is not quite so simple. The gynaecium is strongly reduced. This drew attention of many investigators. One of the first to study the embryology of *Loranthus* and *Viscum* was GRIFFITH (1838 : 71 and 1844 : 171). HOFMEISTER (1858 : 188) too examined *Viscum*. At Buitenzorg it was TREUB (1881 : 54 and 1883 : 1 and 184) who investigated the embryology of several tropical *Loranthaceae*. During the last years many articles have been published on the subject by RUTISHAUSER (1935 : 389 and 1937 : 5), STEINDL (1935 : 343), RAUCH (1936 : 5) and SCHAEPPI and STEINDL (1942 : 301). All these investigators used the ample material collected by A. ERNST (1942 : 269) and Mrs. M. ERNST-SCHWARZENBACH during their excursions to Ceylon, Indonesia, and Hongkong from July 1930 to April 1931. The latest publication on the subject I know is by SINGH (1952 : 449), who studied the embryology of *Dendrophthoë falcata*.

Below follows a short summary the knowledge of which is essential to understanding the germination. In the young flower-bud the connate carpels enclose a single cavity, which afterwards is almost filled up by the growth of cells on the adaxial side of the carpels. The embryosacs of representatives of *Lepeostegeres, Macrosolen, Elythranthe,* and *Amyema* arise in an elevation on the base of the cavity in the ovary. All parts are even more reduced with the species of the genera : *Helixanthera, Baratranthus, Dendrophthoë, Scurrula,* and *Taxillus* and also with those belonging to the *Viscoideae*. The embryosacs arise in the tissue forming the base of the carpellary cavity, even though *Viscum* still has a small central elevation. SCHAEPPI and STEINDL look upon this elevation with the first three genera as a placenta. *Lepeostegeres, Macrosolen,* and *Elytranthe* still have very reduced ovules, but *Amyema* has not. All other *Loranthoideae* and *Viscoideae* have no ovules, not even rudimentary ones. In this respect the first three genera can be looked upon as primitive. This also finds expression in the structure of the seed and the germination.

The base of the ovary of all species has a mostly patelliform layer of collenchyma. The tops of the embryosacs grow upwards into the style tube ; with *Helixanthera* the embryosacs have developed furthest, because here its top lies immediately under the epidermis of the stigma. There are always several collateral embryosacs, although the ripe seed, rarely contains more than one embryo. With *Viscum album* it is a common phenomenon that the seed has more than one embryo.

When the egg-cell is fertilized it forms the embryo which remains connected with the top of the embryosac by means of a suspensor. This suspensor develops rapidly and pushes the embryo downwards. When more egg-cells are fertilized more embryos penetrate at the end of suspensors through the style At the same time the formation of the endosperm begins after the fertilization of the secondary nucleus. In the beginning the various endosperms are disconnected, but finally the walls of the embryosacs disappear, the endosperm becoming one mass, while of the embryos also only one is left. I am following now the description given by SINGH (1952: 463) of the development of *Dendrophthoë falcata*. The endosperm first grows upwards and then forms an annular bulge around the collenchyma. Later one side of the bulge begins to grow down faster pushing the collenchymatous pad laterally. As described above the embryos grow rapidly downwards owing to the strong development of the suspensors, at first through the style canal, afterwards through the wall of the style. Finally the embryos get into the endosperm; one embryo mostly grows as far as the collenchymatous pad and this is the embryo which remains alive. The others degenerate and are absorbed in the tissue of the endosperm.

That one embryo now takes up a more central position, being lifted by the suspensor and is now club-shaped with 2 cotyledons Afterwards these cotyledons grow together to form one conical organ, only the bases surrounding the plumule remain free. The embryo is green and the base of the hypocotyl projects slightly beyond the endosperm.

With the species of the genera together forming the *Elytranthinae*, the 2 cotyledons remain free. With the other genera of the *Loranthoideae* and with the *Viscoideae* the 2 cotyledons are connate. I will come back to this detail when discussing the germination. Also to the fact that *Korthalsellas* have no coltyledons.

With a normal seed the seed-wall arises from the tissues of the ovule outside the embryosac and from the coats of the ovule. All this is absent with the *Loranthaceae* and the seed therefore has no real seed-coat. The endosperm is surrounded by the wall of the fruit. This wall does not only consist of the wall of the ovary but also of that of the receptacle with which the ovary is consolidated. Therefore one might call the fruit of the *Loranthaceae* a spurious berry. For convenience it is called a one-seeded berry.

The fruit-wall consists of 4 layers. Starting from the inside the first is a thin vascular zone enclosing the endosperm, the coat which remains round the seed, just as the second wall consisting of oblong cells which are diagonally oriented; thirdly a layer of very elongated cells. These contain a white, yellow, or green sticky substance of pectine mucilage. This layer serves to make the seeds stick. Finally the outer layer of cells, consisting of a tissue of amall parenchymatous cells with stone-cells. All this is surrounded by two layers of thin-walled hypodermis and the uniseriate epidermis, the last layers forming together the though skin of the berry. The small-celled parenchyma of the 4th layer contains the food for which the birds eat the berries.

Dr D. R. KOOLHAAS, at the time at Buitenzorg, who carried out the investigations for me, examined the chemical contstituents of the 4th layer. From his report I take the following particulars.

116 collected fruits of *Dendrophthoë pentandra* weighed together 36,3 g. The seeds and the mucous layer were taken away and the rest weighed 26.7 g. Before inversion the sugarcontent amounted to 2275 mg and after

inversion 2320 mg invertsugar (SCHOORL, 1929 :566). Before inversion the sugarcontent per berry amounted to 19.61 mg and after inversion to 20 mg invertsugar. The sugercontent per gram of fruit without the seeds before the inversion amounted to 85.21 mg and after inversion to 86.89 mg invertsugar.

From the small difference of the invertsugar before and after inversion it is clear that glycosides and/or decomposable sugars are practically not there and that the fruits only contain glucose and that about 20 mg per berry. As the birds eat a great number of fruits a day (see chapter 2) they get a large quantity of easily digestible sugar.

With the representatives of the genera *Dendrophthoë, Scurrula. Barathranthus.* and *Helixanthera* the whole surface of the seed is covered with the viscid layer. With the species of other genera the viscous layer is best developed on the side of the seed which is opposite the place where the base of the hypocotyl projects from the endosperm. These species mostly have rounded seeds which stick on one side only. The other species have elongated seeds which are sticky all over. The *Viscum* seeds are round but more or less flattened and they stick with the flattened side to the substratum.

In the tropics of Asia and Australia the seeds are dispersed by birds belonging to the family of the *Dicaeidae*. Many other birds eat the fruits but like in Europa it is not known whether and if so how these birds help in the distribution of the seeds. The viscous layer is not digested, but may give difficulties when the seeds are voided.

TOMANN (1926 : 365) examined the composition of this visced layer. With *Viscum album* this layer consists of two kinds of mucus, an outer cellulose mucous layer with inside a pectose mucous layer. *Hyphear europeum* only has a pectose mucous layer. TOMANN writes that the outer layer of *Viscum album* consisting of cellulose mucus is digested by the birds; the pectose layer is indigestible and therefore it remains a sticky layer after the seed has passed the intestinal tract. Others too have discussed this subject, see WANGERIN and BUXBAUM (1937 : 1187).

The germination of the European *Loranthaceae* have been discussed repeatedly: an extensive summary of the results can be found in WANGERIN and BUXBAUM (1937: 1045, 1155, and 1197). It is important that in *Viscum* the cotyledons remain in the endosperm during germination and therefore only serve to conduct the food from the endosperm to the seedling. The first leaves of the young plant develop from the plumule. I found the germination of tropical *Loranthaceae* first mentioned by GRIFFITH (1836 : 78). He records the germination of a *Loranthus* seed, without giving the name. on the leaf of a guttiferous tree and also germinating seeds on the succulent fronds of a *Polypodium*. With *Scurrula parasitica*, 2 days after the seeds gets lodged, the top of the radicle (the hypocotyl is meant) bends towards the support; this extremity when it reaches this point becoming enlarged and flattened. GRIFFITH states that the cotyledons, also those of other species remain in the seed.

KORTHALS' (1839 : 206) discussion is more important. With several species: *Dendrophthoë pentandra, Scurrula atropurpurea,* and *S. ferruginea,* and *Viscum articulatum* he found that the seed during germination remains stuck to the support and that cotyledons remain enclosed in the endosperm. Only once with *Dendrophthoë* he saw one cotyledon projecting from the seed. This does not seem very probable as the two cotyledons are connate forming one conical organ. If KORTHALS' observation is true it should be looked upon as a case of atavism. For KORTHALS writes that during germination of *Lepeostegeres gemmiflorus* not only the seed is lifted from the support through development of the hypocotyl, but also that the cotyledons develop into the first leaves of the young plant. This is shown in the figures of plate II. Thus KORTHALS is the first to mention that there are two types of *Loranthaceae*, which differ in the way of forming the first leaves.

Karsten (1852 : 321) describes a South American species of *Loranthus*, which he calls *Passowia odorata* and states that the radicle (the hypocotyl is meant) projects from the seed and the cotyledons are released during germination.

Goebel (1889 : 196) discusses the germination of a species of *Loranthus*, without mentioning the name, but figure 64A of the seedling shows it to be a representative of the *Elytranthinae*. The hypocotyl is long and by its growth the seed is lifted from the support. Nothing is said about the cotyledons.

Reiche (1904 : 286) discusses the germination of the Chilian *Phrygilanthus aphyllus* infesting *Cactaceae* and states that the hypocotyl grows from 6 to 8 mm, twining round the spines of the *Cactus*. The end of the hypocotyl adheres to the substratum by means of a whorl of hairs. The cotyledons remain in the seed. The long hypocotyl reminds of the Asiatic *Elytranthinae*, but the cotyledons remaining in the seed do not. In a later article Reiche (1907 : 393) states that with other species of *Phrygilanthus* the germination takes place in the same way and that during germination the seed either remains sticking to the substratum or is lifted on top of the erect hypocotyl. There will be more articles on the germination of American *Loranthaceae*, but I have confined myself especially to the literature about the Asiatic species.

Keeble (1895—1901 : 91) published an extensive article on the biology of the *Loranthaceae* in Ceylon. He describes many species, but mentions them without playing attention to the way of the germination. Of the *Elytranhinae* Keeble at first discusses *Elytranthe parasitica*. The cotyledons are not fused and the hypocotyl at first is erect, but soon bends towards the substratum. As soon as the base touches the substratum, the disc enlarges and forms papillae, by means of which it adheres to the bark. Now the hypocotyl stretches, lifts the seed from the substratum, finally the two cotyledons drop; occasionally they remain attached enclosing the plumule. The first pair of real leaves remain reduced and is soon dropped; the following leaves develop but at first remain small. *Elytranthe capitellata* has a similar development.

Of the *Hypheatinae* Keeble discusses *Dendrophthoë neelgherrensis*. With this species the cotyledons remain in the seed and the base of the hypocotyl grows immediately towards the substratum without bending. The plumule develops first to small leaves; not before a month has gone by the growth is more rapid. With *Dendrophthoë falcata* the short hypocotyl becomes rapidly and sharply bent; the cotyledons again remain in the endosperm. The hypocotyl does not grow out in *Helixantehera hookeriana*. It swells and shows no sign of curvature. The germination is the same with *Tolypanthes gardneri*; with both species the viscin is mainly developed on the hypocotyl side of the seed. On plate 10, fig. 8 Keeble gives a picture of an embryo of the last species on the leaf of a wild durian with a thin runner. Finally *Viscum orientale*: the hypocotyl is 3 to 4 mm long and the viscin is limited in the base of the seed. Therefore the seed is prone to the substratum and the hypocotyl needs not develop far.

Brittlebank (1908 : 650), discussing the Australian *Lysiana exocarpi*, an *Elytranthina*, writes that the germination of the seed begins after one or two days, sometimes even after 50. He does not say whether this is dependent upon the drought of the climate. The hypocotyl bends towards the substratum, to which the base adheres with hairs. The cotyledons become free.

In 1915 I gave a short summary of the germination of some Javanese *Loranthaceae*. Many species could then not yet be classified with certainty. I will combine the details found at various times. After Danser's work classification was easy. At the time, however, I could show for *Macrosolen cochinchinensis* that the cotyledons formed the first leaves of the young plant.

Blakely (1922 : 8) discusses the germination of some Australian *Loranthaceae*. They were mainly species of *Amyema*; the cotyledons remain in the endosperm. Only *Amyema biangulatus* has cotyledons coming forth from the seed.

In 1922 I discussed the germination of *Lepeostegeres*. I will combine this at the end of the chapter with the other data I found.

Stevenson (1934 : 183) writes about the germination of some species of *Korthalsella* in New Zealand. As soon as the seed is lodged on the substratum the hypocotyl develops and adheres to the support. Miss Stevenson writes that the growing point develops under the cotyledonary collar, which remains in the endosperm. It is her opinion that the club-shaped base of the hypocotyl (she calls it haustorium) enlarges by digesting the tissue immediately in front of it. This seems very queer.

Ernst (1942 : 78) describes the germination of *Lepeostegeres gemmiflorus*, a picture of which is found in fig. 3a. He describes the rapid growth of the hypocotyl which reaches the substratum after two days. He made seeds germinate on filter-paper and had good results. The seedling pictured in fig. 3b is definitely not a *Dendrophthoë*, but probably a *Macrosolen cochinchinensis*.

Below I give a summary of the germination of some Javanese *Loranthaceae*, beginning with the species which are most primitive.

1. *Lepeostegeres gemmiflorus*. The fruits are globose, 8 mm in diameter. The seeds are almost globular or very short barrel-shaped, about 5 mm across. The seeds on the outside are provided with fine grooves, from pole to pole, terminating in an excrescence consisting of 5 closely united soft protuberances and covering the base of the hypocotyl. Similar protuberances occur in most, may be in the seeds of all species. Therefore it is not necessary always to mention them separately. The embryo consists of a filiform hypocotyl, swollen at the free base, and two long, narrow cotyledons surrounded by the endosperm. The viscin is best developed opposite the place where the hypocotyl comes out, and the seeds adhere on that side, more or less obliquely errect on the support. The viscin is drawn out forming a long, hyaline thread and is not so sticky as with other species. Nor does it dry so quickly. When there is a shower of rain shortly after the seed has get lodged it can easily be washed away or shifted to the lower surface of the branch. This will be the reason why often plants are found growing on the lower surface of a branch. When the seeds are completely washed off, they may remain pendant on a long viscin thread, where they germinate, but where they cannot get fixed. If it rains some time after the seed got lodged the viscin has dried sufficiently to hold the seed, which at best can slightly slide down.

In moist weather the germination is rapid, in dry weather it is somewhat slower. Two days after adhering the somewhat swollen base of the hypocotyl comes forth from the surrounding weak projections and begins to curve. Next day the hypocotyl has grown, is more bent and grows along the surface of the seed towards the substratum On the fourth day the hypocotyl has reached the substratum and the bud-shaped base swells more so as to form a conical adhesive disc. The seed gets clearly thinner, the hypocotyl begins to straighten and the cotyledons are drawn forth from the adhering, withering seed. Mostly the cotyledons appear one after another. The hypocotyl is now erect with the two cotyledons as the first leaves spread at its top. Sixteen days after adhering the young plant stands by the side of the withered seed and a month later the first cauline leaves develop while the stalk stretches. After the course of 7 or 8 months the plant measures 30 cm and has robust leaves; the first leaves, arisen from the cotyledons are still present, although small and more or less withered. With this species the seed remains sticking to the substratum during the germination. The seed gets but rarely lifted from the substratum. This, however, is the rule with the following species.

2. *Macrosolen cochinchinensis*. The fruits are globose and somewhat ovate, 7 mm long and 6 mm across. The embryo is the same as with the former species. The seeds are globular or barrel-shaped, and adhere with the basal part to the substratum, because the greatest quantity of viscin is found on this side. The seeds are somewhat obliquely erect on the

substratum. The viscous layer is better developed than with the former species, the seeds fix themselves more strongly, and are not so easily washed away by the rains, unless it rains immediately after the seed got lodged. This may be said for all species with the exception of those of *Dendrophthoë* and *Scurrula.*

One day after adhesion the hypocotyl comes forth as a thick, green thread; when emerging from the endosperm it is erect, but soon it curves and grows along the seed towards the substratum. In the meantime the base of the hypocotyl swells and this goes on while it grows and reaches the substratum, and has fixed itself there. At the moment the hypocotyl reaches the substratum, the seed is still there, but soon the seed comes off and is lifted from the support by the raising hypocotyl. The endosperm is used up and finally the empty cover of the seed slipps off the cotyledons, so that these stand free on the top of the hypocotyl and form the first leaves of the young plant. They get larger than with the former species, but mostley no longer than 10 mm, see fig. 21.

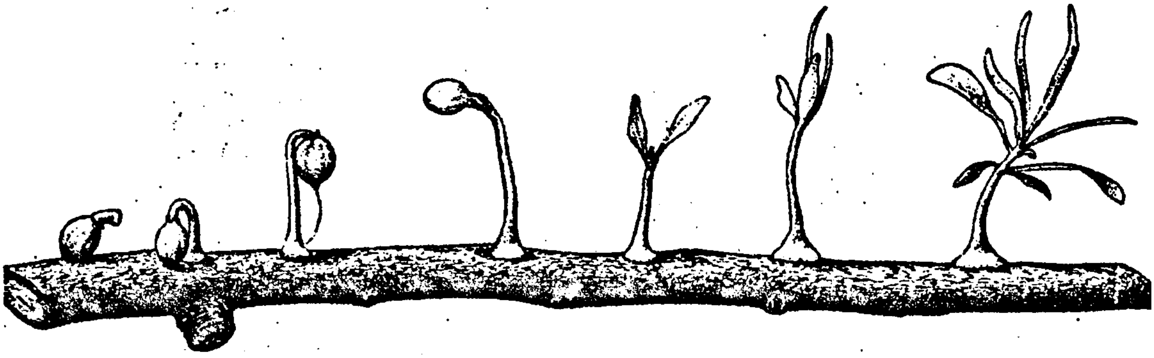


Fig. 21. *Macrosolen cochinchinensis.* Various stages of development of the seeds. × 1½.

3. *Macrosolen formosus* has bigger seeds, but the germination takes place in the same way. The growth, however, is somewhat slower.

4. *Elytranthe albida.* I have little data about the germination of this species, only those collected in the locality where the plant grew. The young seedlings are very similar to those of the former species. Here too the cotyledons are the first leaves of the plant.

5. *Amyema fasciculata.* I found this species only once on a large *Ficus* in Middle Java in 1910, and I have never found it again. I do not possess many data about this plant either. The fruits are ellipsoidal-obovate, about 7 mm long and 4 mm across; they are bright and scarlet like red currants. The food-layer of the fruit is thick and surrounds a relatively small seed, about 3 mm long and 2 mm across. The seed is quadrangular with rounded sides and sticks to the substratum over its full length. The hypocotyl grows as a thick, green thread straight downwards, only bending where it emerges from the endosperm. The hypocotyl remains short, for the distance from the opening in the endosperm to the branch is at best 1 mm. For the rest the germination is like that of *Scurrula.*

6. *Helixanthera cylindrica*. The fruit is oblong-oviform, 13 mm long and 6 mm across, tapering conically. The seed is ellipsoidal, about 7 mm long and 4 mm across. The seeds stick over their full length; the germination is like that of *Scurrula*.

7. *Baratranthus axanthus*. The fruit is ellipsoidal, 4 tot 5 mm long and about 3 mm across, with a thick exocarp; the seed is small, about 2½ mm long and 1½ mm across. The seed ends in a woodened stripe, which is much stronger developed with *Scurrula*. The germination is like that of *Scurrula*.

8. *Dendrophthoë pentandra*. The fruit is ovate, 10 mm long and 6 mm across, rounded at the base and tapering towards the top. The seeds are relatively small when compared to the size of the fruits: 4 to 5 mm long. In the place where the base of the hypocotyl emerges from the endosperm are 5 about 3 mm long viscous, filiform projections, which apparently elongate the seed and hide the base of the hypocotyl from view. The embryo consists of a short hypocotyl with a thick swelling at the base and 2 short cotyledons, which are connate so as to form a conical body; only at the base the cotyledons are free and here is the plumule. The seeds stick to the substratum over their full length and the connection is so firm that not even hard rains can wash them away.

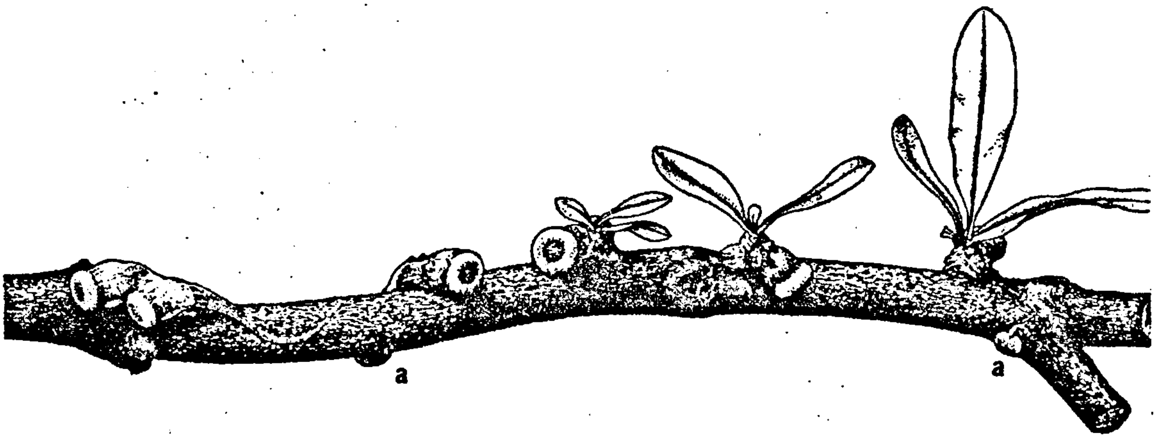


Fig. 22. *Dendrophthoë pentandra*. Various stages of development of the seeds. × 1½ : a : germinating seed of *Viscum articulatum*.

When the seed is stuck to a branch the weak projections wither within the course of a few hours and the thick swollen base of the hypocotyl gets visible. With this species the hypocotyl does not bend; the side which is nearest the substratum grows on and adheres. At the same time that part of the hypocotyl which is surrounded by the endosperm is drawn outwards so that the slits between the cotyledons get drawn slightly outside the seed and all this in such a manner that one of the two slits points upward. This takes place in the course of from one to three days. Further development is slow. At first a small leaf grows from the plumule through the slit outwards, then a second; they are only a few mm long; then more leaves are produced slightly bigger than the first two. Only when the stalk gets visible the growth is somewhat quicker. Even with fairly big plants the withered seed can often be found next to the stem, see fig. 22.

9. *Dendrophthoë praelonga*. The fruit is 12 mm long and 7 mm across, not so tapering and pointed as with the former species. The development takes place in the same way, only slightly slower.

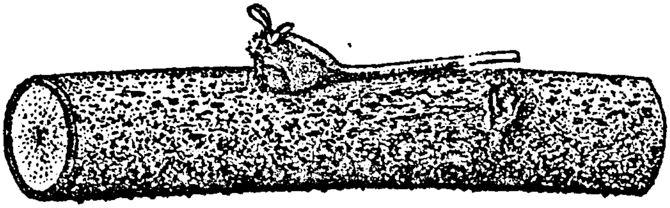


Fig. 23. *Scurrula atropurpurea*. Germinating seed with stalk, × 3.

10. *Scurrula* species diverses. With all species of this genus the fruit is club-shaped with a rounded top, tapering towards the other end. The seed is situated in the thick part of the fruit. This seed differs from almost all other *Loranthus* seeds in having a square cross-section with slightly rounded edges see *Amyema fasciculata*. The seed is widest where the base of the hypocotyl emerges and here are also four succulent short projections. The seeds taper towards the other end finishing in a long threadlike white woodened stripe, which is the central part of the fruit stalk and which comes out connected with the seed and which also passes the intestinal canal of the bird. Therefore these seeds are easily discernable from all other seeds. *Baratranthus axanthus* also has a woodened stripe, but much shorter.

The viscous layer is green and very sticky, developed over the entire surface of the seed and the stalk, so that the seeds stick very firmly over their entire length to the substratum. The embryo consists of a short, round, tapering hypocotyl with two small connate cotyledons. Only at the base where the plumula is situated the cotyledons are free, leaving a narrow slit, one on each side. The pointed base of the hypocotyl hardly projects from the endosperm and is completely hidden by the projections. Shortly after adhesion the base of the hypocotyl comes forth and grows close to the front of the seed towards the branch. The hypocotyl develops still further and grows slightly in between the cover of the seed and the substratum. The base of the hypocotyl does not dilate as is the case with the other species; it touches the branch with the side of the base. It is all very small and difficult to discern. The part which is adpressed against the branch dilates more and more and simultaneously the base of the cotyledons is pulled slightly forth from the seed so that one of the slits above the plumule points upwards. This stage is reached after two or three days. One day later a small green dot soon followed by another comes forth from the slit between the cotyledons, growing through the viscous layer. These dots are the tops of the first leaves which develop from the plumule, see fig. 23. The leaves develop slowly while the hypocotyl dilates more and more. The further growth is slow.

11. *Korthalsella opuntia*. The fruit is more or less pear-shaped with a flattened seed in the upper portion. The seeds are shot out from the fruits and are about 1 mm long and wide, and flattened. The base of the hypocotyl projects slightly from the endosperm. The seeds adhere firmly with the flattened side to the substratum. The hypocotyl begins to grow immediately; one day later the base has reached the support and adheres to it. At the other end of the hypocotyl the seed is lifted and during the erection the seed releases more and more and after two days the hypocotyl stands perpendicular with the seed on top. After some time the empty endosperm with its covering drops and the hypocotyl ends with a small stalk. This parasite does not form leaves and even the cotyledons are reduced so as to form a kind of collar. STEVENSON (1934 : 123) found a cotyledonary collar in stead of cotyledons with the *Korthalsella* species of New Zealand.

12. *Viscum articulatum, liquidambaricolum*, and *ovalifolium*. The fruits of these three species are globular to pear-shaped; when ripe they are white to pale yellow, 3—5 mm in diameter. The seed is flattened and contains a filiform, short hypocotyl and two small connate cotyledons. The seed sticks to the substratum with its flat side. The first day does not yet show any changes, but on the second day the green base of the hypocotyl gets visible on the side of the seed. This hypocotyl develops into a thin, green thread which bends and grows towards the substratum. As soon as the base has reached the support it widens so as to form a small adhesive disk. Sometimes the seed remains in this condition for weeks, just only swelling and getting rounder; apparently it takes up water through the hypocotyl. After three or four weeks the seed releases from the substratum and the hypocotyl stretches. Then the seed withers and the growing point forms the internodes of the stalk with *Viscum articulatum* and *V. liquidambaricolum*, and small leaves with *V. ovalifolium*.

The above data show that the *Loranthaceae* which were described first: *Lepeostegeres, Macrosolen*, and *Elytranthe* may be called primitive. With the representatives of the *Elytranthinae* the cotyledons are real, free leaves of the young plant. An investigation into the embryology has shown that the representatives of these genera, belonging to the *Elytranthinae*, are not yet reduced to such an extent as the other *Loranthaceae*. As to their germination the first mentioned species can be compared with epiphytes. With for instance *Aeschynanthes* and *Dischidia* there is no radicle in the seed and the hypocotyl curves and grows towards the substratum. When the base has reached the support it swells so as to form an adhesive disc, which adheres to the substratum with hairs. The hypocotyl stretches, the seed is released and the cotyledons form the first leaves of the young plant, see GOEBEL (1889 : 153) and DOCTERS VAN LEEUWEN-REIJNVAAN (1913 : 71).

This is an argument in favour of those who think that the *Loranthaceae* trace their descent back to such epiphytic ancestors (GOEBEL, 1889 : 157 ; HABERLANDT, 1910 : 177 ; KOERNICKE, 1910 : 665).

The other *Loranthaceae* have a stronger reduction in the gynaecium and in the structure of the seeds. The reduction is most distinct with

Dendrophthoë and *Scurrula* species. With these plants the cotyledons have grown together so as to form a conical organ; the base of the hypocotyl does not curve towards the substratum, but the end nearest the support develops further, so that the connection with the substratum is brought about in the most efficient and shortest way. With all species, except those of the *Elytranthinae*, the cotyledons are more or less connate; with *Viscum* they are very small and with *Korthalsella* they have disappeared but for a cotyledonary collar. This may depend upon the fact that these plants do not form leaves. Leafless *Viscum* species, however, have small cotyledons.

CHAPTER 16.

Dispersal.

The seeds of the *Loranthaceae* are dispersed by birds with the exception of those of the genera *Arceuthobium* and *Korthalsella* which are flung from the fruits. The dissemination by birds has been known for quite a long time concerning *Viscum album*, the seeds of which are spread by the mistle-thrush: *Turdus viscivorus*. Other birds are also known for eating the seeds of this plant, but I failed to find any data about the seeds being deposited by the birds. The seed dispersal of the tropical species of the Old World is better known, although much remains for investigation.

RUMPHIUS (1747 : 61) has already stated that the seeds are voided together with the faeces. He mentions the Malay name of the bird : tshui ; by which is meant *Dicaeum vulneratum*.

KORTHALS (1839 : 226) writes that the seeds are eaten by birds such as *Turdus* and *Ixos*, and that the seed is excreted together with the indigestible viscous layer. It seems to be quite improbable that in the tropics thrushes should eat the fruits. These birds are apparently mentioned by him because in Europe a thrush disperses the seeds of *Viscum album*. With *Ixos* is meant some bulbul belonging to the *Pycnonotidae*. These birds eat indeed all kinds of pulpy fruits. As disperser of *Loranthus* seeds in the mountain districts he mentions again *Turdus* and *Ixos bimaculatus*, now *Pycnonotus bimaculatus barat*.

KARSTEN (1852 : 321) describes how the seeds of *Passowia odorata*, a South American *Loranthus* are often sticking to the erect branches of the host, and that more often at the top than at the lower part. It is his opinion that the rain makes the seeds swell out of their fruits ; while falling and touching a branch they slide on but finally stick to the support by adhesion. All this has not been observed, but is mere imagination.

TEYSMANN (1856 : 144) states that the fruits of these plants must have passed through the intestinal tract of certain small birds in which process the skin and part of the pulp is digested. The skin, however, is not eaten. After secretion the seeds stick with the viscous layer to each object on which they are dropped.

KEEBLE (1895—1901 : 97) states that in Ceylon there are birds which chiefly feed on *Loranthus* fruits, viz. *Dicaeum erythrorhynchos* and *D. vincens*. The former has, on account of its assiduity in visiting *Loranthus* plants, earned for itself the name of parasite bird. The fruit-skin is thrown away and the intestines of not a single shot bird contained any skin. Other birds eat the fruits whole : a *Chloropsis jerdoni* had whole fruits of *Elytranthe parasitica* in its crop. Part of the seeds from the intestinal canal of *Dicaeum* germinate, most of them were killed by the disgestive fluid, which sounds very improbable. KEEBLE holds that the birds get rid of most of the seeds by striking their bills against branches. This has not been observed, but is just fantasy. According to KEEBLE the above holds good for *Loranthus* with big seeds. With *Viscum* species the viscous layer is less developed and therefore less a mean of protection from digestive juices in these cases than the large-seeded *Loranthus*. It is at least highly probable, says KEEBLE, that birds distribute these smaller seeds also by wiping them of their bills. All these suppositions are contradicted by the actual state of things.

RYAN (1899 : 472) mentions *Dicaeum erythrorhynchos* as disperser of *Dendrophthoë falcata* in India. He also saw the bird eating the fruits of *Ficus glomerata*, and observed a grey squirel eating *Loranthus* fruits. The squirrel sucked the juice from the fruits and dropped the rest. He says that other birds too eat the fruits, but that only *Dicaeum* swallow the seeds whole. He rarely saw such a restless bird ; in the course of 5 hours a caged specimen ate 50 *Loranthus* seeds and besides many fruits of *Ficus glomerata*. Shot birds had seeds in the intestinal canal. A shot specimen of this *Dicaeum* still tried to void a seed. My observations, says RYAN, are entirely opposed to those of Mr. KEEBLE, whose investigations were undertaken in Ceylon, where probably the mentioned *Dicaeum* may be a different charactered bird. It stands to reason that this is not the case, but RYAN actually observed the birds, while KEEBLE depended on his imagination.

REICHE (1904 : 286) stabes that a thrush-like bird : *Mimus thenea* in Chile eats the fruits of *Phrygilanthus aphyllus* and deposits the seed on the spines of *Cactus*, but he does not say in what manner. He fed caged birds with the fruits, but the voided seeds did not germinate.

I have been able to ascertain positively, says BECCARI (1904 : 388) that in Borneo *Trachycomus ochrocephalus* (now *Pycnonotus zeylanicus*) feeds on the fruits of *Loranthus* ; but probably many other birds eat them also. He does not say anything about the dispersal of the seeds.

PARISH (1905 : 69) thinks that eating the seeds is difficult for the birds because of the viscous layer and that the dispersal of the seeds is brought about because they stick to the feathers and legs. This seems very improbable, because the seeds would not release owing to the glue drying soon. Many American birds are said to eat the *Loranthus* seeds. Many deposited seeds can be seen to have passed the intestinal canal. When newly deposited the viscous layer is still intact. Only the epidermis is digested. This seems very unlikely.

According to BRITTLEBANK (1908 : 651) the seeds of *Lysiana exocarpi* are spread by *Dicaeum* in Australia ; also by *Strepera versicolor* and some imported birds. A big bird like *Strepera* eats the fruits whole and like owls vomits the seeds in pellets. These pellets do not stick to the branches, but sometimes they drop and get caught in the fork of a branch. It is not stated whether this has indeed been observed.

It is important to note that KOORDERS (1907 : 43) found fruits of a species of *Loranthus* in the intestines of *Chloropsis cochinchinensis nigricollis* KEEBLE (see above) found the same in a *Chloropsis* in Ceylon.

BLAKELY (1922 : 20) gives many data about the distribution of *Loranthus* seeds in Australia. According to him *Dicaeum hirundinaceum* is not the only disperser of the seeds, as these are eaten by very many birds. He quotes a letter of EDWIN STACK to the "Sydney Herald" of September 26th 1920 which communicates that *Loranthus* seeds are spread by *Zosterops lateralis* and the common house-sparrow, *Passer domesticus*. BLAKELY gives a list of 20 birds eating *Loranthus* fruits : I shall not copy it here, because he does not say in what way the seeds are deposited on the branches and not all birds eating fruits are seed-dispersers.

MAC LUCKIE (1923 : 343) thinks that the distribution of *Loranthus* seeds is not only brought about by birds but also by the wind, which is very improbable.

According to ALI (1931 : 147) *Dicaeum erythrorhynchos* is undoubtedly the most important agent in the dispersal and propagation of the *Loranthus* parasites (see chapter 2). ALI states finally : "When one considers that these two species" (of mistletoe-birds), "which are by no means uncommon in these parts (India) are ceaselessly engaged throughout the day and month after month on their task of seed dissemination, one can form a fair idea of their power for evil to humanity and of their vital services to the plants on which they are in turn dependent".

Also SAYEED-UD-DIN and SALIM (1935 : 162) give as their "incorrect" opinion that the birds rub the seeds from their bills on the branches. Some seeds are eaten but most of them die by the digestive juices. Only a few pass the intestines of the birds and can germinate.

Another very remarkable dispersal of the seedlings is described by BROWN (1881 : 142). He says that Dr. G. WATT has observed how a seed of *Loranthus* has the power of volentary locomotion from place to place. It is only whilst the seed is germinating that the motion takes place. "When the long hypocotyl has reached the substratum and the spot should not be a favourable one, the germinating embryo has the power of changing its position. The seed that had stuck already is released and then the radicle" (the hypococtyl is meant) "curves and the berry" (he means the seed) "is carried by it to another spot, where it adheres again. The disc than releases itself, and by curving about of the hypocotyl is advanced to another spot. This can be repeated several times. It seems to select a certain place in preference to others". I insert this communication as a typical example of a concoction. One should realize that when the hypocotyl reaches the substratum the seed is so firmly adhering that when loosened pieces of the bark are often taken along too. MECHAN (1882 : 21) questions the truth of BROWN's statement, because, he says, the released adhesive disc cannot adhere again in another place, nor can the seed produce viscin to replace the dried layer. Extremely queer is WATT's remark that the seedlings should be able to discern that it has alighted in the wrong place. A deposited seed germinates; if the place is favourable the embryo develops, if the place is unfavourable the plant dies. Tertium non datur.

It is well-known that *Dicaeidae* in India, Ceylon, Java, Ambon, and Australia are the real distributors of the *Loranthaceae*. This has been observed in nature and with caged birds (see chapter 2). It is known from another bird in Java: *Chloropsis cochinchinensis nigricollis* that *Loranthus* seeds were found in its entrails and also about another species of this genus in Ceylon. There will be more species of birds in Java eating the seeds, see KORTHALS (1839 : 266), but no further data are known. I experimented on some caged birds: *Pycnonotus cafer aurigaster*, *Sturnus contra jalla*, and *Acridotheres fuscus javanicus*, all of them real fruit-eating birds. Fruits of *Dendrophthoë pentandra* were added to their normal food. When the new food was put in the cage, the birds approached, picked at it, but left it. Such feeding experiments are sometimes tried on starved birds and with the proverb "Hunger is the best sauce" in mind, one might expect the birds to eat fruits which they otherwise despise; such experiments, however, have not much conclusive force, unless to find out whether the seeds leave the intestinal canal germinable. It does, however, not show what food the birds take when in the fields, for in nature the birds are not starved; the food is mixed and they can take their choice. The above described experiment does on the other hand not prove that these birds in the fields never eat the *Loranthus* fruits. But even if they did, we should not know how the seeds get lodged on the branches of the trees. Much is still left to be investigated and observed.

The Dicaeums loosen the inner part of the fruit from the skin, the skin drops or may sometimes be rubbed off on a branch. The rest is swallowed. The seeds when voided are rubbed off by the animals. It may happen occasionally that the seeds drop with the faeces during the flight and happen to get lodged on the branches of a host.

In chapter 2 it has been described how the Dicaeums when they have eaten some fruits move little and wait until the seeds have left the body. It stands to reason that in this way the seeds do no get far away from the mother-plant. It explains that a tree infested by *Loranthus* may carry lots of seeds while the seeds are completely absent some distance away. Yet there must be a dispersal over greater distances. Some species have a very wide distribution. *Korthalsella opuntia* has been found in Abessinia, Ceylon, India, China, Japan, Formosa, the Philippines, Malay Peninsula, Borneo, Sumatra, Java, and Australia. The seeds are expelled from the fruits and do not get far away from the mother-plant. There must, however, be a dispersal over greater distances, but how? *Dendrophtoë pentandra* has been collected in India, Siam, Cochin China, The Philippines, Malay Peninsula, Sumatra, Borneo, and Java.This is a species with large fruits which are preferred by *Dicaeum*; when the birds, however, have eaten three or four of them they become very quiet as if they feel congested by the large fruits. Yet the seeds have been dispersed over sea from island to island. In 1932 I visited the island of Toppers Hoedje in the Sunda Straits, not far from Krakatau, see DOCTERS VAN LEEUWEN (1934 : 149). Many specimens of the parasite mentioned grew on trees and shrubs near the shore and the Dicaeums were present too. At one time a *Dicaeum* must have crossed the sea and deposited it here. It must be a question of chance. Krakatau, the vegetation of which was completely destroyed by the eruption of 1883, is now again densely covered with a new vegetation; during many excursions to the island *Loranthus* has not yet been found; yet a species of *Dicaeum* is present : *D. trigonostigma flaviclune*. This sub-species *flaviclune* is only known as occurring in Java and Bali and must have crossed from the former island. The bird was collected as early as 1919 and since then several times. This proves that *Dicaeum* can live and propagate without the presence of *Loranthus*; see ERNST (1934 : 107) and DOCTERS VAN LEEUWEN (1936 : 232). Before the eruption TEYSMANN (1857 : 249) collected *Dendrophthoë pentandra* and *Viscum articulatum* in the island. Earlier the seeds must have been transported from Java or Sumatra or one of the interjacent islands. One day it may happen again, but how ? DAMMERMAN (1948 : 343) says that the viscous kernels after being excreted often stick to the feathers of the bird and in this way might be carried over longer distances. This may be true, but in what way do the firmly sticking seeds get released from the feathers and how do they get lodged on a branch ? Many more observations and investigations will be due for solving these problems. There is a chance that the seeds may stay in the intestinal canal over a longer period of time without being excreted, but this is no more than a supposition. As far as I can see it, the dispersal of *Loranthus* seed over longer distances remains for the present an open question.

The third part of the General Considerations in his publications on the *Loranthaceae* of the Netherlands East Indies (DANSER, 1931 : 479) is entitled: "Phylogenetical". It is a survey of the geographical distribution of the genera and descent of the genera mutually. On page 483 DANSER gives an outline of the phylogeny of the different genera occuring in the Malay Archipelago. He makes use of biological data, which according to me are too little known or not yet sufficiently established to be used without comment. I will quote him fully: "The *Loranthaceae (Loranthoideae)* of the Malay Archipelago are, in their distribution, highly dependent on special kinds of birds, especially honey-birds" (this should be mistletoe-birds), "which both spread the seeds and pollinate the flowers. This justly causes, that not only a species can die out when there is no more a species of bird that likes to eat the fruits and to drink the nectar of its flowers, but that even the presence of a certain *Loranthacea* can be the cause of the extinction of some other species. This will namely be the case, wherever a honey-bird prefers the flowers of a certain species, that formerly it used to visit. I think we may suppose that honey-birds at least sometimes do so, as the appearance of different *Loranthaceae* seems to be very differently alluring. In the same way it will sometimes happen, that the fruits of certain *Loranthaceae* are not eaten by birds, when at the same time another *Loranthacea* is present, that is preferred by those birds. In that way a species may cause the extinction of another, or may prevent another from penetrating into a country. And consequently it may occur, that a *Loranthacea* gets extinct, when it gives origin to a new form, that seems more preferable to the birds that used to eat its fruit or pollinate its flowers. So it is possible, that the genera *Amyema*, *Amylotheca* and others, may have occured in certain regions, where later they haven been expelled by forms, to which they themselves gave origin. If this line of thought contains a nucleus of truth, our fancy has much more liberty in imagining a phylogeny of the *Loranthaceae*".

These considerations sound very interesting, but they are not supported by facts and observations and may certainly not be used for such far reaching conclusions. My investigations have shown that many *Loranthaceae* are self-fertile and can fructify by self-pollination. It is not sure either that the seeds can only be dispersed by *Dicaeidae*, although practically nothing is known about dispersal by other birds. *Loranthaceae* occur in many parts of the world, where *Dicaeidae* are not found. Yet these plants are regularly distributed. One species of *Loranthus* seems more alluring to us than others, but does this hold good to the same extent for the birds? In the same locality the birds regularly visit various species with very different flowers. Plants can be found close together the fruits of which differ greatly as to size, colour, and quantity of food and which yet live and propagate side by side. That a species might get extinct after giving origin to a new form the fruit or flowers of which are more alluring to the birds is a thing which I deem highly improbable. Because the organs of two successive forms will not differ mutually so much as the fruits and flowers of two species which just chance to grow close together. Think for instance of the big, nutritious fruits of *Dendrophthoë pentandra* which are preferred by Dicaeums and compare the small fruits of *Viscum articulatum* which usually grows as a parasite on *Dendrophthoë*. If DANSER's supposition had even a small measure of truth, two such different species could never grow side by side. The birds often swallow seeds of very divergent fruits in the course of a very short time and excrete them together, see figure 2.

The investigations as to the pollination and the distribution of the seeds has led me to believe that the above mentioned opinions of DANSER are contradicted by the facts. It is better not to give free rein to one's imagination in studying the phylogeny of the *Loranthaceae*.

Imagination may play an important role in scientific work, but one is not justified in deviating from the facts or interprete them to preconceived conceptions. This would lead to mistakes and wrong conclusions. I am, however, convinced that the intuition, that is the personally acquired knowledge and the profound reflections of this prominent taxonomist cannot be overrated. DANSER has succeeded in giving a survey of this difficult plant family which in many respects is admirable. The more I got acquainted with DANSER's work, the greater was my admiration for this scientist, who unfortunately died all too young.

When in 1908 I started these investigations I could not make much progress, because many *Loranthaceae* could not be classified. VERDOORN (1950 : 4) has expressed it so clearly: "Without good basic floras the botanical knowledge of a region will necessarily be greatly retarded. Whatever one may think about the relations between taxonomy and general botany, the taxonomists have to inventarize the resources of any region critically before other botanists will be able to work there well and successfully."

My studies about the biology of the *Loranthaceae* have taught me the truth of VERDOORN's statement. Not before DANSER had published his work on the *Loranthaceae* could I continue my own comparative investigations.

LEGEND TO PLATES

Plate I. *Dicaeum t. trochileum* on the branches of *Dendrophthoë pentandra,* parasitizing on *Ceiba pentandra.* (Photo G. F. J. BLEY).

Plate II. Village jungle showing two specimens of *Ceiba pentandra.* The tree to the right with abundant foliage, the tree to the left with many bare branches, being heavily infested with *Dendrophthoë pentandra.* (Photo G. F. J. BLEY).

Plate III. Nest of *Dicaeum t. trochileum* among leaves of *Enterolobium saman.* (Photo G. F. J. BLEY).

Plate IV. A Seeds of *Dendrophthoë pentandra,* deposited by a young *Dicaeum t. trochileum* on its perch in the course of one day. The young bird was fed by parent birds. (Photo C. C. OLIJ-REIJNVAAN).
Plate IV. B. Young specimen of *Lepeostegeres gemmiflorus* attached to the underside of a branch of *Ixora.*

Plate V. Branch of *Altingia excelsa* with specimens of *Viscum liquidambaricolum.*

Plate VI. Branch of *Altingia excelsa* with an old specimen of *Viscum liquidambaricolum.*

Plate VII. Branch of a male specimen of *Barathranthus axanthus.* On the leaves black spots of *Polystomella sordidula.*

Plate VIII. A. Petiole of *Angiopteris evecta,* carrying a young specimen of *Dendrophthoë pentandra,* its runners being unable to gain a hold.

Plate VIII B. Swollen branch of *Baccaurea,* carrying at the end a young *Viscum ovalifolium.*

Plate IX. Branch of *Citrus* carrying a shrubby specimens of *Scurrula atropurpurea.*

Plate X. A. A fully grown specimen of *Korthalsella opuntia* in fruit.
Plate X B. Branch of *Altingia excelsa,* showing three knobs caused by *Korthalsella opuntia* in rest. The oldest knob near the base, the youngest near the end of the branch.

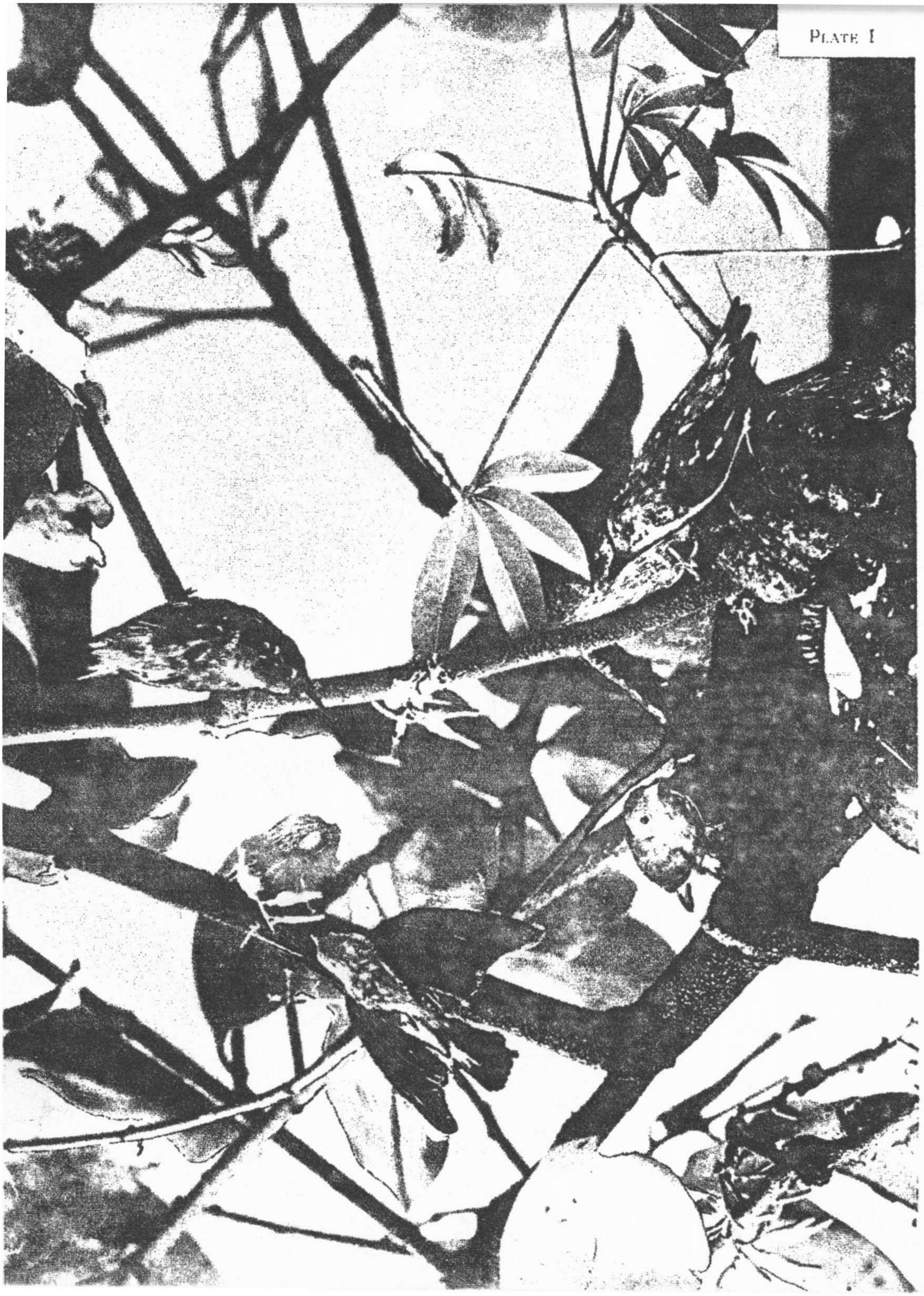
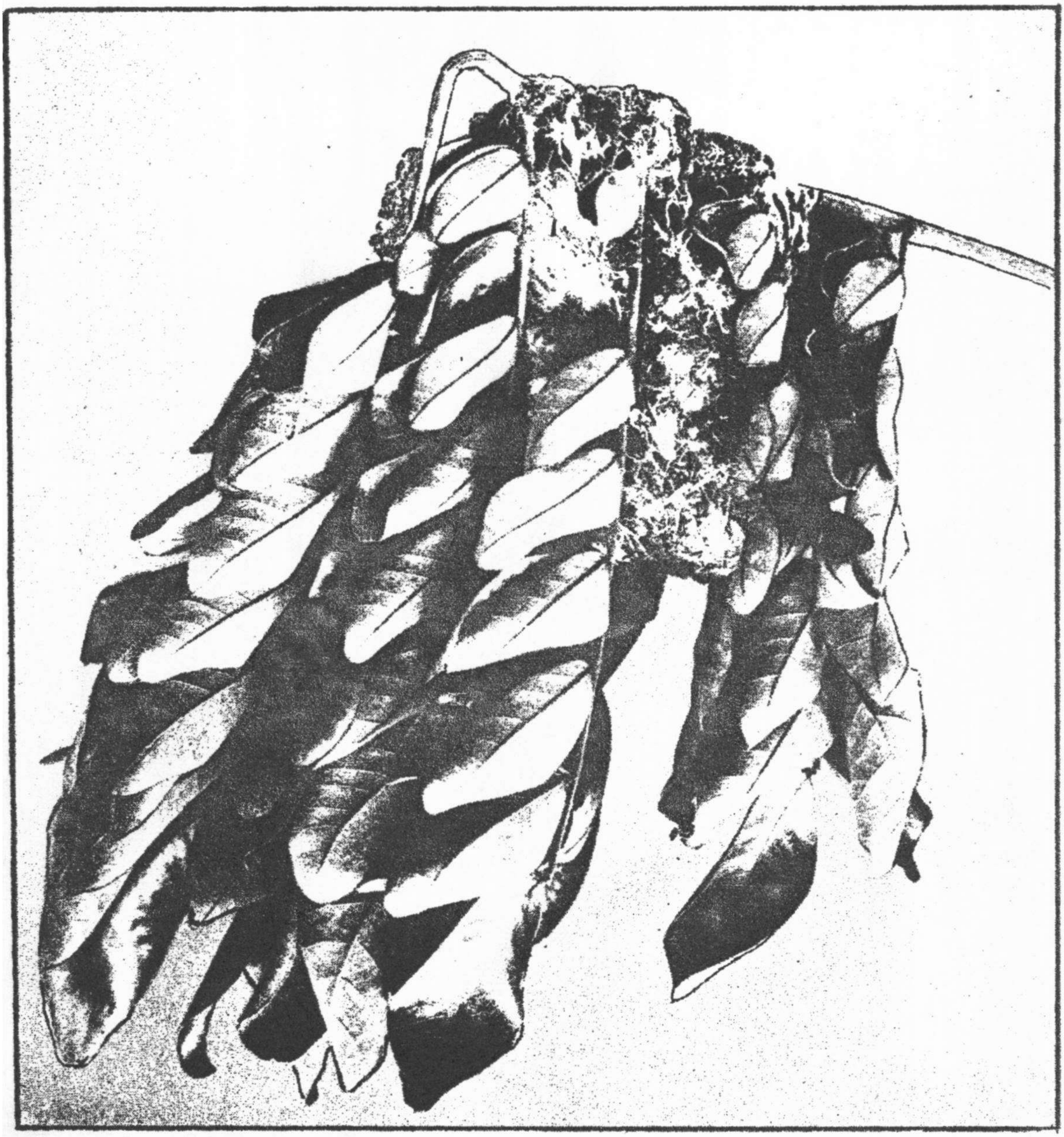
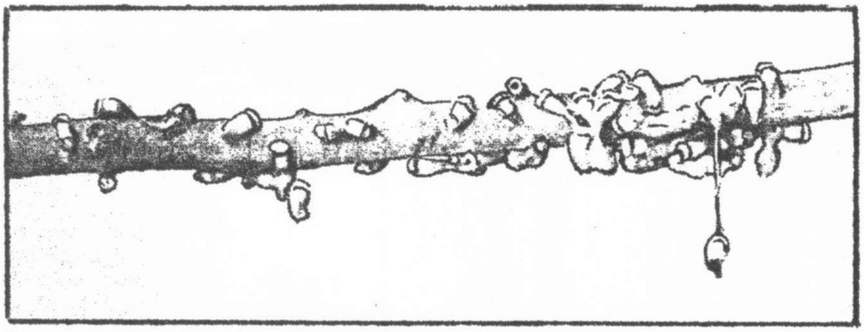


PLATE II





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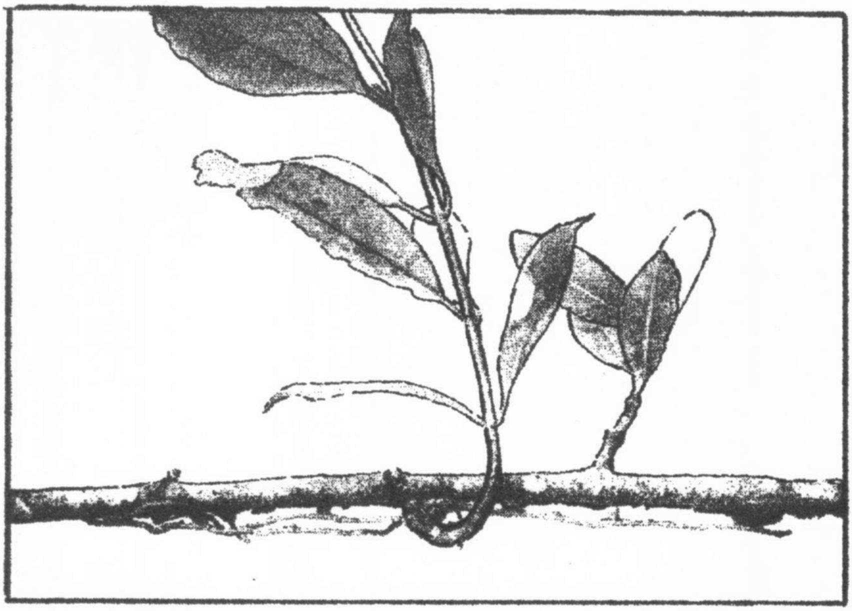

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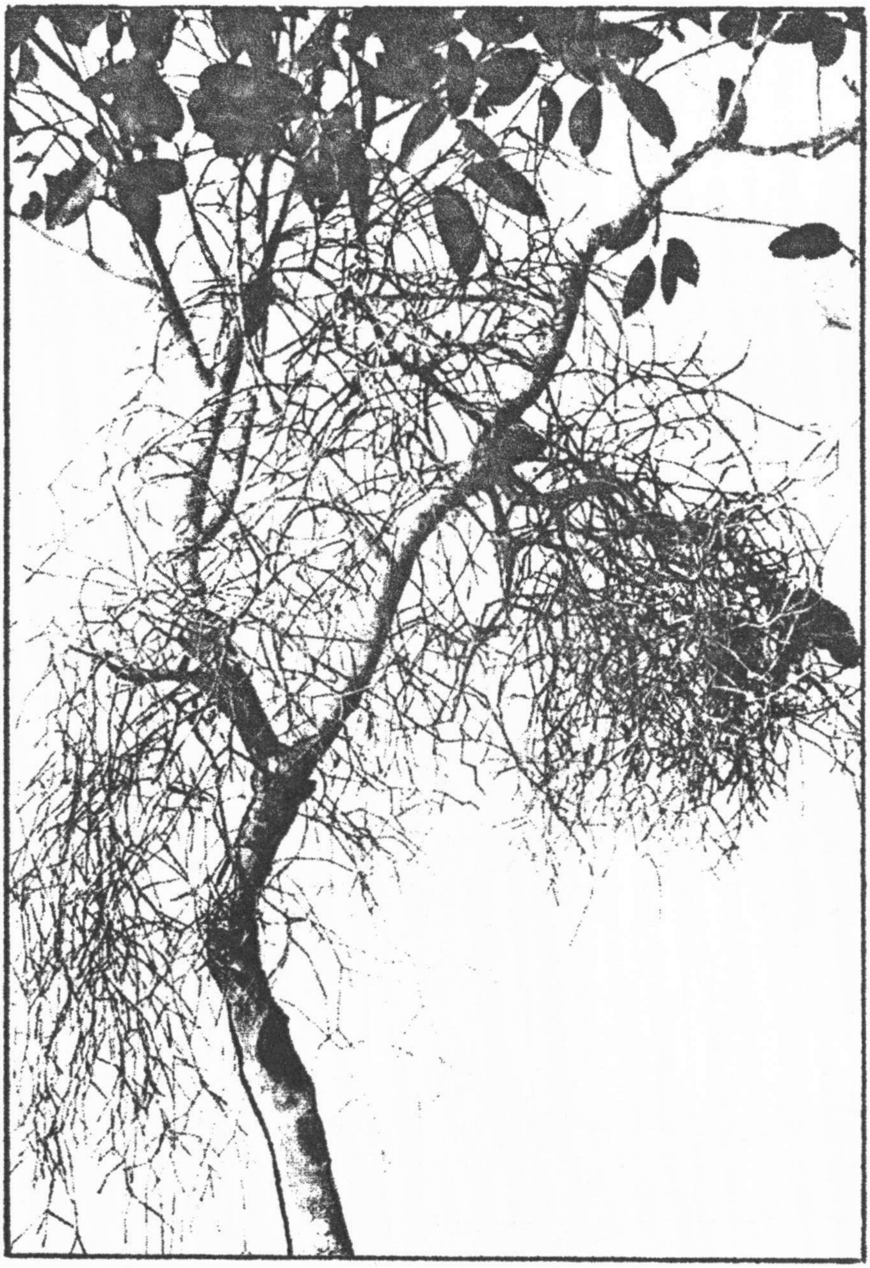

PLATE VI

Plate VII

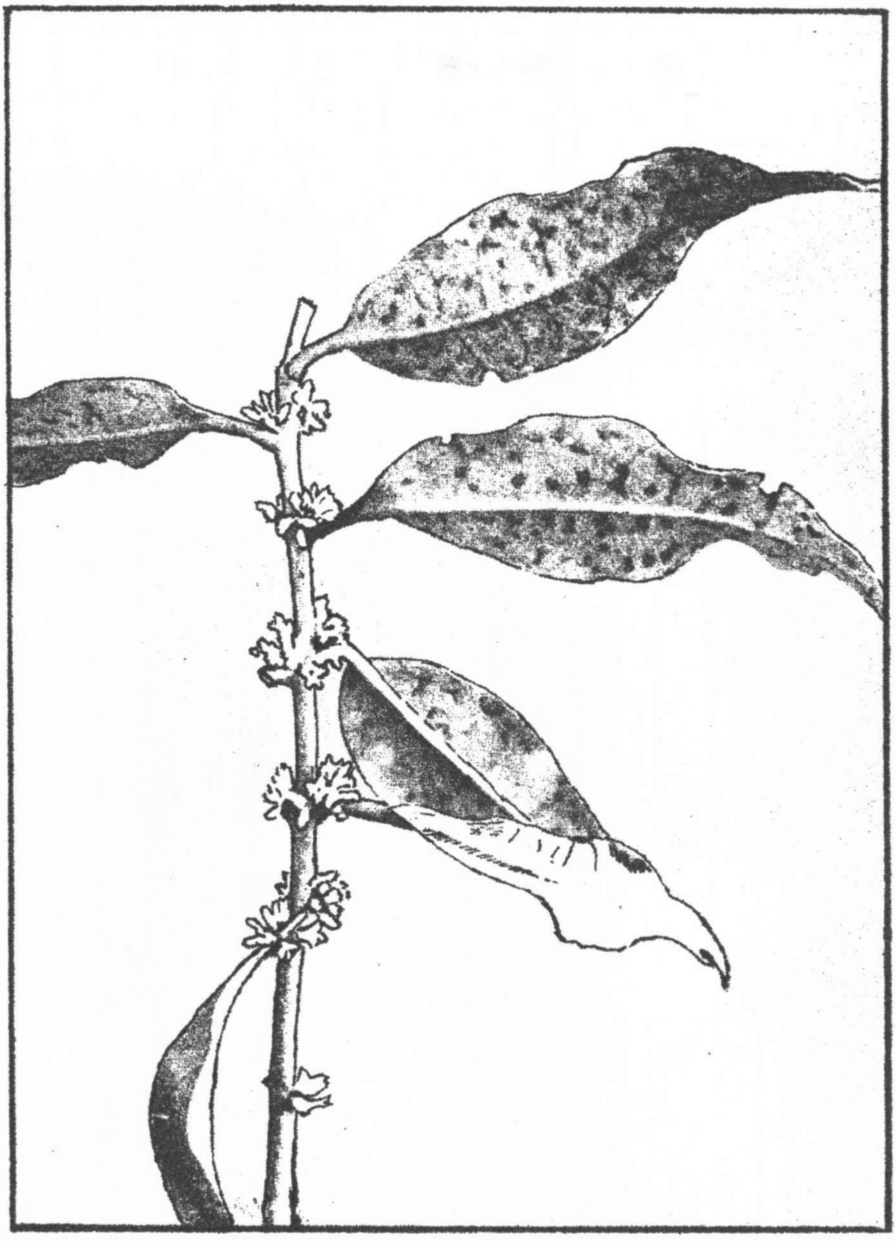

PLATE VIII

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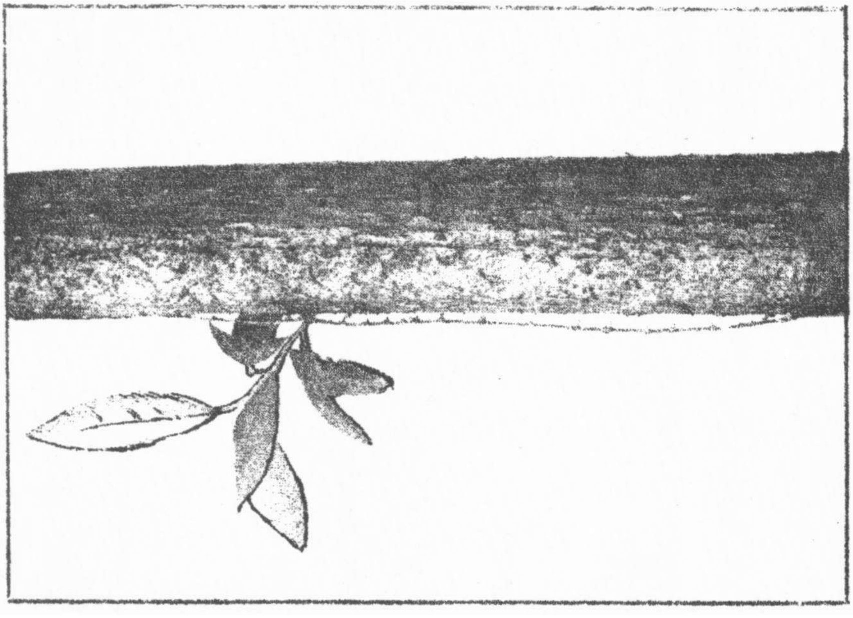

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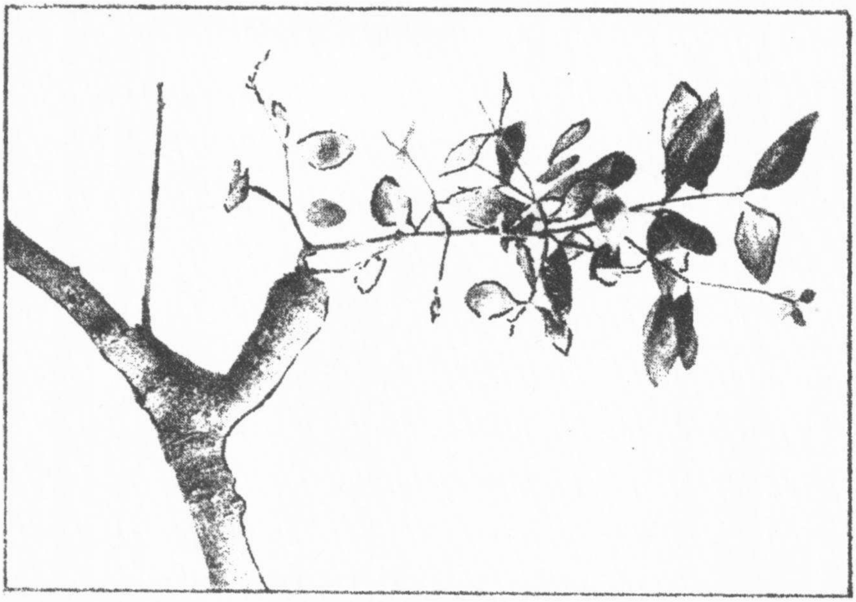


PLATE IX

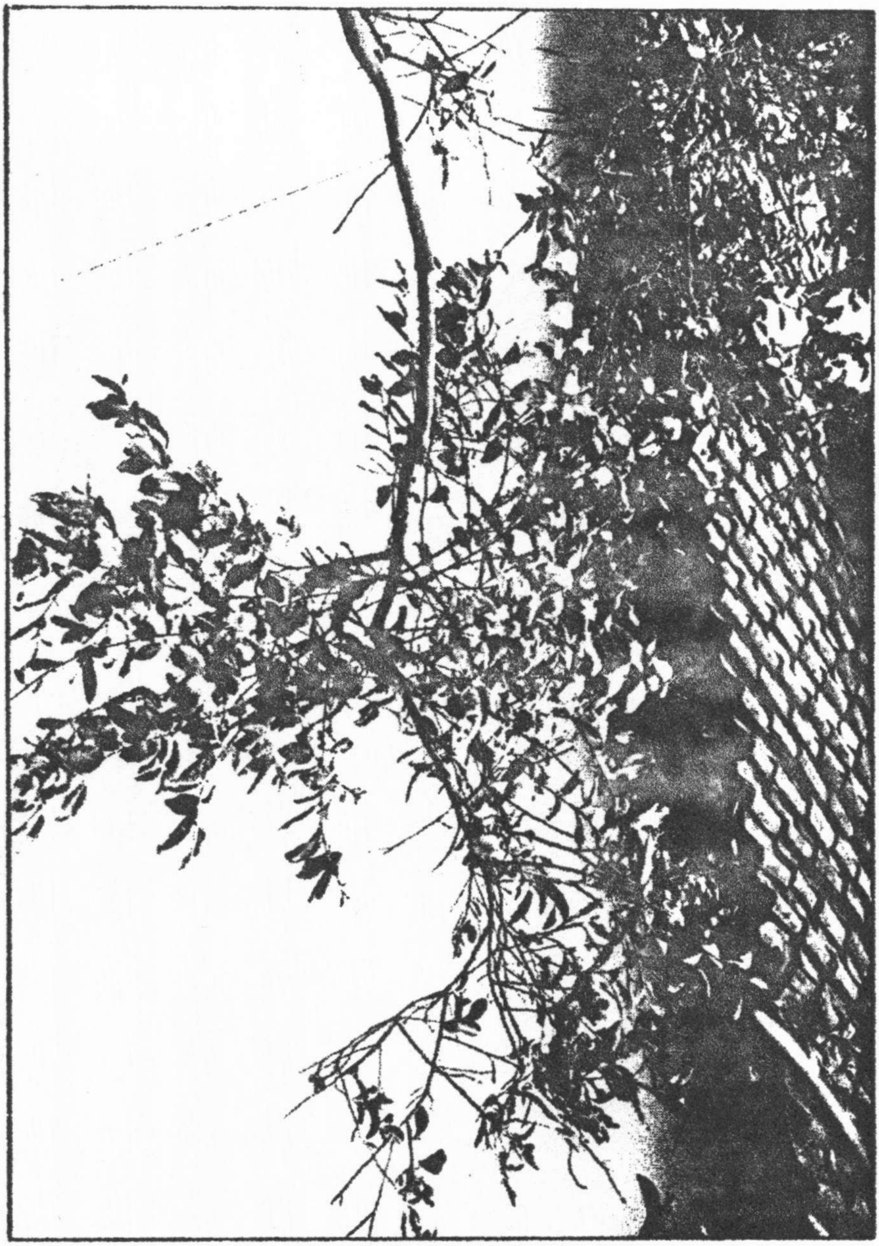
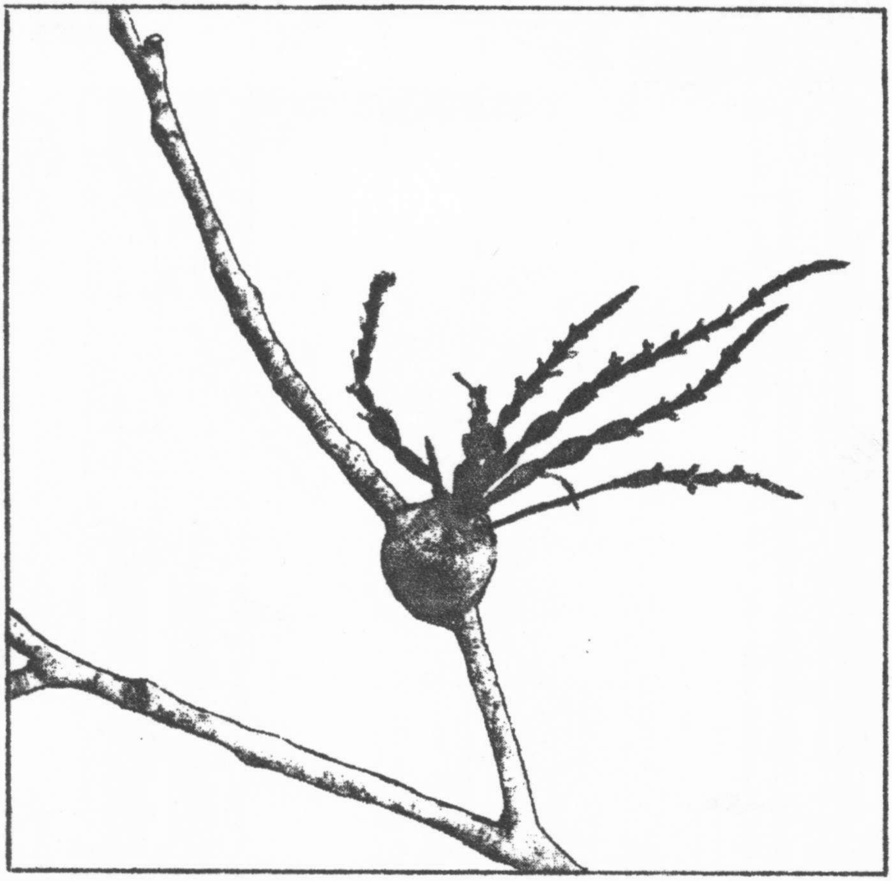


PLATE X



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