

**Orchids  
in the  
Transactions**

Part 2

# Orchids in the Transactions

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compiled by Ian St George

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From Thomson GM. The Pollination of New Zealand Flowers by Birds and Insects. 1927. 57: 106-125.

In a paper on "The Fertilization of New Zealand Flowering Plants" read before the Otago Institute in May, 1880, I stated that very little was known as to the relation of birds and insects to flowers in this country. Up to that time only a few scattered references to the subject were available. My own contribution (34) added a little to the sum of knowledge, and since then a few more data have been obtained. But even to-day the amount of information is very fragmentary. Botanists, as a rule, do not trouble themselves with the insects that visit the flowers which they collect; and entomologists are seeking the insects themselves, and seldom notice the flowers they are found on. Yet the subject is one of great interest to the naturalist, as it displays in a marked degree the principle of adaptation in nature. I do not propose to go into the general question in this paper, my object is only to summarize what has been done in New Zealand in the hope that further observations may be made and published.

Pollination of flowers by birds is practically unknown in Britain, and, as far as I know, in Europe. It is found to occur only among certain families of birds, and of these three occur in this country.

ORCHIDACEAE.

6. *Dendrobium Cunninghamii* Lindl.

The flowers secrete a considerable quantity of nectar and appear quite incapable of self-pollination.

In 1878, out of 22 flowers examined by me, 5 had their pollinia removed. In January 1880 I found the plant flowering in gorgeous profusion in Stewart Island, and examined 80 flowers, but only found 10 with the pollinia removed. I saw no insects actually at work.

7. *Earina mucronata* Lindl.

Flowers very fragrant and producing a considerable quantity of nectar.



8. *Earina autumnalis* Hook. f.

The flowers are fragrant and secrete nectar. They appear to be quite incapable of self-pollination, but I have never seen nor taken insects on them. Out of 91 flowers examined, 41 had the pollinia removed. In 1878 I pollinated six flowers with their own pollinia, and also cross-pollinated sixteen with pollinia taken from other flowers on the same bunch, but in neither case were they fertilized.

9. *Sarcophilus adversus* Hook. f.

This little species produces minute inconspicuous flowers, which are slightly fragrant and produce a relatively large amount of nectar. They appear (34) to me quite incapable of self-pollination, owing to a mechanical depression and separation of the pollinia when removed from the anther.

10. *Thelymitra longifolia* Forst.

This is a very variable species, some forms bearing conspicuous blue or even white flowers, while others which are nearly always white or pinkish scarcely open their blossoms at all. In my paper on the fertilization of Orchids (33) I stated that the species was probably self-fertilized. Cheeseman (3 and 7) considers them nearly always self-fertilized, and Fitzgerald says the same of the Australian forms of the species. When, however, I was in Stewart Island in January 1880, I found many lilac- and pink-flowered specimens, which were very conspicuous, and in many of them the pollinia had been removed, showing that insects had visited them.

11. *Microtis unifolia* Reichenbach.

The flowers are green and inconspicuous. I could detect neither nectar nor fragrance, yet in one fine spike examined by me (33) I found that 31 flowers out of 32 had the pollinia removed, the top flower being just opened. In the majority of cases, however, and I have examined hundreds of flowers, the pollinia were glued to the upper edge of the stigma, and in many cases the pollen tubes could be detected, showing that self-pollination had taken place.

12. *Prasophyllum Colensoi* Hook. f.

Though the flowers are sweet-scented, and are occasionally visited by insects, they are mostly self-pollinated, as in a majority of those examined the pollen grains were found to be adhering to the stigma. Of 75 flowers examined only 4 had the pollinia removed.

13. *Caleana minor* R. Br.

Cheeseman (9) states "that it seems probable that small Diptera or other minute insects alight on the labellum, which then capsizes, imprisoning the insects in the concavity of the column; that they then

disturb the pollinia, and either fertilize the flower with its own pollen, or when escaping convey the pollinia to other flowers. The latter supposition appears to me the most likely; but Mr. Fitzgerald, who had good opportunities of studying the fertilization of the plant in Australia, considers that it is almost invariably self-fertilized."

Kirk (20) describes the same species, and quotes from Fitzgerald's "*Australian Orchids*" as to its method of fertilization. He tried to produce pollination by experimenting with blowflies, houseflies and ladybirds, but was unsuccessful in every case. I think his chosen insects were too large. In most small orchids upon which I have seen flies, they were small species of Culicidae.

14. *Pterostylis Banksii* R. Br.

The flowers of all the species of *Pterostylis* examined by me (33) appear to be incapable of self-pollination, but out of 39 flowers of this species looked into, only one had the pollinia removed. Cheeseman (3) considered that "the insect which fertilizes this species is nearly twice the size of that which performs the same office for *P. trullifolia*."

I pollinated a number of flowers of this species with their own pollinia, but the results were inconclusive, as the plants were in the open, and I was not able to follow the experiment satisfactorily.

15. *Pterostylis australis* Hook. f.

I examined 22 specimens of this species, and found that all had their pollinia intact. The flowers may be self-fertilized, though I think it very improbable. The impression in my mind is that the insects which formerly pollinated it are become very rare.

16. *Pterostylis graminea* Hook. f.

The same remarks apply to this species as to *P. Banksii*. Of those examined, the number of which I have unfortunately lost, none had the pollinia removed.

17. *Pterostylis trullifolia* Hook. f.

In this species the flowers are fragrant. The labellum is extremely sensitive, springing up at once when touched; only very small insects could enter the flowers, which are only about  $\frac{1}{4}$ -inch long. Of 14 flowers examined by me, 5 had their pollinia removed, while the other 9 were newly opened and probably had not had time to be visited by insects.

18. *Acianthus Sinclairii* Hook. f.

Cheeseman (4) states that numerous Diptera were seen on a bed



of *Acianthus* flitting from flower to flower. Out of 134 flowers examined by him 115 matured their capsules.

19. *Cyrtostylis oblonga* Hook. f.

Cheeseman (4) records that "notwithstanding the minuteness of the flowers they are frequently visited by insects, chiefly minute species of Diptera."

20. *Caladenia bifolia* Hook. f.

My own record of this species (33) states that "the arrangement of the parts (of the flower) is so simple that an insect alighting on the labellum and advancing its head into the base of the flower could hardly fail to remove the pollinia; nor could one entering fail to leave these on the stigma, for in withdrawing pollinia from a flower they are always slightly depressed by the cap of the anther. The pollen is very incoherent, and the lower surface of the stigma projects a little, so that I am inclined to think self-fertilization takes place in flowers which have not been visited by insects. The majority of the flowers appear to set good capsules, and flowers which I fertilized artificially, produced good full seed-vessels." Of 22 flowers growing in the open, 3 had both pollinia removed, in one the pollinia were removed from one anther lobe, in 5 others the pollen masses appeared more or less disturbed, while in the remaining 13 the anthers were untouched.

21. *Corysanthes oblonga* Hook f. D. Miller (in *N.Z. Journ. of Science and Techn.* 1 (1918) 4) describes *Exechia Thomsoni*, a fungus-gnat, which fertilizes this orchid.

21a. *Corysanthes rivularis* Hook f.

All the species of *Corysanthes* appear to be incapable of self-pollination, and from the evidence already acquired, the work is done by small Diptera, probably all of the Culicidae, and perhaps each species has its own particular fly. None of the flowers secrete nectar, but when the surface of the labellum is slightly punctured, a considerable amount of sweetish purple juice exudes, which is probably grateful to insects.

22. *Corysanthes macrantha* Hook. f.

I closely examined 143 flowers (33) and found that in 47 the pollinia were still in the anthers, from 90 they had been removed, while in 6, dead or living flies were found glued to the stigma. Of the whole number examined only a small proportion ultimately produced capsules. In addition to the insects which were caught by the

viscid stigmas and which were unable to get away again, many flowers were found to contain only wings and legs of flies. This was due to the presence of small spiders which seemed to lie in wait for the flies which were entering the flowers, and in many cases captured them while inside. Indeed I think that all the insects which were found glued to the stigmas got caught there in their endeavours to escape from the spiders. In every case in which an insect was found by me withdrawing from a flower, the pollinia were removed also, securely attached to the front of the head. I regret that I did not preserve these flies, as I could not get them identified at the time.

From Crosby Smith J. The Vegetation of the Awarua Plain. 1928. 58: 55-56.

ORCHIDACEAE.

*Prasophyllum Colensoi*.  
*Thelymitra longifolium*.  
— *uniflora*.

From Laing RM and Oliver WRB. Vegetation of the Upper Bealey River Basin, with a List of the Species. 1929. 59: 715-730.

ORCHIDACEAE.

<i>Prasophyllum Colensoi</i> Hook. f.	Bog, forest.
<i>Pterostylis areolata</i> Petrie.	Forest.
<i>P. Oliveri</i> Petrie.	Forest.
<i>Lyperanthus antarcticus</i> Hook. f.	Bog.
<i>Caladenia bifolia</i> Hook. f.	Bog, forest.
<i>C. Lyallii</i> Hook. f.	
<i>Corysanthes rotundifolia</i> Hook. f.	Forest.
<i>C. triloba</i> Hook. f.	Forest.
<i>Thelymitra uniflora</i> Hook. f.	Scrub (Blimit Peak)
<i>Gastrodia Cunninghamii</i> Hook. f.	Forest.
<i>Chiloglottis cornuta</i> Hook. f.	Damp rock in forest.

From Laing RM and Gourlay HW. Vegetation of the Bealey River Basin.  
Supplement to the list of species (1929) with notes. 1935. 64:  
1-10.

(ORCHIDACEAE.)

*Pterostylis Banksii* R. Br. (forma).

*P. australis* Hook. f. (forma).

*P. graminea* Hook. f. (forma).

In bush, sides of creek, 2500ft.

None of these species is typical of their representatives elsewhere. They occur in a great variety of forms impossible to classify satisfactorily. Intermediates between *P. Oliveri*, *P. Banksii*, and *P. graminea* are all to be found. Colenso, *Trans. N.Z. Inst.* (1883), p. 338, (1886) p. 270, (1899) pp. 488-489, (1896) p. 611, has divided the forms of this group into a number of distinct species, but till an intensive study of the varieties occurring throughout New Zealand is made, it seems scarcely worth while to discriminate more closely.

Some sketches made by Mrs Brownlee of the Arthurs Pass plants accompany this note. (Fig. 1.)

*Thelymitra pachyphylla* Cheesem.

In small quantity near Halpins, 2200ft.

This seems rather an unexpected locality for this West Coast plant, but the specimens exactly fit the description.

*T. longifolia* Forst.

Rocky ground, edge of bush, below Kennedy's.

*Microtis unifolia* (Forst. f.) Reichenbach.

By roadside, 2000ft.



Three forms of *Pterostylis* from creek near Gaya Cottage, Arthur's Pass.

Moore identified two of these *Pterostylis* as *P. irsoniana* and *P. montana*.

From Allan HH. Notes on New Zealand Floristic Botany, including Descriptions of New Species, Etc. (No. 6). 1936. 65: 221-231.

17. *Spiranthes australis* Lindl. Sand-hollows at Himatangi, near Foxton (Ruahine-Cook Bot. Dist.), H. H. A.

From Martin W. Notes on the Indigenous Flora of Marlborough (New Zealand) with Special Reference to Plant Distribution. 1938. 67: 414-425.

*Sarchochilus adversus*—Rarangi; Ship Cove.

From Simpson G and Thomson JS. The Dunedin Sub-district of the South Otago Botanical District. 1938. 67: 430-442.

#### H. PREVIOUS RECORDS BELIEVED TO BE ERRONEOUS.

*Pterostylis micromega*—Probably confined to the North Island.

The common epiphytes are  
*Earina autumnalis*, *E. mucronata*,

From Heine EM. Observations on the Pollination of New Zealand Flowering Plants. 1938. 67: 133-148.

#### THE STRUCTURE OF THE FLOWERS.

It has been mentioned above that most of the New Zealand flowers either attract all possible visitors, or if they are restricted to certain insects, these appear mostly to be short-tongued bees or Diptera. On examination the structure of the various flowers is seen to substantiate these facts.

Where in other countries we find numerous complicated devices to ensure cross-pollination by long-tongued bees, these are comparatively rare in New Zealand. In most cases, the flowers are simple in structure with exposed pollen and nectar in a position where it can be easily reached by most insects, thus enabling cross-pollination to be carried out by a number of different insects. Where insects are so scarce we are not surprised to find that flowers are reduced to exposing their pollen and honey rather than hiding it in such a way that only the more highly-developed insects can reach it.

Where we find highly-specialized flowers, either these are adapted for birds, or, in the case of orchids, their wonderful construction does not seem to have the desired effect. Thomson (1927) states that of 80 *Dendrobium Cunninghamii* examined he found only 10 with the pollinia removed; and of 75 *Prasophyllum Colensoi* only 4 had their pollinia removed, while many of the *Pterostylis* species likewise did not seem capable of bringing about cross-pollination. He also states that in a number of orchids of various species he found self-fertilization taking place. Recent examination supports these facts. A number of *Thelymitra longifolia* and *T. unifolia* were watched and examined, yet, though the air was alive with insects, none were seen to approach the flowers, nor were any found with pollinia removed. The same was the case with *Pterostylis Banksii*. It therefore appears that the simpler structure mentioned above is more likely to ensure pollination by the insects in New Zealand.

This fact probably accounts for the prevalent so-called imperfection of our native flowers. Many species and genera which are hermaphrodite in other parts of the world are unisexual in New Zealand. It is by means of this unisexuality that our flowers can ensure cross-pollination taking place in spite of the comparatively simple structure due to the paucity of insects and large percentage of Diptera. Where in other countries flowers have highly complicated contrivances by means of which they can prevent self-



fertilization taking place, in New Zealand this is not possible, as the chief insect visitors will only visit flowers which are short-tubed, with pollen and nectar within easy reach. To ensure cross-pollination the easiest and safest way is for the flowers to assume a unisexual habit, and this seems to have been brought about in an extraordinarily large number of cases in New Zealand, where unisexuality certainly need not be regarded as any sign of primitiveness.

## ORCHIDACEAE.

*Microtis unifolia*: A small spider.

*Pterostylis Banksii*: A spider. A number of other species (*Dendrobium Cunninghamii*, *Earina suaveolens*, *Thelymitra longifolia*, *Thelymitra uniflora*, *Corysanthes rotundifolia*, and *Gastrodia Cunninghamii*) were also examined, but no insect visitors were observed.

From Zotov VD. Vegetation of the Tararuas. 1939. 68: 259-324.

## Orchidaceae.

*Dendrobium Cunninghamii* Lindl.—B,E,P,Z. WTemp, ATA, ep, c.

*Bulbophyllum pygmaeum* Lindl.—B,E,Z. LWTemp, ATA, ep, rr.

*Earina muconata* Lindl.—B,E,P,Z. LWTemp, ATA, ep, rr.

*E. autumnalis* Hook. f.—A,B,E,Z. WTemp, ATA, ep, cc.

*Sarochilus adversus* Hook. f.—B,E,Z. LMTemp, ATA, ep, rr.

*Thelymitra longifolia* Forst. var.—B,E,Z. WTemp, STA, c.

*T.l.* var.—E,Z. WTemp, STA, r.

*T. venosa* R. Br.—B,E,Z. WTemp, STA, open pl., rr.

*T. uniflora* Hook. f.—B,P,Z. CTemp, ATA, open pl., c.

*Orthoceras strictum* R. Br.—A,E,Z. WTemp, ATA, rr.

*Microtis unifolia* Reichenbach.—B. WTemp, STA, r.

*Prasophyllum Colensoi* Hook. f.—B,E,P,Z. CTemp, ATA, bogs, f.

*Pterostylis confertifolia* Coekn. et Allan.—A,B,E,Z. UCTemp, ATA, r.

*P. Banksii* R. Br.—A,B,E,Z. LWTemp, STA, f.

*P. graminea* Hook. f.—A,B,E. WTemp, STA, r.

*P. foliata* Hook. f.—A,M—A!,E. WTemp, STA, r.

*P. venosa* Col.—E,M—To!,Z. UCTemp, LCSubp, NTA, ETA, WTA, rr.

*P. trullifolia* Hook. f.—E. LWTemp, STA, r-f.

*P. barbata* Lindl.—E. LWTemp, STA, r.

*Acianthus Sinclairii* Hook. f.—E. LWTemp, STA, r.

*Cyrtostylis oblonga* Hook. f.—A,E. LWTemp, STA, r.

*Calochilus paludosus* R. Br.—W—Atkinson,X.

*Lyperanthus antarcticus* Hook. f.—E,P,W,Z. UCTemp, ATA, f.

*Caladenia minor* Hook. f.—E,W. LWTemp, STA, rr.

*C. bifolia* Hook. f.—E,P,W,Z. UCTemp, ATA, c.

*Chiloglottis cornuta* Hook. f.—A,B,E,W. UWTemp, LCTemp, STA, rr.

*Adenochilus gracilis* Hook. f.—E,Z. UWTemp, Ruamahanga basin (NTA), ff.

*Corysanthes oblonga* Hook. f.—B,W—Phillips. LWTemp, STA, r.

*C. rivularis* Hook. f.—E. c. 400 m., Mangatainoka R., r.

*C. rotundifolia* Hook. f.—B. LWTemp, STA, r.

*C. triloba* Hook. f.—B,E,P,Z. LCTemp, ATA, ff.

*C. macrantha* Hook. f.—B,E,Z. WTemp, ATA, c.

*Gastrodia sesamoides* R. Br.—A,W,X.

*G. Cunninghamii* Hook. f.—B,E,P,Z. LWTemp, ATA, ff.

## From Hair JB. The Chromosome Complements of Some New Zealand Plants - I. 1942. 71: 271-6.

Species.	Locality.	Chromosome Number.	
		n	2n
Orchidaceae.			
<i>Thelymitra longifolia</i>	Tataraimaka	—	26

## ORCHIDACEAE.

*Thelymitra longifolia*, which occurs also in Australia and Tasmania, has 26 somatic chromosomes, varying in length from 3.2 to 4.9  $\mu$ . Two pairs are distinguished by the presence of trabants (Fig. 1). The centromere in all is median or nearly so.

*Thelymitra* falls into the systematic sub-group Neottieae. For other genera of this group, Gaiser (1930) records chromosome numbers as follows:—

<i>Epipactis</i>	.. ..	n = 12; 2n = 24.
<i>Neottia</i>	.. ..	n = 16, 18.
<i>Spiranthes</i>	.. ..	n = 12.
<i>Gastrodia</i>	.. ..	n = 8-9; 2n = 16-18.



Fig. 1

FIG. 1—*Thelymitra longifolia*. Somatic metaphase;  $2n = 20$ .

From Healy AJ. Some Hitherto Unrecorded Plant Stations. 1943. 72: 324-332.

*Orthoceras strictum* R.Br.

Sounds—not uncommon in scrub, Pelorus and Kenepuru Sounds; Kaituna Valley.

*Prasophyllum rufum* R. Br.

Sounds—in manuka scrub, Portage; Te Mahia, Kenepuru Sounds.

*Pterostylis trullifolia* Hook.f.

Sounds—not uncommon in scrub, Pelorus Sounds; Forsyth Island; Taradale; Kenepuru Heads; Waitaria Bay; Portage, Kenepuru Sounds.

From Mason R. Station records of Indigenous plants. 1947. 77: 175-180.

ORCHIDACEAE.

*Thelymitra caesia* Petrie. South Auckland: Henderson Valley, at the foot of Spragg's Hill.

From Poole AL. Vegetation of the Caswell and George Sounds District. 1951. 79: 62-83.

Families and Species	Distribution	Approximate Abundance
ORCHIDACEAE		
<i>Dendrobium cunninghamii</i> Lindl.	L. Forest	2
<i>Barina mucronata</i> Lindl.	L. "	2
" <i>autumnalis</i> Hook. f.	L. "	3
<i>Microtis</i> (undetermined species)	L. Bog	1
<i>Lycopanthus antarcticus</i> Hook. f.	L. M. Forest	1
<i>Prasophyllum colensoi</i> Hook. f.	A. Herb-field	3
<i>Aporostylis bifolia</i> (Hook. f.) Rupp	L. M. Forest	3
<i>Corybas rivularis</i> (A. Cunn.) Hook. f.	L. "	3

From Gudex MC. The Occurrence of *Sarcochilus adversus* in the Waikato Basin. 1954. 82: 611-2.

This epiphytic orchid is found in most parts of the Waikato Basin. Usually it occurs on the edge of the bush, where there is plenty of light and the air is able to circulate rather freely.

In the bush on the flats it grows mostly on kahikatea, pokaka, titoki, hinau and mahoe. At higher levels it occurs on more kinds of trees, and in great numbers. Sometimes one tree carries over fifty plants plainly visible from the ground. At Te Aroha North five plants on one tree carried over thirty-five fruits.

At Old's Road, near Taupiri, *Sarcochilus* occurs in abundance on *Olearia furfuracea*, *Olearia rani*, *Weinmannia racemosa* and *Knightia excelsa*.

One plant found on a recently felled tree at Pirongia must have been growing at a height of 75 feet from the ground.

In two localities, Pirongia and Karamu, plants with unusually long and thin fruits were found; the leaves were reddish, but healthy.

After seven years of careful observation, I must conclude that *Sarcochilus adersus* is more common in the Waikato than in the fifty localities that I have examined in various parts of New Zealand.

HOSTS OF *Sarcochilus adersus*

*Podocarpus dactyloides* A. Rich.  
*Dacrydium cupressinum* Solander ex Forst. f.  
*Phyllocladus trichomanoides* D. Don  
*Macropiper excelsum* Miq.  
*Paratropis microphylla* (Raoul) Cockayne  
*Knightia excelsa* R. Br.  
*Laurelia novaezelandiae* A. Cunn.  
*Beilschmiedia taeni* (A. Cunn.) Benth. et Hook. f.  
*Litsaea calicaris* Benth. et Hook. f.  
*Quintinia serrata* A. Cunn.  
*Pittosporum eugenioides* A. Cunn.  
*Alectryon excelsum* Gaertn.  
*Weinmannia racemosa* Linn. f.  
*Dysoxylum spectabile* Hook. f.  
*Corynocarpus laevigata* Forst.  
*Elacocarpus dentatus* Vahl.  
*E. hookerianus* Raoul  
*Hoheria populnea* A. Cunn.  
*Meliccytus ramiflorus* Forst. J.R. et G.  
*Leptospermum scoparium* Forst. J.R. et G.  
*Nothopanax arboreum* (Linn. f.) Seem.  
*Pseudopanax crassifolium* (Sol.) C. Koch  
*Leucopogon fasciculatus* (Forst. f.) A. Rich.  
*Suttonia australis* A. Rich.  
*Coprosma australis* (A. Rich.) Robinson  
*Olearia furfuracea* Hook. f.  
*O. rani* (A. Cunn.) Druce

and four exotic plants:

*Prunus cerasus* L.  
*Fragaria vesicaria* L.  
*Ligustrum ovalifolium* Hassk.  
*Quercus robur* L.

From Gudex MC. The Native Bush Flora of Pirongia Mountain. 1955. 83: 303-311.

Orchidaceae

*Dendrobium cunninghamii*; Lindl.—A.  
*Bulbophyllum pygmaeum*; (Smith, ex Banks & Sol.), Lindl.—F.  
*Earina mucronata*; Lindl. ex Banks & Sol.—A.  
*E. autumnalis*; (Forst. f.), Hook. f.—A.  
*Sarcochilus adersus*; Hook. f. ex Banks and Sol.—F.  
*Thelymitra pauciflora*; R. Br. var. *pauciflora*.—F.  
*Acianthus fornicatus*; R. Br. var. *sinclairii*; (Hook. f.), Hh.—F.  
*Orthoceras strictum*; R. Br.—F.  
*Microtis unifolia*; (Forst. f.), Reichb. f.—A.  
*Prasophyllum colensoi*; Hook. f.—F.  
*Pterostylis banksii*; R. Br. ex A. Cunn. var. *banksii*.—A.  
*Chiloglottis cornuta*; Hook. f.—F.  
*Corybas macranthus* (Hook. f.), Reichb. f. var. *macranthus*.—F.  
*C. trilobus*; (Hook. f.), Reichb. f.—A.  
*Gastrodia cunninghamii*; Hook. f.—F.

From Gudex MC. The Native Flora of Claudelands Bush. 1955. 83: 313-319.

Orchidaceae

*Earina mucronata*; Lindl.—F.  
*Corybas trilobus*; (Hook. f.), Reichb. f.—(1).  
*Pterostylis banksii*; R. Br. ex A. Cunn. var. *banksii*.—(1)

From Gudex MC. The Indigenous Flora of the Taupiri Range. 1957. 85. 53-59.

ORCHIDACEAE

*Dendrobium cunninghamii* Lindl.—O  
*Bulbophyllum pygmaeum* (Smith ex Banks & Sol.) Lindl.—O  
*Earina mucronata* Lindl. ex Banks & Sol.—A  
*autumnalis* (Forst. f.) Hook. f.—C  
*Sarcochilus adersus* Hook. f. ex Banks & Sol.—C (in parts)  
*Thelymitra longifolia* Forst.—C  
*pauciflora* R. Br.—O  
*Microtis unifolia*; (Forst. f.) Reichb. f.—C  
*Pterostylis banksii* R. Br. ex A. Cunn.—A  
*trullifolia* Hook. f. var. *gracilis* Cheesem.—A  
*Acianthus fornicatus* (R. Br.) *sinclairii* Hook. f. Hh.—R  
*Caladenia minor* Hook. f.—R  
*Chiloglottis cornuta* Hook. f.—O  
*Corybas trilobus* (Hook. f.) Reichb. f.—O  
*macranthus* (Hook. f.) Reichb. f. var. *macranthus*—C



From Gudex MC. Additional Hosts for *Sarcochilus adversus*. 1958. 85: 471.

In Vol. 82, Part 2, September, 1954, of the *Transactions of the Royal Society of New Zealand* I gave a list of hosts of the epiphytic orchid *Sarcochilus adversus* (Hook. f.), including 27 native and 4 exotic species.

The following statement was made at the same time: "After seven years of careful observation, I must conclude that *Sarcochilus adversus* is more common in the Waikato than in the 50 localities that I have examined in various parts of New Zealand." Since then, my researches in Stewart Island, in various parts of Southland and Westland and in the Coromandel Peninsula have confirmed that opinion.

I am able now to record the following additional hosts of *Sarcochilus adversus*:

*Podocarpus totara* D. Don, at Brightwater, Nelson.

*Rhopalostylis sapida* Wendl. & Drude, at Kennedy's Bay, Coromandel.

*Beilschmiedia tarairi* Benth. & Hook. f., at Kennedy's Bay, Coromandel.

*Sophora microphylla* Ait. at Whale Bay, Raglan, and on the shores of Raglan Harbour.

*Vitex lucens* T. Kirk, at Whale Bay, Raglan.

*Fuchsia excorticata* Linn. f. on Maungakawa, near Cambridge.

*Tetrapathaea tetrandra* Cheesem. on Maungakawa, near Cambridge.

*Leptospermum ericoides* A. Rich., at Coromandel.

*Crataegus oxyacantha* Linn. (tree hawthorn) near Hamilton.

Fide Mrs. P. Hynes, Auckland, on *Alseuosmia macrophylla* A. Cunn. and on *Metrosideros excelsa* Sol. ex Gaertn. near Auckland.

Fide Mrs. Sanson, Invercargill, on *Metrosideros umbellata* Cav. in Stewart Island.

From Gudex MC. Native Flora of Maungakawa-Te Miro (Waikato). 1959. 87: 5-8.

#### THE SPECIES

Abbreviations: A = abundant; C = common; O = occasional; R = rare.

#### ORCHIDACEAE

*Dendrobium cunninghamii* Lindl.—O

*Bulbophyllum pygmaeum* (Smith ex Banks & Sol.) Lindl.—O

*Earina mucronata* Lindl. ex Banks & Sol.—A

— *autumnalis* (Forst. f.) Hook. f.—C

*Sarcochilus adversus* Hook. f. ex Banks & Sol.—O

*Thelymitra longifolia* Forst.—C

*Pterostylis banksii* R. Br. ex A. Cunn.—O

— *trullifolia* Hook. f. var. *gracilis* Cheesem.—O

— *graminea* Hook. f.—O

*Corybas trilobus* (Hook. f.) Reichb. f.—C

From Elder NL. Vegetation of the Kaweka Range. 1959. 87: 9-26.

A number of species link the Kaweka with the Kaimanawa and the volcanic plateau: *Dracophyllum strictum*, *D. subulatum*, *Aristotelia fruticosa*, *Myosotis australis* and *Caladenia lyallii*.

From Gudex MC. The Native Flora of the Bryant House-Whale Bay area. 1960. 88: 357-362.

#### ORCHIDACEAE

*Dendrobium cunninghamii* Lindl.—

R

*Bulbophyllum pygmaeum* (Smith, ex Banks & Sol.) Lindl.—O

*Earina mucronata* Lindl. ex Banks and Sol.—A

— *autumnalis* (Forst. f.) Hook. f.—R

*Sarcochilus adversus* Hook. f. ex Banks & Sol.—O

*Thelymitra longifolia* Forst.—C

*Microtis unifolia* (Forst. f.) Reichb. f.—O

*Pterostylis banksii* R. Br. ex A. Cunn.—R

— *trullifolia* Hook. f. var. *gracilis* Cheesem.—C

— *graminea* Hook. f.—R

*Acianthus fornicatus* R. Br. *sinclairii* Hook. f. Hth.—O

*Corybas rotundifolius* Hook. f.—C

— *macranthus* (Hook. f.) Reichb. f. var. *macranthus*—O

— *trilobus* (Hook. f.) Reichb. f.—O

From Rigg HH. The Pakihi Bogs of Westport, New Zealand. 1962.  
Botany 1 (7): 91-108.

## KEY TO SYMBOLS

T—Recorded by Townson, 1906. P—Recorded by Petrie, 1913. A—Species abundant.  
C—Species common. O—Species occasional. R—Species rare.

## SPECIES

## LOCALITY and ABUNDANCE

## ORCHIDACEAE

*Spiranthes australis*  
T *Thelymitra pachyphylla*  
T *Orthoceras strictum*  
*Microtis unifolia*  
T *Prasophyllum rufum*  
T *Pterostylis graminea*  
T *P. puberula*  
T *Calochilus paludosus*

Cape Foulwind pakihi—O  
All pakihi areas—A  
Not seen  
Semi-pakihi—O  
Not seen  
Semi-pakihi—O  
Not seen  
Not seen

From Gudex MC. The Native Flora of Fitzgerald Glade (Matamata  
County). 1962. Botany 1 (9): 117-120.

The abbreviations following the names have these meanings: A, abundant;  
C, common; O, occasional; R, rare.

## ORCHIDACEAE

*Dendrobium cunninghamii* Lindl.—R  
*Bulbophyllum pygmaeum* (Smith ex Banks  
& Sol.) Lindl.—R  
*Earina mucronata* Lindl. ex Banks and Sol.  
—A  
— *autumnalis* (Forst. f.) Hook. f.—O  
*Sarcochilus adversus* Hook. f. ex Banks &  
Sol.—O  
*Microtis unifolia* (Forst. f.) Reichb. f.—O  
*Thelymitra longifolia* Forst.—O

From Gudex MC. The Native Flora of Hakarimata Range (Waikato).  
1962. Botany 1 (10): 121-125.

The abbreviations following the names have these meanings: A, abundant;  
C, common; O, occasional; R, rare.

## ORCHIDACEAE

*Dendrobium cunninghamii* Lindl.—O  
*Bulbophyllum pygmaeum* (Smith ex  
Banks & Sol.) Lindl.—O  
*Earina mucronata* Lindl. ex Banks & Sol.  
—A  
— *autumnalis* (Forst. f.) Hook. f.—C  
*Sarcochilus adversus* Hook. f. ex Banks  
& Sol.—O  
*Thelymitra longifolia* Forst.—O  
— *pauciflora* R. Br.—O  
*Microtis unifolia* Reichb. f.—O  
*Pterostylis banksii* R. Br. ex A. Cunn.—C  
— *trullifolia* Hook. f. *gracilis* Cheesem.  
—C  
*Corybas trilobus* (Hook. f.) Reichb. f.—  
O  
— *macranthus* (Hook. f.) Reichb. f.—C

From Burrows C.J. The Flora of the Waimakariri Basin. 1962. Botany 1  
(15): 195-216.

ORCHIDACEAE										
<i>Acianthus reniformis</i> (R. Br.) Schlecht.									6*	U red beech forest
<i>Adenochilus gracilis</i> Hook. f.		3								
<i>Aporostylis bifolia</i> (Hook. f.) Rupp & Hatch	1	2	3	4						T bog
<i>Caladenia lyallii</i> Hook. f.	1	2			5					U snowgrass, streamside
<i>Chiloglottis cornuta</i> Hook. f.	1	2	3	4	5	6	7	8		U forest
<i>Corybas macranthus</i> (Hook. f.) Reichb. f.		2				5	6	7	8	U, L forest
<i>C. oblongus</i> (Hook. f.) Reichb. f.							6			U forest
<i>C. trilobus</i> (Hook. f.) Reichb. f.	1	2	3			5	6			U, L forest
<i>Gastrodia cunninghamii</i> Hook. f.	1	2			4	5	6		8	U forest
<i>Lyperanthus antarcticus</i> Hook. f.		2								
<i>Microtis magnadenia</i> R. S. Rogers						5				L grassland
<i>M. parviflora</i> R. Br.		2								
<i>M. unifolia</i> Reichb. f.		2		4	5	6			8	U, L fescue tussock
<i>Prasophyllum colensoi</i> Hook. f.		2			5	6			8	L fescue tussock
<i>Pterostylis areolata</i> Petrie	1*	2	3	4					8	L, U scrub
<i>P. australis</i> Hook. f.		2								U forest edge
<i>P. cynocephala</i> R. D. Fitzg.						5			8	L fescue tussock
<i>P. graminea</i> Hook. f.		2	3							U forest
<i>P. irsoniana</i> Hatch		2								
<i>P. montana</i> Hatch					5				8	L scrub
<i>P. mutica</i> R. Br.				4	5				8	L fescue tussock
<i>P. oliveri</i> Petrie	1*	2			5					U forest edge
<i>P. venosa</i> Col.		2								
<i>Thelymitra longifolia</i> Forst.		2				6	7	8		L, U scrub
<i>T. pachyphylla</i> Cheesem.		2			5				8	L grassland
<i>T. uniflora</i> Hook. f.		2							8	
<i>T. venosa</i> R. Br.					5					

Campbell EO. The Mycorrhiza of *Gastrodia cunninghamii*. 1962.  
Botany 1 (24): 289-296.

#### Summary

THE orchid, *Gastrodia cunninghamii*, lives in association with the fungus, *Armillaria mellea*, itself a parasite on the roots of forest trees. Of the three methods by which infection takes place the most important involves penetration of the basal rhizomes by fungal rhizomorphs proceeding from within the root of an adjacent tree. Fungal cytoplasm released into cells of the digestive layer of the rhizome provides nutriment for the orchid which lacks both roots and chlorophyll.

#### INTRODUCTION

*Gastrodia* is a genus of orchids which lack chlorophyll and live in association with a mycorrhizic fungus. Three species occur in New Zealand, one of which, *Gastrodia cunninghamii* Hook. f., is the subject of this paper. Kusano made a detailed study of the host-fungus relationship in a Japanese species, *G. elata* (Kusano 1911), and Burgeff studied species of *Gastrodia* from Indonesia (Burgeff 1959). Recently McLennan reported on the mycorrhizal condition in *G. sesamoides* as it occurs in Australia (McLennan 1959). Hamada also has added to our knowledge by investigating the mycorrhiza of *Galeola septentrionalis* and making a comparison with *Gastrodia* (Hamada 1939).

#### COLLECTION AND TREATMENT OF MATERIAL

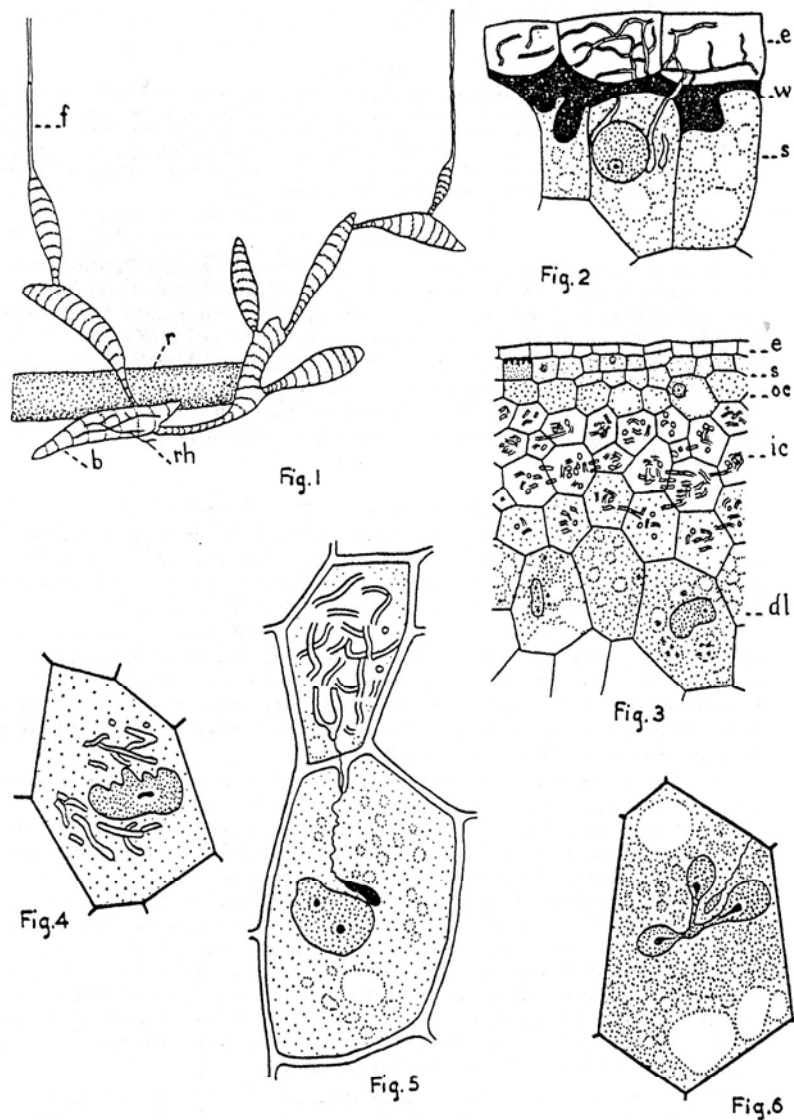
The bulk of the material was collected in mid-December from the *Nothofagus* forest between Cascade Creek and the southern end of Lake Gunn in Fiordland National Park. In this forest *Nothofagus menziesii* Oerst. is dominant but some *Nothofagus fusca* Oerst. occurs at a distance of 250 m from the lake.

The floor of the forest is carpeted to a depth of 10-15 cm with green moss, and below this is a zone 15-45 cm deep of brown, decaying moss penetrated by large roots and more or less horizontal, cavernous spaces left where roots have rotted away. Fine roots form an entanglement in the lower part of the brown, mossy layer. Below is the stony, gravelly zone of the old morainic deposit, penetrated throughout by large roots up to 12 cm in diameter.

In a few places it was found possible to excavate to sufficient depth to expose the complete underground portion of a *Gastrodia* plant. Often, however, this could not be accomplished. Sometimes the flowering stem emerges between the somewhat buttressed roots at the base of a tree trunk, in which case any attempt to follow the underground system of the *Gastrodia* would necessitate removal of the tree itself. Always the rhizomes are exceedingly brittle and are interwoven with a mass of roots. In the clay soil of the mixed rain forest in South Westland it was found to be even more difficult to follow the rhizome system and all attempts failed owing to the compact nature of the soil and the interwoven root systems of the trees and shrubs belonging to the different strata; but some material was obtained from the eastern side of Lake Manapouri where a thin moss and leaf-litter stratum approximately 10 cm deep overlies clay and where the beech—in this case *Nothofagus solandri* var. *cliffortioides* (Hook. f.) Poole—has a shallow rooting system.

Small portions of the rhizomes were killed and fixed in formalin-acetic-alcohol immediately following removal from the soil. The material was later dehydrated by the tertiary butyl alcohol method (Johansen 1940), embedded in paraffin and sectioned on the Cambridge rocker microtome at thicknesses of 7 $\mu$  to 20 $\mu$ . For general





## DESCRIPTION OF THE PLANT

The above-ground portion of *Gastrodia cunninghamii* Hook. f. consists of an erect, mottled-brown, flowering stem up to 2 mm in diameter and 60 cm high. It carries sheathing, scale leaves and a raceme of 15-25 whitish flowers. Below ground is a system of rhizomes, each one swollen for most of its length but constricted where it is attached to a more deeply-placed rhizome (Fig. 1). The rhizomes lack roots but bear the tawny, ragged remnants of scale leaves. At the Cascade Creek site the deepest rhizomes, which may be termed the basal rhizomes, are 60 cm or more below the surface and are always found lying in the gravel zone immediately underneath a large, horizontally-growing *Nothofagus* root of diameter 8-12 cm, but near Lake Manapouri they occur at a depth of only 20 cm. In one specimen from Cascade Creek 4 flowering stems lying on the circumference of a circle 1.2 m in diameter were attached to the one basal rhizome.

Thick rhizomorphs of the fungus, *Armillaria mellea* (Fr.) Quél., form a network around the basal rhizomes, attaching themselves at intervals, and also penetrate the tree root lying immediately above.

New rhizomes arise laterally on any of the old rhizomes and these may in their turn give rise to flowering stems. Old tubers, even those which have borne flowering stems, do not decay except when the food source becomes exhausted and then, unless a new nutritive supply becomes available, the whole plant dies away.

## ANATOMY OF THE RHIZOME

The rhizome as seen in transverse section shows the following structure. On the outside there is a protective region of suberized cells consisting of an epidermis of tangentially flattened, pavement-like cells which lose their protoplasts early and a subepidermal layer of larger, isodiametric cells with sparse contents (Fig. 3). Occasional hairs grow out from the epidermis. The rest of the rhizome when young has collateral vascular bundles scattered throughout a parenchymatous ground tissue, at first lacking starch and of uniform appearance except at the periphery where frequent tangential divisions may produce a layer of flattened cells. In enlarged tubers several regions can be distinguished within the protective layer. A cortex 4-11 cells deep consists of parenchyma containing small starch grains and occasional deposits of calcium oxalate in the form of a bundle of raphides. In regard to fungal infection it can be differentiated into an outer cortex 2-5 cells wide, in which the cells are sometimes tangentially flattened, and an inner cortex 2-6 cells wide, the cells gradually increasing in radial diameter inwards. Next is a storage region, some 14 cells deep, of larger cells which also increase in size inwards and are packed with large, compound starch grains. Collateral vascular bundles are scattered throughout this region and also throughout the broad central region of large parenchyma cells which may lack starch.

FIG. 1.—Part of the underground system of a plant of *Gastrodia cunninghamii*. b. basal rhizome, f. base of flowering stem, r. root of *Nothofagus*, rh. rhizomorph.  $\times 75$ .

FIG. 2.—Transverse section of the protective layer of a rhizome showing the first type of temporary infection. e. epidermis, s. subepidermal layer, w. wall thickening.  $\times 350$ .

FIG. 3.—Transverse section of the outer part of a young rhizome showing the second type of temporary infection. e. epidermis, s. subepidermal layer, o.c. outer cortex, i.c. inner cortex, d.l. digestion layer.  $\times 80$ .

FIG. 4.—Cell of inner cortex showing hyphal coils and amoeboid nucleus.  $\times 240$ .

FIG. 5.—Method of infection of a digestive cell showing the fine, convoluted hyphae with its expanded tip lying near the enlarged nucleus.  $\times 240$ .

FIG. 6.—Cell of the digestive layer showing the extreme deformation of the nucleus.  $\times 180$ .

anatomical study greatest contrast in staining was obtained by the use of a combination of safranin and Delafield's haematoxylin, although Heidenhain's haematoxylin was tried also. Suberization of the cell wall was determined by staining with Sudan IV, cellulose by testing with iodine followed by strong sulphuric acid, and lignification by the use of phloroglucin and strong hydrochloric acid, aniline sulphate, chrysoidin and fast green, crystal violet and erythrosin, and by the Mäule reaction.

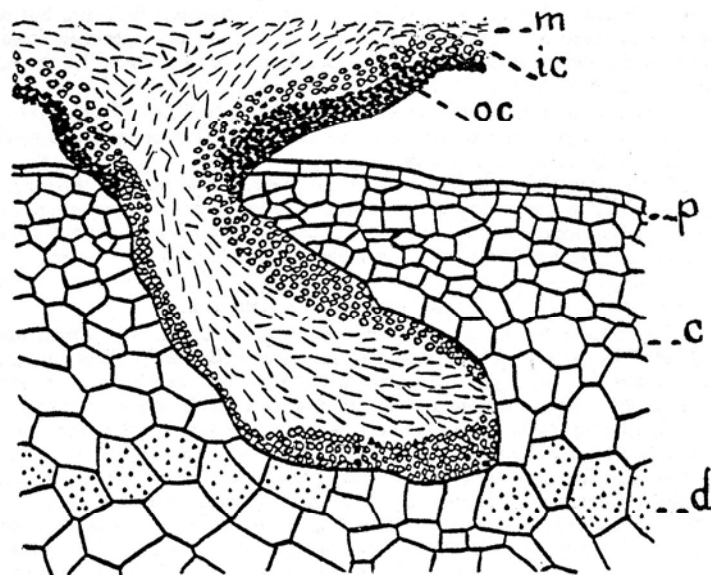


Fig. 7

FIG. 7.—Early stage in the development of the intraradical rhizomorph. The rhizome shows c. cortex, d. digestive layer, p. protective layer. The rhizomorph shows i.c. inner cortex, m. medulla, o.c. outer cortex.  $\times 74$ .

#### THE FUNGUS

The fungus involved is *Armillaria mellea* (Fr.) Quél., well-known throughout the world as a destructive parasite of the roots of trees. It is able to persist for some time after the death of the host and may even colonize dead timber saprophytically (Garrett 1960). Its presence in the forest was proven by the distinctive honey-coloured fructifications found at the base of a *Nothofagus* stump and by the characteristic rhizomorphs described below.

*Armillaria mellea* exists in two forms. The first, known as *Rhizomorpha subcorticalis*, appears as white sheets of mycelium beneath the bark of trees or lining the cavities of the moss zone where tree-roots have decayed. The second form, *Rhizomorpha subterranea*, occurs as brown rhizomorphs composed of fungal hyphae aggregated into a cylindrical strand up to 1.5 mm in thickness, which radiate through the soil and possibly infect another root. These have been reported to extend to a distance of 22 yards from the original host (Ellis 1929).

The thicker rhizomorph strands show several regions; an outer cortex of brown, thick-walled hyphae which acts as a protective layer and from which fine, colourless, peripheral hyphae grow outwards; an inner cortex of broad, thin-walled hyphae showing numerous septa; and a broad medulla of fine, hyaline hyphae loosely interwoven (Fig. 7).

#### THE FUNGAL INFECTION

Comparatively few of the rhizomes have fungal hyphae within them and even in these their presence tends to be localised.

There were found to be three methods by which infection takes place. Two methods have been classed as temporary infections since they are seasonal in occurrence and of limited extent. The third method, on the other hand, has been called a permanent infection since, although its activity is seasonal, once established it persists until the death of the plant.

The first type of temporary infection is confined to the protective region on the surface of the tuber. Mycelial strands, 3 to 12 cells in width, composed of rather thick hyphae lie in the axils of the scale leaves and slender, peripheral hyphae arising from these invade the outermost cells as single strands. An open network of septate, filamentous hyphae forms within the host cell which reacts by depositing additional material on the radial and the inner tangential walls (Fig. 2). The protoplast of the host cell disappears and the cell cavity is occupied by brown and somewhat thick-walled fungal hyphae which remain in an apparently dormant condition. At times some of the hyphal segments round off and have the appearance of thick-walled, brown chlamydo-spores.

Sometimes the infection is arrested at this stage. Sometimes hyphae penetrate laterally into an adjacent cell. More frequently hyphae penetrate into a subepidermal cell. Usually the subepidermal cell obtains nutriment from the fungus in the manner described below, but occasionally the fungus destroys the protoplast, forms an open network, and then passes on to a deeper cell where it yields up its content. In the usual course of events one or several hyphae penetrate the outer wall of the subepidermal cell which becomes much thickened on its inner face. Starch disappears from the cell. The hyphal tips grow towards the nucleus and curve round it like tentacles, while the nucleus itself becomes very granular with a conspicuous nucleolus and increases to three times its original diameter without becoming deformed (Fig. 2). The hyphal tips enlarge and then break down releasing fungal protoplasm which is rapidly absorbed except for a small amount of rejected material which remains in the form of minute granules staining darkly with haematoxylin in the augmented cytoplasm of the host cell. Wall material composed basically of cellulose is laid down as a sheath around the hypha where it entered the cell and, as successive layers are deposited, there arises a finger-like outgrowth, often lamellated, and sometimes extending the whole width of the cell. These so-called *röhrentüpfel* have a surface coating of suberin and usually show a narrow axial canal where the hypha passed. They differ from the hyphal sheaths which occur in the inner cortex and digestive layer in the types of infection described later, for these lack suberin and often become strongly lignified.

In the second type of temporary infection thick hyphae of the mycelial strand penetrate the epidermal cells and pass through into deeper cells where they form tight coils almost completely filling the cells. The infection may be halted in the subepidermal layer in which case thickening is deposited on the inner tangential and the radial walls and as a sheath around the hyphae at their point of entry and sometimes on hyphae within the cell. Usually the hyphae penetrate more deeply, up to a depth of 8 cells from the surface. Once they reach the cortex they spread laterally, extending for varying distances up to one-half of the circumference of slender tubers, depending on the virility of the infection as compared with that of the host plant.

Three regions of the host plant can be distinguished in each of which the course of the infection is different. These are the outer cortex, the inner cortex and the outermost part of the storage zone (Fig. 3).

The inner cortex is the region in which tangential spread of the fungus occurs. Sometimes there can be distinguished an inner zone of rapid tangential spread from which branches arise and spread more slowly in an outer zone. Within each cell a tight coil of hyphae develops. The starch grains disappear from the cell on entry of the fungus leaving vacuoles in the cytoplasm. The nucleus becomes very granular and enlarges to a lobed, amoeboid form (Fig. 4), then gradually shrinks and fades away. Later the cytoplasm disappears also. The central hyphae persist as thick-walled hyphae and function in translocation between the external hyphae in the soil and the advancing tips within the plant, but peripheral hyphae of the clump eventually collapse and disappear. Alteration occurs in the walls of the cells, which become slightly thicker and give characteristic lignin reactions with all the stains used except with the Mäule reaction, when the colour, as in the xylem of the bundles, is a brownish-yellow similar to that produced by gymnosperm lignin and not the red usually given by angiosperms. Some of the hyphae are ensheathed at the point of penetration of the wall and occasionally their sheaths are lignified in the same manner as the wall itself.

The outer cortex usually remains free of infection for a considerable period. Sometimes hyphae spreading outwards from the inner cortex form coils within the cells which persist for a time until in the end the nucleus and cytoplasm disappear. Eventually all the cells of the region become occupied by hyphae which destroy the remaining protoplasts and fill the cell cavities with a brown, thick-walled, pseudoparenchymatous tissue, corresponding in appearance to the outer cortical tissue of the rhizomorph and no doubt performing a similar protective function within the tuber. Affected areas are recognisable externally by a local darkening of the tuber.

The outermost cells of the storage zone function as a digestive region. Changes occur even before infection as evidenced by the enlargement of the cells in a radial direction. Infection always takes place by one or a few fine hyphae growing radially inwards from the cortical layer, never laterally from cell to cell. These take on a slender, spiral form as they pass through the cytoplasm to the vicinity of the nucleus (Fig. 5). Much of the starch disappears, especially on the side furthest from the hyphae, and is apparently utilised by the nucleus or by the cytoplasm. The nucleus enlarges to a lobed structure up to four times its original diameter and becomes very granular—an indication that it is in a highly metabolic state. It then undergoes a characteristic deformation by becoming deeply constricted into two or three spherical portions which move apart but still remain connected together by attenuated, isthmus-like regions (Fig. 6). The nucleolus at first enlarges to eight times its original diameter so becoming very conspicuous, and then fragments into several small nucleoli. Once an entering hypha reaches the vicinity of the nucleus, its tip swells

and becomes deeply staining as protoplasm and reserve food accumulate within it (Fig. 5, 6). Then it undergoes plasmolysis; the hyphal tip bursts and the hyphal contents are ejected as a cloud into the host cell. Some of the material rounds off as free fungal bodies (ptyosomes) which are digested immediately, some becomes surrounded by a membrane and constitutes a vesicle which is digested later, and part is rejected and remains in the protoplasm of the host cell as small, spherical excretory bodies. The hypha itself disappears, but a basal, lignified sheath is often present and persists as a papillose projection into the cell. The adjoining portion of the cell wall, and eventually the whole of the penetrated wall, becomes lignified also, but the composition of the other walls of the digestive cell is not altered. The protoplast of the host cell persists, now containing the excretory bodies as an indication that digestion has occurred.

The third type of infection is the one of greatest importance in supplying nutriment to the mature *Gastrodia* plant. It occurs in the basal rhizomes which lie close underneath a large root at some depth in the soil. Large rhizomorphs emerging from the root above form a network over the surface of the tuber and also penetrate into the cortex and outer part of the storage zone, where they construct what Hamada has called in *Galeola* "intraradicale Rhizomorpha" (Hamada 1939) by growing through the tissue mainly in a length-wise direction parallel to the surface of the rhizome, destroying by their passage the cells in their immediate path (Fig. 7). Only the inner cortical and medullary hyphae of the external strand make up most of the length of the intraradicale Rhizomorpha; the brown, cortical hyphae at first penetrate no further than three cells from the surface and spread laterally into the cell cavities to a distance of only some ten cells from this point, destroying the protoplasts and filling the cells with a brown, pseudoparenchymatous tissue. Strands of wide cortical hyphae and slender medullary hyphae radiating from the intraradicale Rhizomorpha travel laterally through the inner cortex of the host plant advancing most rapidly in the innermost zone of cells. The wide hyphae form a coiled mass within each cell as they proceed and the slender storage hyphae grow around and amongst them. Starch disappears from the cells; the nucleus assumes an enlarged, lobed form and then becomes evanescent and disappears, followed gradually by the cytoplasm; the slender hyphae break down but the thick hyphae remain as transporting hyphae and these may be ensheathed at their point of penetration of the wall. A few of the sheaths and all of the cell-walls in the region become lignified.

The outer cortex of the rhizome remains free of infection for a considerable time but in the end penetrating hyphae travelling either radially outwards or tangentially may destroy the protoplasts and replace them with a thick-walled, brown pseudoparenchyma. So altered, the outer cortex reinforces the still intact, surface layers of the tuber in the protection of both the intraradicale Rhizomorpha and the extended hyphal strands.

Outer cells of the storage region constitute a digestive layer. These are infected radially from the cortical region by slender hyphae which take a convoluted path towards the nucleus. The rupture of the hyphal tips and digestion of fungal material take place as in the temporary infection described above. As before the cells remain alive and may again store starch.

#### DISCUSSION

The mycorrhizal condition of *Gastrodia cunninghamii* corresponds in some respects with that of *G. elata* which has been fully described by Kusano (Kusano 1911), for in both cases the rhizomes are infected by *Armillaria mellea*. In *G. sesamoides* also it is the rhizome which becomes infected by a fungus (McLennan

1959). But in two other species of *Gastrodia*, namely *G. callosa* and *G. javanica*, the root forms the mycorrhizal association (Burgeff 1959), although the method by which the orchid obtains food from the fungus is the same as in the rhizome-infected ones. The situation in *G. cunninghamii*, however, is more complicated than in any of the others because of the fact that the infection may take one of three forms.

The first type of temporary infection in *G. cunninghamii* is of limited importance in the adult plant. The second type shows some similarity with that described for *G. sesamoides* (McLennan 1959) but in *G. cunninghamii* it also is of limited importance. The permanent infection on the other hand is without doubt of the greatest importance in supplying nutriment to the *Gastrodia* plant. The rhizomorph obtains food in the first instance by its parasitic action on the roots of the *Nothofagus* (or other) tree and some of this becomes available to the *Gastrodia* plant as a result of the digestion processes within its basal rhizomes. Only when the permanent system is established has the *Gastrodia* sufficient nutriment to enable flowering to take place. This type of permanent infection is paralleled by the permanent infection recorded for *Galeola septentrionalis* (Hamada 1939); but in this *Galeola* species it is the orchid root which is penetrated by fungal rhizomorphs of *Armillaria* and the digestion process involves hyphal coils and not ejected fungal cytoplasm.

#### ACKNOWLEDGMENT

The writer is indebted to the Commissioner of Crown Lands, Invercargill, for permission to collect specimens of *Gastrodia* from Fiordland National Park.

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#### From Esler AE. Botanical Features of Abel Tasman National Park. 1962. Botany 1 (25): 297-311.

Three orchids, *Dendrobium cunninghamii*, *Earina mucronata* and *E. autumnalis* occur as terrestrial plants.

#### ORCHIDACEAE

- Acianthus sinclairii* Hook. f.  
*Adenochilus gracilis* Hook. f.  
*Bulbophyllum pygmaeum* Lindl.  
*Caladenia bifolia* Hook. f.  
*C. lyallii* Hook. f.  
 — *minor* Hook. f.  
*Corysanthes oblongus* Hook. f.  
 — *rotundifolia* Hook. f.  
*Dendrobium cunninghamii* Hook. f.  
*Earina autumnalis* Hook. f.  
*E. mucronata* Lindl.  
*Microtis unifolia* Reichb.  
*Orthocerus strictus* R. Br.  
*Prasophyllum colensoi* Hook. f.  
*Pterostylis banksii* R. Br.  
 — *graminea* Hook. f.  
 — *trullifolia* Hook. f.  
*Sarcochilus adversus* Hook. f.  
*Thelymitra longifolia* Forst.

#### From Gudex MC. Native Flora of Motukokako Reserve (Raglan Harbour, West Coast of North Island). 1962. Botany 1 (26): 313-316.

#### ORCHIDACEAE

- Dendrobium cunninghamii* Lindl.—R  
*Earina mucronata* Lindl.—O  
 — *autumnalis* Hook. f.—R  
*Sarcochilus adversus* Hook. f.—O  
*Pterostylis banksii* R. Br. ex A. Cunn.—  
 O  
*Acianthus fornicatus* (R.Br.) var. *sinclairii* (Hook. f.) Hatch—R  
*Corybas macranthus* (Hook. f.) Reichb.  
 f. var. *macranthus*  
*Pterostylis banksii* R. Br.—R  
 — *trullifolia* Hook. f. var. *gracilis*  
 Cheesem.—O



From Gudex MC. Native Flora of Tauhei-Pukemokemoke. 1962. Botany  
1 (27): 317-321.

## ORCHIDACEAE

- Dendrobium cunninghamii* Lindl.—O  
*Bulbophyllum pygmaeum* (Smith) Lindl.—O  
*Earina mucronata* Lindl.—C  
 — *autumnalis* (Forst. f.) Hook. f.—O  
*Sarcochilus adversus* Hook. f.—O  
*Pterostylis banksii* R. Br. ex A. Cunn.—O  
 — *trullifolia* Hook. f.—O  
*Corybas trilobus* (Hook. f.) Reichb. f.—O  
 — *macranthus* (Hook. f.) Reichb. f.—O  
*Acianthus fornicatus* R. Br. var. *sinclairii*  
 (Hook. f.) Hatch—O

From Gudex MC. The Native Flora of the Bridal Veil Falls Scenic  
Reserve. 1962. Botany 1 (28): 323-6.

## ORCHIDACEAE

- Dendrobium cunninghamii* Lindl.—O  
*Bulbophyllum pygmaeum* (Smith) Lindl.—R  
*Earina mucronata* Lindl.—A  
 — *autumnalis* (Forst. f.) Hook. f.—O  
*Sarcochilus adversus* Hook. f.—R  
*Thelymitra longifolia* J. R. et G. Forst.—O  
*Acianthus fornicatus* R. Br. var. *sinclairii*  
 (Hook. f.) Hatch—O  
*Microtis unifolia* (Forst. f.) Reichenbach  
 f.—O  
*Pterostylis banksii* R. Br.—C  
*Chiloglottis cornuta* Hook. f.—R  
*Corybas macranthus* (Hook. f.) Reichb.  
 f.—O  
 — *trilobus* (Hook. f.) Reichb. f.—O  
 — *rivularis* (A. Cunn.) Reichb. f.—R

From Gudex MC. The Native Flora of Arnold's Bush, Piarere. 1962.  
Botany 1 (29): 327-9.

## ORCHIDACEAE

- Earina mucronata* Lindl.—O  
 — *autumnalis* (Forst. f.) Hook. f.—O  
*Thelymitra longifolia* J. R. & G. Forst.—R

From Cochrane GR. The Alderman Islands: A Remnant of Primaeval  
New Zealand. 1962. Botany 1 (30): 331-341.

## PLANT LIST

Comparative floristic lists are given for the four main islands of the Alderman Group. No indication is given as to the percentage frequency of each plant, the symbol "p" only indicating the presence of that species on the island. Nomenclature follows Allan (1961), except for Monocotyledons which are based on Cheeseman (1906).

Species	Ruamahua-nui	Ruamahua-iti	Hongiora	Middle Island
ORCHIDACEAE <i>Thelymitra longifolia</i>		p	p	p

From Elder NL. Vegetation of the Kaimanawa Ranges. 1962. Botany 2  
(1): 1-37.

The large green and white flowered orchid *Prasophyllum suttonii* though rare has been collected here and at Horotea, a few miles north of the swamp, with similar vegetation. (*P. suttonii* has also been collected from a swamp at Hautu, near Tokaanu, on the margin of the Northern Kaimanawa.)

two South Island species, an orchid, *Caladenia lyallii*, and a yellow forget-me-not, *Myosotis australis*, though not common, are distributed widely across both Kaimanawa and Kaweka Ranges.

## Epiphytes:

<i>Earina mucronata</i>	2
<i>E. autumnalis</i>	2

## LIST 9.—Central Kaimanawa, Species Associated with Snowgrass Tussock.

<i>Pterostylis humilis</i>	loc. 2
<i>Prasophyllum colensoi</i>	2
<i>Caladenia lyallii</i>	2

## LIST 12.—Southern Kaimanawa, Bog Species

<i>Thelymitra uniflora</i>	2
<i>Corybas macrantha</i>	loc. 2



Campbell E.O. *Gastrodia minor* Petrie, an epiparasite of Manuka. 1963. Botany 2 (6): 73-81.

### Summary

THE non-green orchid, *Gastrodia minor*, obtains its nutrient supplies by the absorption of fungal cytoplasm in the digestive layer of its tubers. The fungus concerned is partially ectotrophic and partially endotrophic on the roots of manuka and behaves, at least in part, as a root-inhabiting parasite.

### OCCURRENCE OF *Gastrodia minor*

*Gastrodia minor* Petrie was first described by Petrie from material collected in the Town Belt, Dunedin, in shady manuka bush (Petrie, 1892), but from this locality it has now disappeared. It is very plentiful at the eastern end of Lake Manapouri growing under the manuka, *Leptospermum scoparium* J. R. and G. Forster, which occurs as a scrub vegetation in clearings in the southern beech forest and as a fringing belt along the shore of the lake. There may be no other plants present except the mosses, *Dicranoloma billardieri* (Schwaegr.) Par. and *Thuidium furfursum* (H.f. and W.) Jaeg., as an open floor-covering. At the beech-manuka ecotone *G. minor* occurs only 60 cm distant from the larger *G. cunninghamii*, a plant of the *Nothofagus* forests in this area. Neither *Gastrodia* species was found in association with the kanuka, *Leptospermum ericoides* A. Rich., which occurs in groves in some of the clearings. *G. minor* may also be found growing under manuka in the Taihape-Taupo region of the North Island.

### DESCRIPTION OF *Gastrodia minor*

An account of the above-ground portion of the plant has been given by Petrie (Petrie, 1892) and further details have been added by Hatch (Hatch, 1948). There is a slender, amber-brown, flowering stem 8-24 cm high bearing 3-9 flowers. The flowers either do not open at all or open very slightly and were not visited by insects so far as could be determined, but in every case a seed-capsule developed. Hatch has already shown that the structure of the flower is such that self-pollination is possible (Hatch, 1954).

Below ground there is a branching system of 2 to 12 tubers, the largest up to 10 mm in diameter and 40 mm in length (Fig. 1). They lie at a depth of about 70 mm in the soil, the new tubers spreading laterally from the old ones rather than growing to a higher level. Interwoven with the tubers are numerous fine manuka roots not more than 12 mm in diameter and often much less, some of the finest roots of diameter 0.1 to 0.2 mm lying closely appressed to the tubers and even encircling them. Older rhizomes die away in the autumn, and only those of 2 to 3 seasons persist through the winter, some as vegetative tubers and others with the flower-primordia for next season already present. The tubers lack roots but carry the ragged remnants of scale leaves. Regions of fungal infection are visible as concave, circular marks 2 to 3 mm in diameter or as larger, brown, roughened patches up to 10 mm in length. With a lens it can be seen that in places slender brown hyphae form an open network over the surface of the rhizomes and extend on to the fine roots lying alongside.

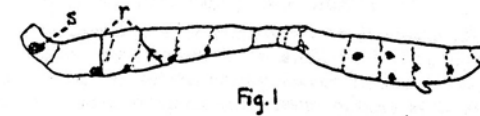


Fig. 1

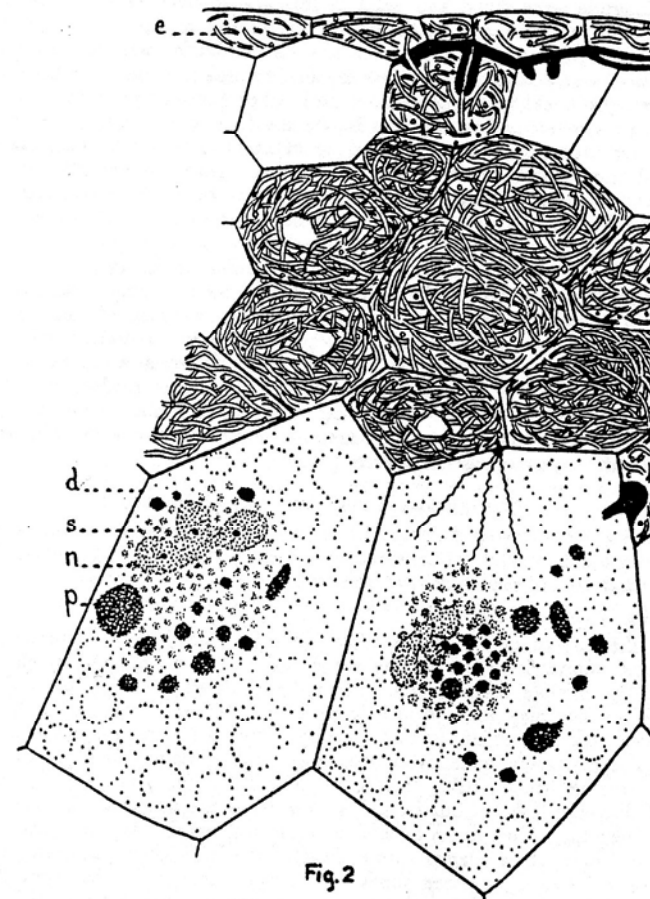


Fig. 2

FIG. 1.—Tuber system of *Gastrodia minor* × 1. r. encircling manuka root, s. scar left by fungal infection.

FIG. 2.—Transverse section of the outer part of a tuber with the second type of infection. × 375. d. digestive layer, e. epidermis, n. nucleus, p. pyrosome, s. starch.

#### COLLECTION AND TREATMENT OF MATERIAL

Most of the material was collected in mid-December and early May from the Lake Manapouri site. Here a water-retentive, organic-matter layer, some 70 mm deep, composed of decaying manuka leaves and mosses and penetrated by fine manuka roots is readily lifted from an underlying, morainic gravel or sandy-clay zone. The tubers of *Gastrodia minor* occur at the base of the organic horizon and are readily excavated from the soil.

Immediately following their removal some of the rhizomes and the manuka roots alongside were killed and fixed in formalin-acetic-alcohol. Later these were embedded in paraffin and sectioned at thicknesses of  $8\mu$  to  $20\mu$ . For general anatomical study safranin and Delafield's haematoxylin, safranin and fast green, or chrysoidin and fast green proved satisfactory stains. Other rhizomes and roots were brought back to the laboratory and either potted up in the glasshouse or used in an attempt to identify and isolate the fungus as described below.

For comparison of the root structure of manuka in other soils, material was collected from a terrace site in the Manawatu, where the soil type is Tokomaru silt loam with a heavy textured subsoil, and this root material was later sectioned and stained. Also, plants were grown from seed in sterilised potting soil in a glasshouse.

#### ANATOMY OF THE *Gastrodia* RHIZOME

A transverse section of the rhizome shows the following structure. On the outside is a protective region of suberised cells, consisting of an epidermis of flattened, pavement-like cells and a subepidermal layer of isodiametric cells. The layer immediately below may be suberised also. There is a cortex some 3 cells deep, a few of the cells containing a deposit of calcium oxalate in the form of a bundle of raphides and the rest storing small starch grains. A wide, central zone has vascular bundles scattered throughout the ground tissue of thin-walled cells packed with large, compound, starch grains.

#### THE FUNGAL INFECTION OF THE RHIZOME

There are two types of fungal infection. The first affects the epidermal cells, sometimes the subepidermal cells, and occasionally the outermost cortical cells also. The second affects deeper cells of the tuber.

##### *The First Type of Infection*

On the surface of the tubers there are septate hyphae of diameter  $6\mu$  showing clamp connections and having rather thick, brown walls when old (Fig. 8). Usually the hyphae occur singly, but in the confined space of the axils of the scale leaves they may entwine in a loose strand. Infection takes place by a hypha, after first attaching itself, forcing its way along the middle lamella of a radial wall, or occasionally penetrating the outer wall directly, then entering the cell and destroying its contents. Inside the cells the hyphae are usually thin-walled and of diameter  $2-2.5\mu$ , but in a few cells there are brown, thick-walled hyphae of diameter  $4\mu$ . They lie in a band or loose coil within the cell cavity, and if of sufficient length show clamp connections. Sometimes they penetrate no further than the epidermis; at other times the subepidermal cells and even the outermost cortical cells are affected also. Entry into a subepidermal cell is effected by hyphae forcing their way along the middle lamella and entering probably through a weakened pit. The hypha grows towards the nucleus which becomes enlarged, then evanescent and finally together with the cytoplasm disappears completely. The hyphae themselves collapse and disappear. Often the pene-

trated wall is considerably altered, appearing much thicker than previously and, as well as being suberised, giving a slight reaction for lignin. In some cases suberised, cellulosic sheaths which were secreted around the entering hyphae persist as papillose outgrowths (röhrentüpfel) projecting into the cell cavity. In isolated cells where the hyphae have penetrated to the outermost cortex all the walls of the subepidermal cells are thickened. Occasionally röhrentüpfel occur also on the radial walls of the epidermis. The thickened walls and röhrentüpfel appear to seal off areas damaged by the fungus.

##### *The Second Type of Infection*

This occurs where the tuber lies alongside a young manuka root on which the fungus is well established. Hyphae are densely aggregated between the surfaces of the root and rhizome. Some of the hyphae enter the epidermal cells of the tuber and form a dense coil within each cell over a band some 10 cells wide (Fig. 2). They grow into the cortex through a single passage cell of the subepidermal layer in which a similar, tight coil develops and in some cases röhrentüpfel also. Once within the cortex the hyphae spread tangentially in a zone some 3 cells deep, filling each cell with a tight coil of uniform diameter as they proceed (Fig. 2). The nucleus of each infected cell enlarges, becomes slightly lobed in outline with a conspicuous nucleolus, then becomes evanescent and disappears, leaving a gap in the position it formerly occupied. The cytoplasm disappears also. A single layer of cells on the inner side of the cortex functions as the main digestive layer (Fig. 2). Although not predetermined, the region soon becomes conspicuous by enlargement of the cells in a radial direction and by the course of the infection. The digestive cells are infected by hyphae growing radially inwards from the cortex and not by hyphae travelling tangentially. The entering hyphae branch into many fine threads which become greatly coiled along their length and expanded at their tips as they grow towards the nucleus (Fig. 3). Starch gradually disappears from the cell commencing at the periphery. The enlarged nucleus becomes grossly deformed by constricting into 4 or more portions held together by narrow, isthmus-like regions. Fungal cytoplasm released into the host cell appears as numerous spherical bodies (ptyosomes) which gradually shrink in size as they are slowly absorbed until they disappear completely. In the last stages of absorption the cytoplasm of the digestive cell becomes coarsely granular. The coiled remains of the hyphal walls persist for a time together with a lignified basal sheath at the point of entry. The penetrated wall itself becomes lignified. Gradually the nucleus reassumes a more spherical shape though still enlarged, then eventually loses its stainability and together with the cytoplasm disappears. Usually one or two layers of cells on the inner side of the main digestive cells are also affected by the fungus. Hyphae forcing their way along the middle lamella enter the cells as a fine, coiling, unbranched thread which grows towards the nucleus. Starch gradually disappears from the cells. The nucleus enlarges, sometimes becoming lobed, loses its staining properties, and then disappears together with the cytoplasm and the hyphal thread.

Eventually the whole region of invaded cells below the protective layer collapses, leaving a cavity in the tuber. The protective layer, now unsupported from below, sags inwards and presents a roughened, irregular surface to the exterior, or breaks away exposing a brown scar.

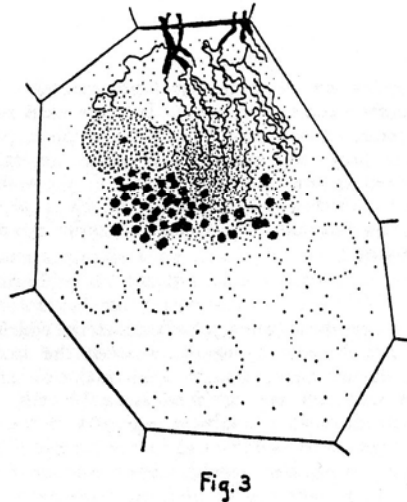


Fig. 3

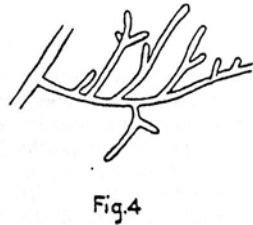


Fig. 4

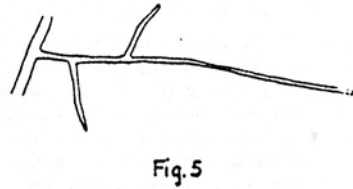


Fig. 5

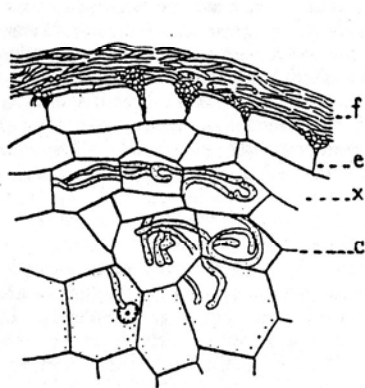


Fig. 6

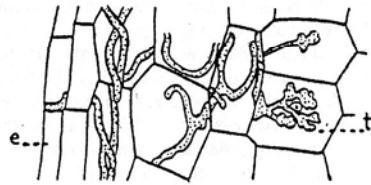


Fig. 7

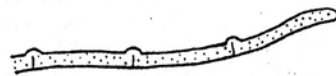


Fig. 8

FIG. 3.—Transverse section of a digestive cell of a tuber showing numerous coiled hyphae.  $\times 320$ .

FIG. 4.—Lateral mycorrhizal root of manuka  $\times 5$ .

FIG. 5.—Lateral non-mycorrhizal root  $\times 5$ .

FIG. 6.—Transverse section of the outer part of a manuka root with ectotrophic and endotrophic infection  $\times 375$ . c. cortex, e. epidermis, f. fungal mantle, x. exodermis.

FIG. 7.—Longitudinal section of the outer part of a manuka root with endotrophic infection.  $\times 375$ . e. epidermis, t. swollen ends of hyphae.

FIG. 8.—Single hypha from the surface of a tuber  $\times 400$ .

#### THE MORPHOLOGY OF THE MANUKA ROOTS

Two types of root system were investigated in well-established plants, namely that occurring in Tokomaru silt loam in the Manawatu and that found in the raw humus soil of the Manapouri region.

In plants 1 m high which were carefully dug up from Tokomaru silt loam near Palmerston North and washed free of soil it could be seen that the main framework of the root system consists of a few, long, slender roots on which arise numerous lateral roots. Approximately 1% of the lateral roots are long and slender, with copious, long-persistent, root hairs (Fig. 5), the rest are short, branching roots lacking root hairs, the majority being somewhat wider, mycorrhizal roots which persist for only a limited time, when they are replaced by new ones (Fig. 4). A transverse section of a long root with no secondary growth shows an epidermal layer of rather flattened cells bearing root hairs and beneath this an exodermis which becomes slightly suberised as the root ages. The rest of the cortex some 3-5 cells wide consists of larger cells with thin, cellulose walls. The endodermis at first has a deposit of suberin and lignin in the Caspary's bands, and at a later stage a deposit of suberin in all the walls. At the centre of the root is a small stele usually tetrarch in build.

A few of the short roots have no root hairs, but are not typically mycorrhizal in that the fungal mantle is lacking. They have an epidermal layer of flattened cells with somewhat thickened, slightly suberised walls and an exodermis which likewise is slightly suberised. Hyphae may be present within the epidermal cells but only at a few places along the length of the root do hyphae penetrate to the cortex.

Typical mycorrhizal roots have a superficial mantle of fungus with hyphae penetrating in the form of a Hartig net along the radial walls of the epidermal cells. The epidermal cells are themselves enlarged in a radial direction. Some hyphae penetrate into the cortical cells destroying the contents, and soon the affected cells collapse, leaving a cavity beneath the exodermis.

The root system of the manuka in the raw humus soil of the Manapouri region was found to consist of a few main roots on which arise numerous simple or branched, mycorrhizal roots that form a dense entanglement in the organic matter layer. The branching of the root system is much more extensive than in the Tokomaru silt loam and typical mycorrhizal roots are more numerous. The mycorrhizal roots last for a limited time and are replaced by new ones arising adventitiously.

The apical region of the mycorrhizal root ensheathed by the root cap is loosely enveloped by the fungus. Immediately behind this region the root over a length of some 5 mm has the appearance in transverse section of a typical, ectotrophic mycorrhiza with the fungus forming a dense external mantle some 8 hyphae in thickness and penetrating along the walls of the epidermal cells as a Hartig net (Fig. 6). The epidermal cells become enlarged in a radial direction to as much as three times the original diameter. This enlargement together with the external fungal mantle is responsible for the appearance of stoutness in comparison with a non-infected root. At the stage when the protoxylem is lignified, hyphae may enter the epidermal cells and grow towards the nuclei which enlarge, then become evanescent, and together with the cytoplasm disappear. The hyphae persist in the cells for some time probably in a dormant condition. Further advance is to a large extent barred by the exodermis with its radial walls by now suberised. At a later stage all the walls of the exodermis are suberised and the rest of the

cortex in the absence of fungal infection develops thickened, lignified walls which appear brown in sections of fresh roots.

However, every now and then, hyphae penetrate into an exodermal cell where the nucleus enlarges and then disappears. Occasionally hyphae break through into the cortex by penetrating along the radial walls of the exodermis and then spreading along the walls and through the cells. Cortical infection was found to occur more commonly in older parts of the root where the cortex was still unligified but where no external mantle was evident, only long, tangled strands of brown hyphae connecting one root to another. In the outer cortex the intracellular hyphae, at first somewhat swollen and staining deeply, soon destroy the cell contents and lie curved inside the wall or as a band running through the cell cavity. In the inner cortex the intracellular hyphae are more slender and their tips branch and enlarge in the vicinity of the nucleus to form coralloid masses retentive of stain, which appear to be haustorial in nature (Fig. 7). The nucleus loses its affinity for stains and gradually disappears together with the cytoplasm. In no case were hyphae found to penetrate the endodermis which gradually accumulates tannin-like compounds. The infected cortex soon collapses leaving a cavity beneath the exodermis, its disintegration hastened by the arrival of other species of fungi.

Since under natural conditions in both the Tokomaru silt loam and in the Manapouri raw humus soil a fungus was found to be closely associated with the roots of the manuka, it was decided to investigate the roots of plants grown from seed in some other type of soil. Seedlings grown in a glasshouse in a sterilised potting soil consisting of 1 part peat:1 part sand:2 parts loam were turned out of the pots after 6 months' growth when the stem was 11-13 cm high. Examination showed a slender tap-root system supplemented by long adventitious roots arising on the proximal portion of the main root. Root hairs were present on all the rootlets and there was no sign of fungus. The plants appeared very healthy. Seedlings grown under comparable conditions in Manapouri soil were 4-8 cm high with a less well-developed root system, but they also had root hairs on all the rootlets, though sparsely distributed on the smaller plants, and there were no mycorrhizal roots.

#### THE FUNGUS

Some preliminary experiments were carried out in an attempt to isolate and identify the fungus.

In the first set of experiments manuka roots which had been collected in December from the vicinity of *Gastrodia* rhizomes were washed for 3 hours by shaking in ten changes of sterile distilled water in 500 ml cylindrical flasks and then dissected on sterile slides. Single hyphae were transferred to agar plates and kept in an incubator at 22° C. Either malt agar was used on the plates or medium A, namely:

Malt extract	5.0 gm
Peptone	1.5 gm
Agar	20.0 gm
Water	1,000.0 ml
With or without the addition of dextrose	20.0 gm

After an interval of either 7 or 14 days portions of any colonies produced were transferred to medium B which was based on the experiments by Garrett in connection with the growth of rhizomorphs of *Armillaria* (Garrett 1953). The plates were examined at intervals over a period of 28 days.

Dextrose	20.0 gm	Ferric chloride	2.0 gm per litre
Potassium phosphate	1.0 gm	Thiamin	0.25 mg per litre
Magnesium sulphate	0.5 gm	Agar	20.0 gm
Peptone	6.0 gm	Water	1000.0 ml

Since the cultures either proved sterile or yielded rapidly growing soil saprophytes it was concluded that single hyphae were too small to be of value as a source of inoculum.

A second set of experiments was set up following the lines of the first except that pieces of rhizomes 2 mm long or of roots 1 mm long were used as a source of inoculum. A drop of sterile 5% lactic acid was added to depress the growth of bacteria. Hyphae of the endophyte spread in the cells of the tuber, but only in 1% of the cases did hyphae grow out into the culture medium and then for only a short distance. When pieces of root were used, soil saprophytes quickly dominated the culture plates. A number of fungi were isolated, but in no instance was *Armillaria* found to be present.

In a third set of experiments rhizomes were collected in May. Immediately following their removal from the soil these were placed in tubes which had previously been partially filled with damp sphagnum moss, plugged with cotton wool and autoclaved. On return to the laboratory these rhizomes were washed by shaking for 3 hours in sterile distilled water in McCartney tubes on an end-over-end shaker (40 r.p.m.), the water being changed at 15 minute intervals. The rhizomes were then cut into pieces 3 mm long, and these after shaking in a fresh lot of sterile distilled water were placed on agar plates and kept at 22° C. in an incubator.

Media used were:

1. Plain agar
2. Medium A as given above
3. Medium B as given above
4. Dextrose 20.0 gm, Peptone 6.0 gm,  $\text{KH}_2\text{PO}_4$  1.0 gm, Agar 20.0 gm,  $\text{MgSO}_4$  0.5 gm, Water 1,000.0 ml
5.  $\text{NH}_4\text{NO}_3$  10.0 gm, Lactic acid 2.0 gm,  $\text{K}_2\text{HPO}_4$  5.0 gm, Agar 20.0 gm,  $\text{MgSO}_4$  1.0 gm, Water 1000.0 ml

In some cases there was added to each 5 ml of the medium, prior to autoclaving, either 1 ml root extract or 1 gm filter paper, but no increased growth of the endophyte was observed as a result.

In some cases to each 50 ml solution there was added, prior to autoclaving, either 10 ml root extract or 10 gm filter paper, but no increased growth of the endophyte resulted.



The cultures were examined after 14 days with the following results:

Culture Medium	1	2 — sugar	2 + sugar	3	4	5
Percentage showing slight growth of the endophyte	0	25	4	4	15	0
Percentage showing growth of other fungi	1	75	100	92	94	88

A fourth set of experiments followed the lines of the third set, except that pieces of manuka root growing adjacent to the rhizome were used. After a period of 14 days these yielded the following results:

Culture Medium	1	2 — sugar	2 + sugar	3	4	5
Percentage showing slight growth of the endophyte	0	0	0	29	0	0
Percentage showing growth of other fungi	86	100	74	71	100	100

In a fifth set of experiments pieces of root or rhizome were placed on a medium of sterilised filter paper and root extract, but the cells and the endophyte soon died under these conditions.

One difficulty in interpreting these results arises from the fact that the pieces of inoculum were not equivalent as regards either the presence or the activity of the endophyte. However, it was found that even when the endophyte was alive, any growth on the media used was extremely slow. When no other fungi were present the endophyte grew along the surface of the root or rhizome, but only in two instances did it grow out a short distance into the surrounding medium. It did not attack cellulose and seemed to be able to utilise peptone. The presence of clamp connections and failure to form rhizomorphs indicated that it was not *Armillaria*. It was concluded that the endophyte is a basidial fungus specialised to growth on living manuka roots. Which fungus it might be amongst the vast array of fungi in the manuka scrub could not be determined. All the fructifications which were examined were found to arise from saprophytic mycelia penetrating decaying leaves and twigs of the organic horizon.

#### DISCUSSION

Since *Gastrodia minor* lacks both roots and chlorophyll it is fairly obvious that it obtains its nutrient supplies by the process of digestion of fungal cytoplasm within the digestive cells of the tubers. The fungus concerned is present not only within the tubers but also on and within the roots of manuka. Since disintegration of the cortex of the manuka root occurs once the intracellular infection is established, but in its absence only occurs in those roots where secondary growth has commenced and a phellogen has arisen in the pericycle, the fungus in its endotrophic phase is interpreted as being parasitic on the root. What happens during the ectotrophic phase is not clear. The roots have been termed mycorrhizal because of the similarity in appearance to the ectotrophic mycorrhizas of beech and other forest trees. It appears that the fungus is stimulated by substances excreted from the root and waits for the opportunity to penetrate further, but possibly there is some interchange between root and fungus during this phase. Björkman has applied the term epiparasite to *Monotropa hypopitys* which he has shown obtains nutrient material from a fungus ectotrophic on pine and spruce (Björkman, 1960). Although the situation in *Gastrodia minor* differs in details from that in *Monotropa*, the term epiparasite seems appropriate.

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#### THE SPECIES

The abbreviations following the names have these meanings: A, abundant; C, common; O, occasional; R, rare.

#### ORCHIDACEAE

- Dendrobium cunninghamii* Lindl.—C  
*Bulbophyllum pygmaeum* (Smith) Lindl.—O  
*Earina mucronata* Lindl.—A  
 — *autumnalis* (Forst. f.) Hook. f.—C  
*Sarcophilus adversus* Hook. f.—O  
*Thelymitra longifolia* J. R. et G. Forst.—C  
*Microtis unifolia* (Forst. f.) Reichb. f.—A  
*Pterostylis banksii* R. Br.—O  
*Acianthus fornicatus* R. Br. var. *sinclairii* (Hook. f.) Hatch.—O  
*Corybas macranthus* (Hook. f.) Reichb. f.—O  
 — *rivularis* (Hook. f.) Reichb. f.—O  
 — *trilobus* (Hook. f.) Reichb. f.—C



Campbell EO. The Fungal Association in a Colony of *Gastrodia sesamoides*. 1964. Botany 2 (18): 237-245.

**Abstract**

At Silverdale *Gastrodia sesamoides* behaves as an epiparasite on the roots of *Acacia melanoxylon*. A fungus occurs both as a root-inhabiting parasite on the *Acacia* and also as an endophyte in roots and rhizomes of the *Gastrodia*. In the orchid a digestion process takes place. The fungus is thought to be *Fomes mastoporus*.

**OCCURRENCE OF *Gastrodia sesamoides***

*Gastrodia sesamoides* is growing in an area of a few square yards in one part of a 4-acre stand of *Acacia melanoxylon* R.Br. at Bankside, Silverdale. The original trees were imported from Australia 80 or more years ago and planted out in what was at the time manuka scrub country. Natural regeneration of the *Acacia* has taken place resulting in a well-established stand. Where some of the oldest trees have been milled, the stumps now carry the large sporophores of a bracket fungus, *Fomes mastoporus* (Lev.) Cooke, and a circle of adjacent trees have died. In some cases a tree-trunk has died only on the side facing the stump, thus suggesting that the causative agent is a root-infecting fungus spreading outwards from its base in the old stump through contact between roots below ground. The soil in the area is very shallow, consisting of a brown, organic horizon 8 to 10cm deep overlying a stiff, grey clay. Fine rootlets of the *Acacia* trees penetrate throughout the organic layer, and lying horizontally amongst them are found tubers of the *Gastrodia*. In November the tall, flowering stems of the orchid grow up above the soil. Illustrations of these and of the structure of the flowers have been given by Hatch (Hatch 1949, 1954).

*Gastrodia sesamoides* has been reported from other parts of New Zealand (Cheeseman 1925, Hatch 1949) and also from Australia (McLennan 1959). In many areas in New Zealand where it formerly occurred the original vegetation is now known to have been destroyed and no record has been kept of the plants with which the *Gastrodia* was associated. However, V. M. Scott in correspondence has mentioned that at Takaka in 1952 and 1953 she found *Gastrodia sesamoides* in mixed native forest and also amongst *Pteridium* on a hillside where the former forest cover had been burnt some 30 years previously. On visiting the forest area again this year she noted enormous bracket fungi on two ancient prostrate logs of *Laurelia novae-zelandiae* A. Cunn. In 1959 A. J. Healy found a colony at Foxton Beach growing amongst *Coprosma acerosa* A. Cunn., *Leptocarpus simplex* A. Rich., and *Scirpus nodosus* Rottb. in a damp hollow between the dunes.

**COLLECTION AND TREATMENT OF MATERIAL**

Tubers were collected from Bankside on November 6, 1962, as the new season's shoots were emerging from the soil, and on February 22, 1963, as the new tubers for the next flowering season were enlarging. Unfortunately the area contains only about a dozen flowering plants and is subject to interference by birds and stock. An attempt was made to select what might be regarded as typical plants, but it was not possible to check with others without destroying the whole colony. The tubers, together with adjacent roots of *Acacia melanoxylon*, were killed and fixed immediately in formalin-acetic-alcohol. Selected portions were embedded in paraffin and sectioned at thicknesses of 8  $\mu$  to 20  $\mu$ . Double staining with safranin and fast green proved satisfactory for showing detail in the sections, although combinations of chrysoidin and fast green and of crystal violet and erythrosin were tried also. Lignification was determined by the staining reaction of phloroglucin followed by strong hydrochloric acid, and suberization by staining with Sudan III. In order to trace the distribution of hyphae in *Acacia* roots and stems hand-cut sections were stained in cotton-blue and mounted in lacto-glycerine.

The identification of the orchid species was determined from flowers collected at Bankside in December. These were dissected and compared with pressed specimens from the herbarium of Botany Division, D.S.I.R.

**THE UNDERGROUND SYSTEM OF *Gastrodia sesamoides***

The tubers for the most part are those of one season only, as older ones tend to rot away in the autumn. They occur singly (Fig. 1) or occasionally as 2 to 4 joined together in a sympodial rhizome system extending horizontally in the soil (Fig. 2). Each tuber is up to 8cm long, 3cm broad and 2cm deep. At intervals along their length they carry the torn remnants of scale leaves and lateral buds, some of which will form new tubers. In the autumn there may occur on the tubers one or more slender roots 1mm in breadth and up to 13cm in length, but the tips of these die back, and in the summer any roots present are shorter, often coralloid or bearing very short, coralloid laterals. The roots are distinguishable from young lateral rhizomes by the lack of scale leaves and the presence of a root cap. Regions of fungal infection are evident on the surface of both roots and rhizomes as brownish or black, irregular, pock-like marks 2-10mm in diameter. Interwoven with the *Gastrodia* plants grow slender roots of the *Acacia* trees, some of the finer rootlets of diameter 0.2-0.3mm lying closely appressed to the surface of either root or tuber or occupying a position between the lobes of the coralloid roots.

**ANATOMY OF THE RHIZOME OF *Gastrodia sesamoides***

In transverse section the mature tuber is either circular or else flattened in the plane of the ground to a somewhat oval shape. Externally there is a protective region, 1 to 3 cells in depth, composed of flattened cells with walls brownish due to the presence of tannin-like compounds (Fig. 5). Beneath this is a sub-epidermal layer of isodiametric cells showing suberization of the radial and outer tangential walls and in some cases of the inner tangential walls also. The outer cortex 3 to 4 cells in depth is a thin-walled tissue of small cells most of which contain small starch grains, but a few scattered cells show a deposit of calcium oxalate in the form of a bundle of raphides. The rest of the cortex has larger cells containing larger starch grains. It merges into the wide central portion of

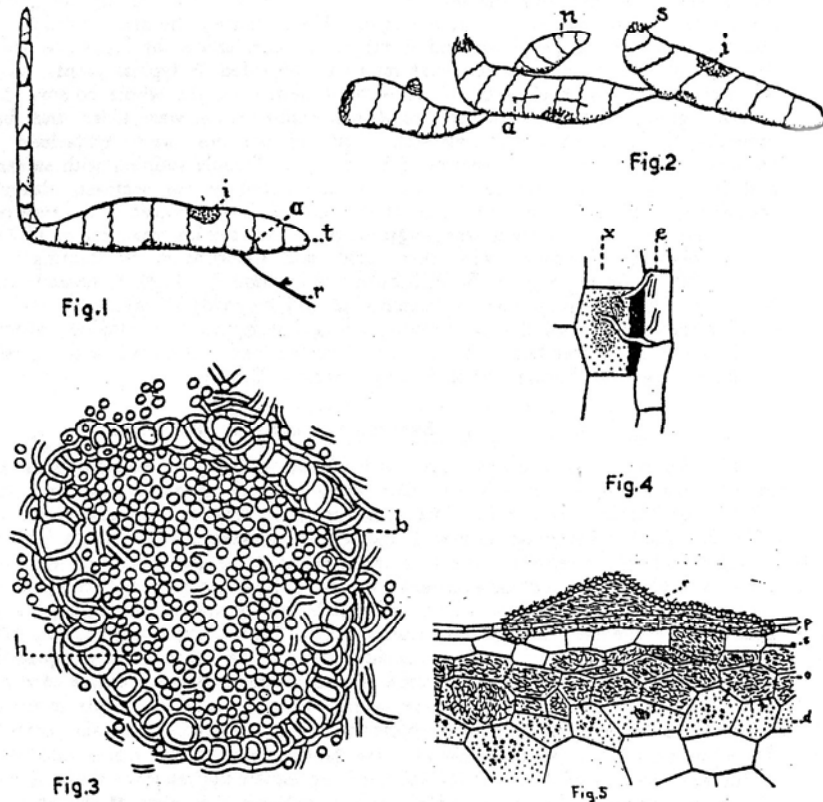


FIG. 1.—Plant of *G. sesamoides* in November.  $\times \frac{1}{2}$ . a—*Acacia* root; i—area of fungal infection; r—*Gastrodia* root; t—tuber.

FIG. 2.—Tuber system of *G. sesamoides* in February.  $\times \frac{1}{2}$ . a—*Acacia* root; i—infected area; n—new tuber; s—scar of old flowering stem.

FIG. 3.—Transverse section of a rhizomorph.  $\times 800$ . b—brown-walled hyphae; h—hyaline hyphae.

FIG. 4.—Transverse section of the outer part of a *Gastrodia* root showing infection of the exodermis.  $\times 400$ . e—epidermis; x—exodermis.

FIG. 5.—Transverse section of a *Gastrodia* tuber showing infection from a rhizomorph.  $\times 160$ . d—digestive layer; o—outer cortex; p—protective layer; s—subepidermal layer; r—rhizomorph.

the tuber where collateral, vascular bundles are scattered throughout a ground tissue of rather large, thin-walled cells stocked with large, compound grains of starch. In young tubers the protective layer is composed of colourless cells whose walls lack tannin-like compounds and the subepidermal layer lacks suberin.

#### ANATOMY OF THE ROOT OF *Gastrodia sesamoides*

A transverse section of the orchid root shows on the outside an epidermal layer of flattened cells lacking root hairs, and beneath this a well-marked exodermis of larger, more isodiametric cells (Fig. 6). In older parts of the root the walls of the epidermal cells are brown and the radial and outer tangential walls of the exodermal cells are suberized. The rest of the cortex is 8 to 12 cells in width, the outermost 2 or 3 layers consisting of smaller cells and the remainder of larger, thin-walled cells. The central stele, delimited from the cortex by an endodermis with a well-marked casparian strip on the radial walls, consists of a pericycle 2 cells in width and a radially built, vascular core with 4 to 10 protoxylem strands alternating with a corresponding number of protophloem strands. Starch is present in the root, stored as tiny grains in the exodermis and in the small cells of the outer cortex and as larger, compound grains in the deeper cortical cells. Occasional cells of the outer cortex have a deposit of calcium oxalate in the form of a bundle of raphides.

#### THE FUNGUS

The fungus appears in the soil in two forms. Normally it occurs as brown, and often thick-walled, septate hyphae of diameter 2.5 to 5  $\mu$ , visible under the microscope as long, sparingly branched threads on the surface of the *Gastrodia* root or on the fine roots of the *Acacia* trees, and sometimes in the axils of scale leaves on the tuber. Each thread consists of a single hypha lacking clamp connections. The fungus also occurs as a dark-brown, cylindrical, rhizomorphic strand up to 0.1mm in diameter projecting from the surface of the rhizome. The rhizomorph is difficult to detect owing to its fragile nature and its resemblance to the fine *Acacia* rootlets amongst which it lies. In section it shows a central core of hyaline hyphae running lengthwise, enclosed by brown-walled hyphae which are arranged in a characteristic pattern (Fig. 3). Fringing, brown hyphae lie more or less parallel in a lengthwise direction or radiate outwards, but the innermost ones by branching at a wide angle and interweaving construct an openly braided meshwork. The hyphae of the rhizomorph are 2.5 to 3.5  $\mu$  in diameter.

A similar fungus occurs as a white web under the bark of some of the *Acacia* trees and may build up into white, mycelial strands, 0.05mm in diameter, in the region of the cambium. These strands have the outermost hyphae arranged in the form of a meshwork as in rhizomorphs in the soil, and can be traced along the trunk to the sporophores of *Fomes mastoporius*. In affected trees the bark lifts easily from the xylem beneath.

#### THE FUNGAL INFECTION OF THE ORCHID

##### *Infection of the Root*

Roots collected in November and in February showed active invasion by the fungus, and all phases of the process were in evidence. Single hyphae of the fungus penetrate along the radial walls in young parts of the root and enter a

few of the epidermal cells. Once inside the cell they ramify within the cell cavity as thin-walled hyphae, of diameter 1.5 to 2.5 $\mu$ , lacking clamp connections. The nucleus of the infected cell at first enlarges and then together with the cytoplasm disappears. The hyphae may persist either in the thin-walled condition or in a wider form up to 3.5 $\mu$  in diameter with thicker walls of a brown colour. Some hyphae penetrate into single cells of the exodermis growing towards the nucleus where their tips may break down, resulting in the release of fungal cytoplasm into the invaded cell. Invasion of the exodermis is accompanied by alteration of the penetrated tangential wall which now appears much thicker and yellowish-brown in colour (Fig. 4). Often cellulosic sheaths impregnated with material similar to that in the altered wall are deposited around the hyphae at the point of entry and remain projecting into the exodermal cell as papillose outgrowths (röhrentüpfel) staining deeply with safranin as does the penetrated wall itself.

The infection may be halted at this stage and the hyphae in the exodermal cell disappear. At other times the living contents of the exodermal cell are destroyed while adjacent cells of the outer cortex react in the same way as does a typical exodermal cell. However, the usual course of events when hyphae penetrate to deeper tissue is that an exodermal cell which may be called a passage cell becomes occupied by fine, loosely coiled hyphae, some of which penetrate into the underlying tissue (Fig. 6). Surrounding exodermal cells remain free of the fungus except that on rare occasions there are two adjoining passage cells.

Once through the exodermis the hyphae spread laterally in the two or three layers of small cells of the outer cortex and gradually extend to a varying distance ranging from 3 to commonly as much as 10 to 15 or more cells from the point of entry (Fig. 6). Neighbouring infection areas may merge, with the result that the fungus may be present in most or all of the outer cortical cells in any transverse section. In each infected cell there develops a coil of hyphae which at first are thin-walled and of diameter 1.5 to 2 $\mu$ . When there is an extensive infection, hyphae occupying the centre of the coil become thick-walled and up to 4  $\mu$  in diameter. They connect from one cell to the next providing the structural framework of the system, and persist after the fine hyphae have collapsed. Starch disappears from the cells and, wherever calcium oxalate occurs, it also disappears, the idioblastic cells remaining recognisable by the few hyphae present within them. The nucleus of each invaded cell enlarges and the nucleolus becomes prominent, then the nucleus becomes irregular in outline, loses its affinity for stains, and together with the cytoplasm disappears. The walls of the invaded cortical cells become impregnated with brownish, tannin-like compounds and those in the outer part become lightly lignified as well. Very occasionally lignified sheaths are present on hyphae at the point of entry into a cell.

Cells of the root situated on the inner side of the tangentially spreading infection constitute a digestive layer (Fig. 6). Already larger than cells of the outer cortex they increase in size radially until they are as much as four times their original diameter and also show prominent pitting of the enlarged walls. Hyphae growing radially inwards from the outer cortex penetrate the wall and branch into many fine threads which take a convoluted path as they grow towards the nucleus which meantime has become enlarged and very granular with a conspicuous nucleolus. Starch gradually disappears from the cell. The tips of the hyphae swell enormously as they accumulate granular cytoplasm, then alter in staining properties and appear as spherical bodies, retentive of safranin stain, lying in the cytoplasm of the digestive cell either singly or in masses enclosed by a membrane. The nucleus becomes lobed or amoeboid and the nucleolus may

fragment, but the extreme deformation which occurs in digestive cells of the rhizome of *Gastrodia cunninghamii* and *G. minor* (Campbell 1962, 1963) was not observed. Later the nucleus gradually assumes a more spherical shape though still enlarged. Slowly the spherical bodies are absorbed until they disappear completely. Remnants of the coiled hyphal threads persist for some time, surrounded where they entered the cell by a collar formed of cell-wall material. The penetrated wall itself becomes altered in nature and is now impregnated with tannin-like compounds but all other walls of the digestive cell remain of cellulose as formerly.

Eventually in old infection areas the walls of invaded cells in the outer cortex appear dark brown, and the empty hyphal threads of the endophyte have disappeared. The affected region tends to collapse or scale off, and deeper cells may also die off and develop brown walls. So extensive may be the necrotic lesion that the distal portion of the root shrivels.

#### INFECTION OF THE RHIZOME

Tubers collected in November showed no active infection by the fungus, although in roots collected at the same time the endophyte was present. However, the site of previous infections was indicated on the tubers by rough areas left where the surface layers had scaled off or by cavities beneath the external protective region left in the position where invaded cells had collapsed. On the other hand in rhizomes collected in February active infection was in evidence, sited frequently in the axils of the scale leaves.

In young tubers infection occurs from single hyphae, the fungus penetrating only to the subepidermal layer or penetrating to the outer cortex where it extends laterally to a varying extent. The invaded cells react in the same way as in the root. Their walls eventually turn brown but only a few of the outermost cortical ones become lignified. Deeper cells may also develop brown walls and die off. Eventually the region affected by the fungus collapses leaving a cavity beneath the protective layer.

In older tubers infection was found to have occurred also from rhizomorphs, a condition which was not observed in roots. In this latter type the rhizomorph attaches itself to the tuber by a more or less hemispherical disc (Fig. 5). Brown-walled hyphae of meshwork arrangement make the outer covering of the disc and also occupy a circle of adjacent cells of the protective layer so giving a comparatively firm attachment. Hyaline hyphae from the central portion of the disc fill the cells of the protective layer beneath them with coiling hyphae. The hyaline hyphae also penetrate into a subepidermal cell where they form a dense coil completely filling the cell. Entry is accompanied by a thickening of the outer tangential wall of the invaded cell. Subepidermal cells in the immediate neighbourhood show no evidence of the fungus, but supplementary entry points may occur at a distance of 6 to 12 cells from the main infection, initiated by hyphae which have grown outwards from the rhizomorph along the surface of the tuber. From the passage cell in the subepidermis with its tight, fungal coil hyphae extend into the outer cortex, often ensheathed as they penetrate the wall, and then spread tangentially for a considerable distance in a band 2 to 3 cells wide. In each invaded cell a coil of hyphae develops and the protoplast disappears. Cells on the inner edge of the band function as digestive cells where the process of digestion corresponds with that found in the root, except that radial enlargement

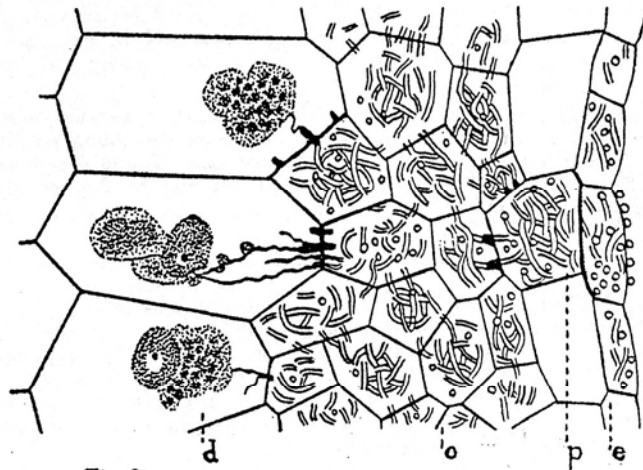


Fig. 6

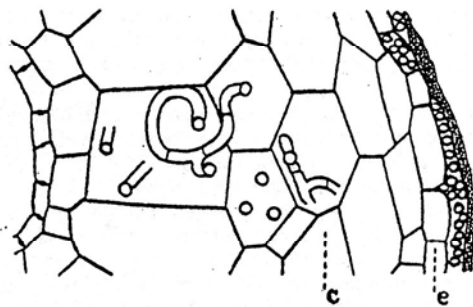


Fig. 7

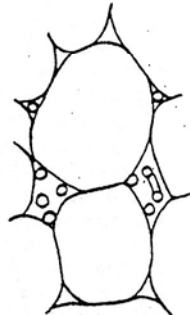


Fig. 8

FIG. 6.—Transverse section of the outer part of a *Gastrodia* root showing fungal infection.  $\times 380$ . e—epidermis; d—digestive layer; o—outer cortex; p—passage cell in exodermis.

FIG. 7.—Transverse section of the outer part of an *Acacia* rootlet showing fungal infection.  $\times 400$ . e—epidermis; c—cortex.

FIG. 8.—Transverse section of a part of the cortex of a fine *Acacia* root showing intercellular hyphae.  $\times 400$ .

of the cells is less pronounced and the nucleus becomes deeply constricted into three or more portions as in corresponding cells in the rhizomes of *Gastrodia cunninghamii* and *G. minor*. The infection persists for a longer time and is much more extensive than that produced in the rhizome by single hyphae.

#### THE MORPHOLOGY AND ANATOMY OF THE *Acacia* ROOTS

In order to determine what could be regarded as the normal structure of the root system of *Acacia melanoxylon* some plants growing in Tokomaru silt loam alongside Clifton Terrace in the Manawatu were examined. In young plants 1m high there was found to be a tap-root system with numerous long, lateral roots 1mm to 2mm wide, bearing short rootlets 0.2mm to 0.3mm in width, some of which were nodulated.

A transverse section of a young rootlet shows, from the outside inwards, an epidermal layer with occasional root hairs, then a thin-walled cortex 5 to 7 cells in width, delimited by an endodermis from a central stele consisting of a uniseriate pericycle and a narrow vascular core with 2 to 5 protoxylem and protophloem strands. At a later stage the epidermal cells have a thickened outer wall of a yellow-brown colour.

The *Acacia* trees at Silverdale also had slender, lateral roots bearing short rootlets, some of which carried bacterial nodules. The rootlets corresponded in general anatomy to those from the Manawatu. However, near the *Gastrodia* plants very few of the rootlets were nodulated, although in some cases bacteria were abundantly present in cells of the inner cortex.

#### THE FUNGAL INFECTION OF THE *Acacia*

An examination of sections of fine roots and rootlets collected from the vicinity of *Gastrodia* tubers or roots, and in some cases from grooves on the surface of these, showed the presence of septate, fungal hyphae up to  $5\mu$  in diameter without clamp connections. The location of the hyphae differs in different cases. In fine roots of diameter 1 to 2mm the hyphae have brown walls and lie mainly lengthwise in the intercellular spaces between the cortical cells (Fig. 8). They were not seen to penetrate the walls. On the other hand, in the rootlets air spaces are absent and the hyphae are intracellular (Fig. 7). They accumulate beneath the layers of thickening on the external walls of the epidermis and at times inside the epidermal cells, then penetrate deeper, often starting in the region of a root hair, and invade the cortical cells. Thin-walled, hyaline hyphae are particularly abundant in cells containing endophytic bacteria and branch profusely amongst the bacterial colonies. The protoplast of each invaded cortical cell disappears and, where bacteria are present, these die off leaving for a time a granular deposit. Later the infected part of the cortex may collapse leaving a cavity beneath the surface layer. Hyphae do not readily penetrate the endodermis but in the two cases where they were seen in the pericycle a phellogen had arisen beneath the damaged cells so impeding further penetration by the fungus.



## DISCUSSION

Although *Gastrodia sesamoides* has been reported from several localities in New Zealand, growing amongst native vegetation as well as occurring at Silverdale in a stand of *Acacia melanoxylon*, it nowhere seems to be abundant. It differs from the two other indigenous species of the genus not only in the structure of the flower but also in possessing roots on its fleshy rhizomes, as well as in several minor respects.

Like the related species, *G. sesamoides* is interpreted as being an epiparasite on the roots of other plants. By a digestion process in both its roots and its rhizomes the orchid obtains nutriment from an endophytic fungus which, in the locality investigated, occurs also in *Acacia melanoxylon*, where it behaves as a specialised, root-inhabiting parasite spreading as a result of contact between roots in the soil and also by rhizomorphs. Although the orchid has only a limited rhizome system as compared with *G. cunninghamii* the possession of roots provides it with additional opportunities for making suitable contacts with the *Acacia*.

The fungus associated with *G. sesamoides* at Silverdale is a different fungus from that found in either *G. minor* or *G. cunninghamii* (Campbell 1962, 1963). The presence of rhizomorphs indicates that it belongs to a wood-rotting or possibly a cellulose-decomposing genus of the Basidiomycetes. Although clamp connections are characteristic of Basidiomycetes, a few genera such as *Fomes* are known to lack these. On stumps nearby there grow the sporophores of *Fomes mastoportunus*, a species of widespread occurrence in New Zealand producing a white rot of trees (Cunningham, 1948).

The behaviour of the fungus associated with the *Gastrodia* corresponds in many respects with that of *Fomes annosus* (Rishbeth, 1950, 1951 a, b). In this latter species a mycelium originating by germination of spores on freshly-cut stumps can grow down to the roots and then spread through contact between living roots in the soil. It is primarily a root-inhabiting parasite, although able to persist for a long time as a saprophyte in the stump. Rishbeth has shown that it is not always disease producing and that it can infect *Pteridium*. It is already known that a species of *Fomes* is associated with another non-green orchid, *Galeola hydra*, in Luzon (Burgeff, 1959).

The fungus associated with *G. sesamoides* in Australia has clamp connections (McLennan, 1959) and so belongs to a different genus. This would indicate that the orchid is not restricted to one particular fungus. Should this be the case, some fungi are probably more efficient than others. Certainly the association of *G. sesamoides* with the fungus at Silverdale results in more damage to the tuber and also to the orchid root than is the case when *G. cunninghamii* is associated with *Armillaria*.

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