

**Arthropod Community Centred upon the Neolitsea Leaf
Gall Midge, *Pseudasphondylia neolitseae* Yukawa
(Diptera, Cecidomyiidae) and Its Host Plant, *Neolitsea
sericea* (Blume) Koidz. (Lauraceae)**

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Introduction

A gall provides extremely favourable breeding conditions to a great variety of organisms with its localized concentration of highly nutritive substances and its marked succulence⁴⁾. Nearly every gall is associated with diverse organisms, so called "*locatari*"⁴⁾, the term for the cecidocole and cecidophile arthropods other than the true cecidogenetic species, "*cecidozoa*". The *locatari* are divided into 33 sorts of category according to their ecological niches and different manners of life⁴⁾. In addition to the *cecidozoa* and *locatari*, many phytophagous insects accompanied with their parasitoids and predators feed on the host plant of the *cecidozoa*. Thus, the arthropod community centred upon the *cecidozoa* and its host plant is extremely complex. Therefore, the survey of arthropod community comes to be fundamentally necessary for understanding the inter-relations of these diverse organisms and for promoting further studies on the *cecidozoa* and its associated inhabitants.

The neolitsea leaf gall midge, *Pseudasphondylia neolitseae* Yukawa⁵⁾ is normally univoltine and produces leaf galls on its host plant, *Neolitsea sericea* (Blume) Koidz.^{5, 8)}. This non-pest gall midge has been surveyed since 1970 by the present author and his collaborators at several places in Kagoshima prefecture to detect natural regulation mechanisms operating on the gall midge population. During the course of the study, four parasitoid species and some spiders were noted to have attacked the gall midge^{5, 8)}, but any detailed arthropod community centred upon the species and its host was not previously reported.

Prior to the analytical studies on the life tables of the gall midge, the present paper is intended to clarify the biological agents which act as mortality factors directly or indirectly upon the gall midge population.

Materials and Methods

A total of 120 trees (less than 3 m high) of *Neolitsea sericea* were selected as census trees at Shiroyama and its vicinity in Kagoshima city. The census trees and the produced midge galls were surveyed at least 60 times a year during the period from 1970 to 1981 in order to observe ar-

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thropods inhabiting the trees and the galls, and to determine their ecological niches in the community. About 90 % of the field survey was concentrated to the emergence season of the adult midges in April and May. Adults or larvae of the associated arthropods were occasionally collected for identification from the trees other than census ones. Most of the larvae were reared in the laboratory to obtain adult specimens. The midge galls were also sometimes collected and dissected to investigate the inhabitants.

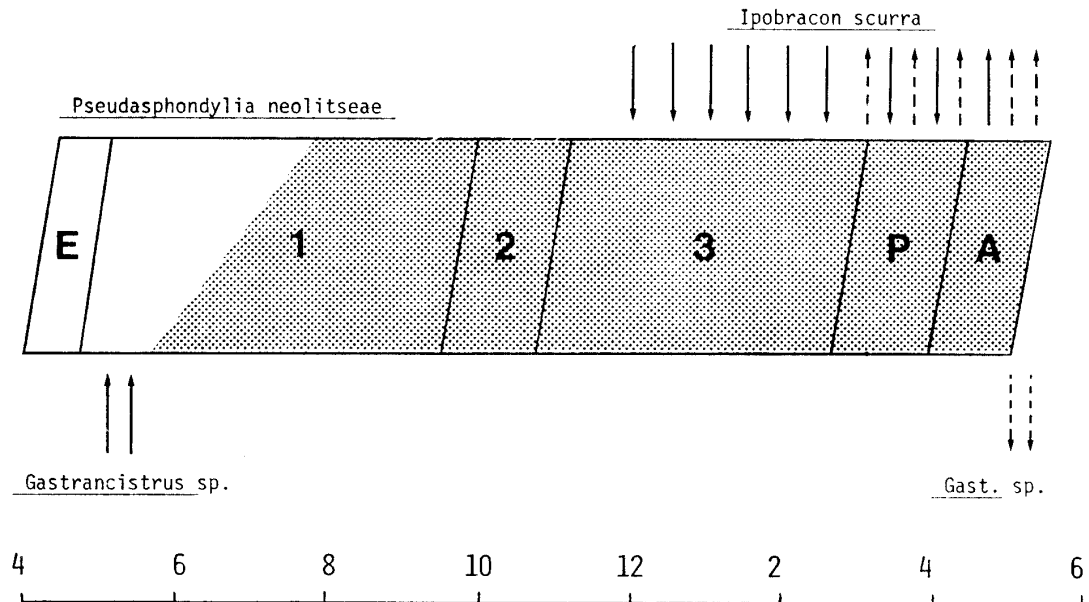


Fig. 1. Life history of the neolitsea leaf gall midge, *Pseudasphondylia neolitseae* Yukawa, and ovipositing and emerging seasons of its parasitoids, *Gastrancistrus* sp. and *Ipobracon scurra* Fischer. Dotted area indicates the maturity of the gall, solid lines point towards the developmental stages of the host midge to be oviposited, dashed lines indicate the emergence of the parasitoids from the host midge.

Arthropod community

1. Cecidozoa

As already mentioned by Yukawa⁵⁾ and Yukawa *et al.*⁸⁾, the neolitsea leaf gall midge, *P. neolitseae* Yukawa⁵⁾ is normally univoltine (Fig. 1) and passes the winter in the gall as a third (final) instar larva. Pupation takes place in February or March, and adults emerge in late March or April in Kagoshima city. Females deposit their eggs in the leaf buds of the host plant, *N. sericea*. The first signs of attack are small reddish spots on the upper surface of the newly opened leaves. Later, apically rounded subconical swellings appear on the leaf surface accompanied by hemispherical swellings on the lower surface (Fig. 2C). The galls mature in early summer (Fig. 1) and each gall contains one midge larva.

2. Parasitoids on the cecidozoa

The following 4 hymenopterous parasitoid species were recognized to be associated with the gall midge⁵⁾: *Gastrancistrus* sp. [Pteromalidae], *Aclastus* sp. [Ichneumonidae], *Apanteles* sp. [Braconidae] and an unidentified species of Braconidae. There is, however, no further collecting record of *Aclastus* sp. and *Apanteles* sp., thereafter. These two, possibly polyphagous species may be

considered to utilize the gall midge as a temporal host. Another braconid was described by Fischer²⁾ as a new species under the name, *Ipobracon scurra*, based on the specimens forwarded from the present author. *Gastrancistrus* sp. (Fig. 2A) and *I. scurra* (Fig. 2B) were commonly observed not only in the census fields in Kagoshima city but also in other localities in Japan.

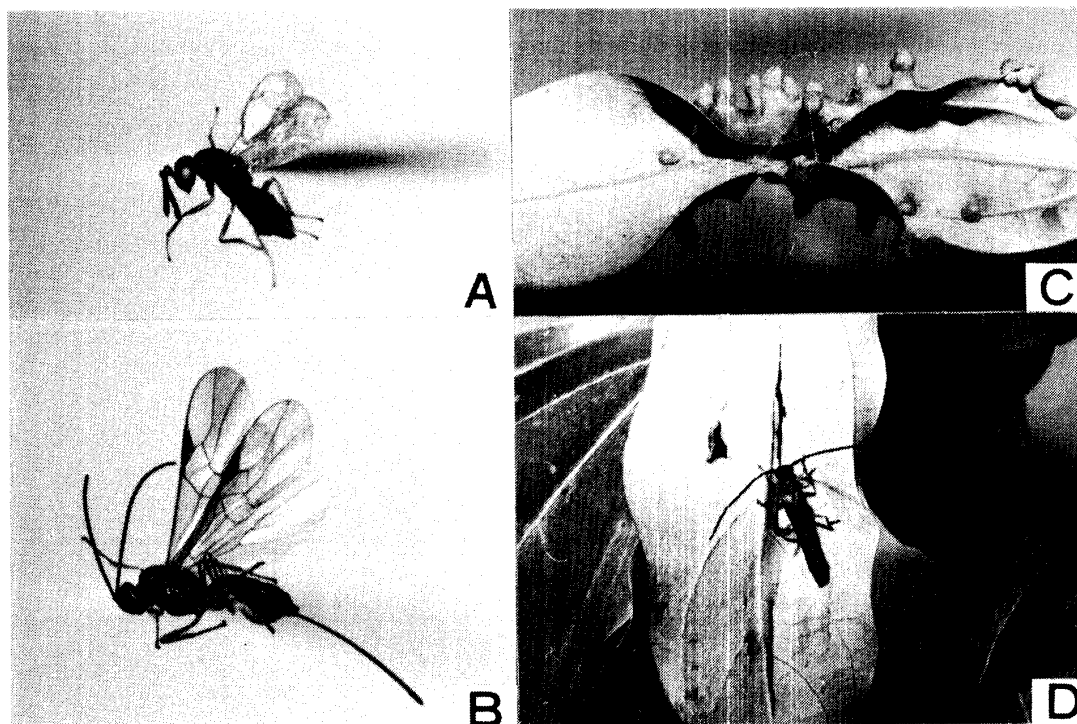


Fig. 2. A: *Gastrancistrus* sp., B: *Ipobracon scurra* Fischer, C: Heavily galled and folded leaf of *Neolitsea sericea* webbed by the spider, D: *Oberea hebescens* Bates feeding on a host leaf.

Gastrancistrus sp. is an univoltine and possibly monophagous endoparasitoid of the gall midge. In May, the females laid their eggs inside the first instar larvae of the host midge which inhabited small galls under the very early developmental stage (Fig. 1). The attacks of the pteromalid parasitoid did not prevent further growth of the galls, and its young larvae allowed the host larvae to grow until late autumn when the hosts moulted into the third instar. The parasitoid larvae rapidly grew shortly after the hosts had attained the third instar, and they hibernated inside the host larval skin in the galls. Only one parasitoid larva could grow per host. Pupation took place in March and April, and emerged adults remained in the galls for a certain period. The adults escaped from the galls in May, well synchronized with the time when the host larvae were under an early developmental stage of the first instar.

Contrary to the pteromalid, *I. scurra* is a multivoltine and polyphagous ectoparasitoid of the gall midge. The females laid their eggs on the inner wall of the galls or on the body surface of mature host larvae or pupae including those that had already been parasitized by *Gastrancistrus* sp. The parasitoid grew rapidly, and only one parasitoid adult could emerge per host. There were at least 2 generations during the period from December to the following April (Fig. 1). At the same time, *I. scurra* attacks other gall midges belonging to such genera as *Asphondylia* and *Daphnephila* of the supertribe Asphondyliidi^{2, 3, 7)}. However, some aspects of the life history and host range of *I. scurra* during the period from May to November still remain unclear.

3. Predators on the cecidozoa

In March and April, a hole was sometimes made on the hypophyllous portion of the respective gall by workers of the ant, *Monomorium nipponense* Wheeler, and the mature midge larvae and pupae including parasitized ones were removed from the galls. Evidences of the predation by *M. nipponense* were observed almost every year on a few restricted host trees, where the local midge populations were largely and concentratedly destroyed.

At least 11 species of spider were observed to be feeding on adults of the gall midge at the time of emergence or of oviposition (Table 1). A relatively small, reddish brown spider, *Agelena* sp. was most abundant among them, particularly on the leaf buds of the host plant.

Table 1. A list of spiders webbing the leaf buds and the surrounding area, and the lower surface of the galled leaves on *Neolitsea sericea* (Blume) Koidz. at the census fields in Kagoshima city during the period from March to May

<i>Agelena</i> sp. (subimago)	(B, L)
<i>Anelosimus crasipes</i> (B. et S.)	(L)
<i>Clubiona lena</i> B. et S.	(L)
<i>Clubiona</i> sp. A (subimago)	(L)
<i>Clubiona</i> sp. B (subimago)	(L)
Micryphantid gen. sp. (subimago)	(L)
<i>Myrmarachne</i> sp. (subimago)	(B, L)
<i>Philodromus subaureolus</i> B. et S. (subimago)	(B)
<i>Prolinyphia yunohamaensis</i> (B. et S.)	(B)
<i>Theridion</i> sp. (subimago)	(B)
<i>Thomisus</i> sp. (subimago)	(B, L)

(B): webbing the leaf buds and the surrounding area.

(L): webbing the lower surface of the galled leaves.

Heavily galled leaves of the host plant are frequently folded outward in various degrees, providing favourable webbing conditions to the spiders (Fig. 2C). In April, more than 50 % of such leaves was webbed by the spiders in Kagoshima city. According to Yukawa *et al.*⁸⁾, the emergence of adult midges normally occurs during 7:30 to 10:00 a.m. The midge pupae push open the operculum on the lower surface of the galls and stretch themselves half way out of the galls. Then, the pupal-skin is ruptured by protrusion of the head and thorax. The actual emergence takes 20 to 45 minutes, and during this time the gall midges are in a helpless condition. Advantage is taken of this by the spiders webbing the lower surface of the galled leaves. The adult midges were not only killed by the direct predation but also caught in the webs and then attacked by the spiders. When the emerging adults were caught in the webs, they could not survive due to the failure in emergence, even when unnoticed by the spiders or caught in the abandoned webs.

The normally emerged and survived adult midges mate during 9:30 to 11:30 a.m. under favourable conditions. Mated females fly from plant to plant for oviposition in search of suitable host buds measuring 22 to 38 mm in length⁸⁾. The flying females were rarely caught by empidid flies [Diptera], but they could not be identified.

The females were occasionally observed to be caught immediately or some time after their arrival at the ovipositing site by the spiders webbing the host buds and the surrounding area. Even if the spiders failed to catch the victims, their ovipositing action was disturbed and the females had to fly off the host buds to find the others.

4. Phytophagous insects on the host plant

Another cecidomyiid species, *Dasineura* sp. [Diptera] was noted to be associated with *N. sericea*. This species was easily distinguished in the field by its size distinctly smaller than *P. neolitseae*. In April, the females laid their eggs inside the leaf buds, which remained closed and withered gradually. Later, the leaf buds containing the mature larvae fell down to the ground. At the same time, the eggs or the first instar larvae of *P. neolitseae*, if any, were killed by the fall and the successive decay of the infested leaf buds.

The most outstanding damage given to the host plant is caused by a cerambycid beetle, *Oberea hebescens* Bates [Coleoptera]. The damages were seen almost every year at the census fields in Kagoshima city. In May, females of the cerambycid beetle lay their eggs inside the distal portion of newly extended host twigs⁶⁾. Prior to oviposition, the females hurt the basal portion of the twigs to soften the pith, through which the first instar larvae of the beetle can easily bore a tunnel downward. Shortly after the oviposition, the twigs are folded a little above the ovipositing part and the leaves attached to the twigs wither rapidly. In June and July when the cerambycid larvae bore downward, attaining the distal portion of one year old twigs, all the healthy new twigs extended from the infested old ones and all the leaves attached to these new and old twigs start withering. Therefore, the galls, if produced on such leaves, also wither and result in the death of midge larvae and of its endoparasitic inhabitants. As the galls are frequently produced concentratedly on certain trees, the mortality caused by the cerambycid, if any, sometimes becomes extremely high.

Free-living phytophagous insects like lepidopterous larvae can escape from the damaged portions to the healthy ones, but sessile or sessile insects such as psyllid nymphs [Homoptera] and other cecidocols suffer death by the shortage of food resources and water.

An unidentified scolytid [Coleoptera] was found inhabiting the trees and withering the host twigs and leaves, but such a case was not noted so frequently.

Several phytophagous species of Lepidoptera were found on the host trees. In May and June, *Odites leucostola* Meyrick [Xyloryctidae] and some unidentified geometrids were observed to be feeding on the newly extended host buds. When the eggs of the gall midge were already deposited inside the buds, they suffered death by the infestation of the lepidopterous larvae. Four other defoliators, *Spilactia imparilis* Butler [Arctiidae], *Dendrolimus undans flaveola* Motschulsky [Lasiocampidae], *Phrixolepia sericea* Butler [Heterogeneidae] and *Graphium sarpedon nipponum* Fruhstorfer [Papilionidae] were occasionally found feeding on the host leaves of the current year. Since all of these lepidopterous larvae were oligo- or polyphagous species, they were not tightly associated with *N. sericea*, causing a relatively small damage to both the host trees and the gall midge population.

Adults of an unidentified megachilid [Hymenoptera] sometimes cut off a part of the host leaves in summer, but they always avoided collecting the galled portion of the leaves.

Two species of Psyllidae [Homoptera] were frequently found on the host leaves in southern Kyushu. They did not produce galls, but caused fading of the affected parts by sucking, resulted in yellowish flecks on the leaves. There was, however, no evidence that the galls or the gall midge larvae were ill influenced by the psyllids on such leaves.

Adults of *Petaloccephala discolor* Uhler [Homoptera, Ledridae] were rarely found on the host leaves or twigs in winter, however, their actual role in the community could not be determined.

5. Successori

The *successori* represent the inhabitants of the empty galls after the escape of the *cecidozoa* and *inquilines*⁴⁾. As the galls usually do not decay some time after the escape of the *cecidozoa*, the dry galls provide shelters to a variety of arthropods.

A cecidomyiid species, *Lasioptera* sp. [Diptera] was observed to utilize the empty galls from which *P. neolitseae* or its parasitoids had escaped. In April and May, the females of *Lasioptera* sp. laid their eggs one by one inside the respective empty gall. Later, the exit hole of the gall was closed with white fungi-like material and the larvae rapidly matured within a month. The mature larvae escaped from the galls to pupate in the soil.

An unidentified species of Collembora and some species of Acarina were frequently found in the empty galls, but these *successori* including the above-mentioned cecidomyiid did not in any way interfere with the normal developments of the *cecidozoa* and of its parasitoids.

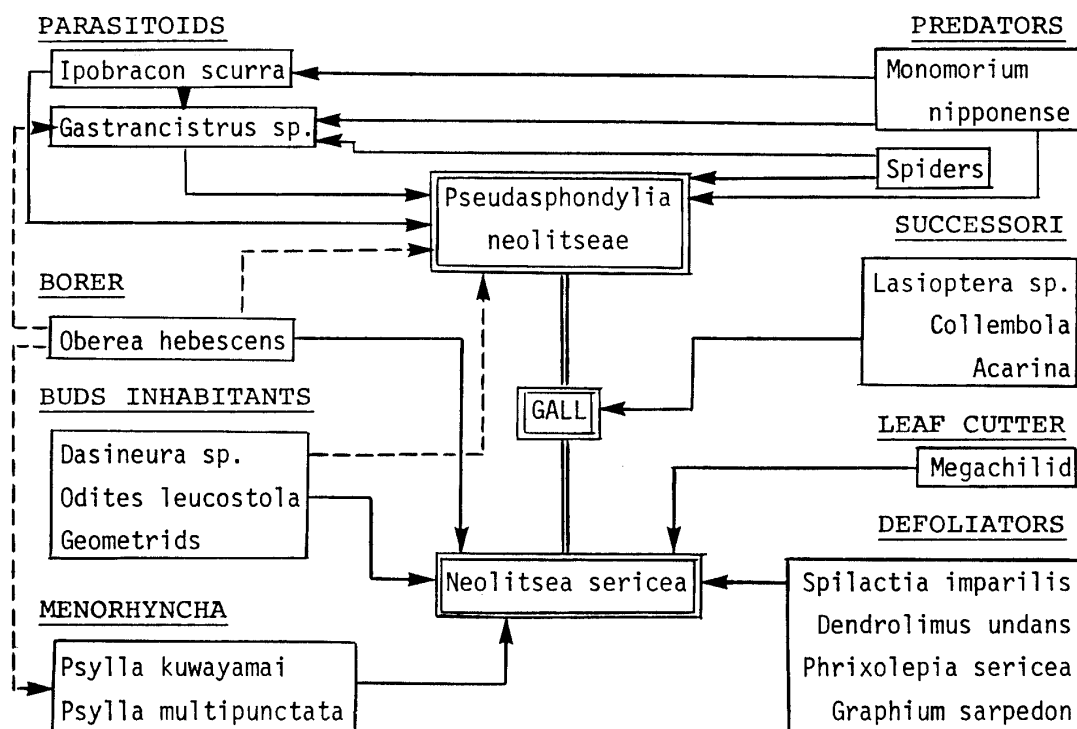


Fig. 3. Schematic representation of inter-relations among the arthropods centred upon the neolitsea leaf gall midge, *Pseudasphondylia neolitseae* Yukawa and its host plant, *Neolitsea sericea* (Blume) Koidz. Double lines indicate the inter-relation between the cecidozoa and host plant, solid lines point towards the food source, dashed lines point towards the inhabitants killed by the indirect action of the phytophagous insects.

Discussion

The present study reveals that at least 17 species of insect, 11 of spider and some Acarina are associated with the neolitsea leaf gall midge, *P. neolitseae* and its host plant, *N. sericea*. Their possible inter-relations are illustrated in Fig. 3. The gall midge was attacked directly by the parasitoids and predators, and indirectly by some phytophagous insects.

The two parasitoid species, *Gastrancistrus* sp. and *I. scurra* exhibit a striking contrast in their parasitic habits. The status well coincides with the evidence proposed by Askew¹⁾ for the oak

gall wasp community, which includes the parasitoids with two different parasitic strategies: early parasitoids attack small (young) hosts and are usually univoltine, monophagous and endoparasitic; late parasitoids attack large (older) hosts and are usually multivoltine, polyphagous and ectoparasitic. The present gall midge is also attacked by the parasitoids with the two different strategies: *Gastrancistrus* sp. and *I. scurra* are referable to the early and the late parasitoid, respectively. Late parasitoids are generally considered to act more frequently as a key factor influencing the total survival rate from the eggs to the adults.

The local midge populations were occasionally destroyed by the ant, *M. nipponense*. However, the predation is not considered to affect the gall midge severely, because it is highly localized and acts as a mortality factor upon the parasitoids as well.

It is remarkable that the spiders frequently web the lower surface of the heavily galled leaves where many adult midges are expected to emerge. When the population density of the gall midge becomes high, the number of such galled leaves comes to be naturally more abundant in the fields. These facts are suggestive of the possibility that the predation by the spiders acts as one of the density-dependent mortality factors. To confirm the possibility, further studies are necessary, particularly on the behavioural aspects of the spiders.

The cerambycid beetle, *O. hebescens* has superficially an outstanding effect on the host plant and on the diverse organisms inhabiting the plant. However, the mortality caused by the beetle is fundamentally not effective on the gall midge population, because it occurs concentratedly on the restricted trees and does not depend on the density of the population.

Among the biological agents mentioned in the present paper, the two parasitoids and the spiders are, thus, suspected to have certain roles in controlling the gall midge population, in addition to, if any, the density-dependent factors involved in the population itself.

Summary

The arthropod community centred upon the neolitsea leaf gall midge, *Pseudasphondylia neolitseae* and its host plant, *Neolitsea sericea* was surveyed at the census fields in Kagoshima city during the period from 1970 to 1981 to detect biological agents which act as mortality factors on the gall midge population. At least 17 species of insect, 11 of spider and some Acarina were recognized to be associated with the community, and their ecological niches and inter-relations were described. Among the inhabitants, the two parasitoids and the spiders were considered to act as more effective agents on the gall midge population. The mortalities indirectly caused by the phytophagous insects were suspected to be ineffective in controlling the gall midge population.

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