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Further Observations on *Astegopteryx styracicola* (Homoptera: Pemphigidae), an Aphid Species with Soldiers Biting Man

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Synopsis Some wingless individuals of *Astegopteryx styracicola* readily fall on man from galls made on snowbell trees and cause an intense irritation of the skin. In the light of the hypothesis that *A. styracicola* has sterile soldiers which fall from the gall and bite man, and that predation on galls by arboreal mammals is responsible for the evolution of this behavior, the following observations were made: 1) Of 50 soldiers placed on the hand, 45 bit the skin within a minute, whereas only one of 50 apterous adults bit within a minute. 2) Of 3972 individuals collected by shaking the galls, 3970 were soldiers. 3) All the aphids collected on twigs and leaves (349 individuals) were soldiers. 4) Soldiers attacked syrphid larvae placed on the gall. 5) Mice scratched their faces and backs intensely when soldiers were scattered on them. 6) When a place on the gall surface was pecked with a pincette, the nearby soldiers became excited and walked around, raising their posterior abdominal segments.

Introduction

Astegopteryx styracicola is an aphid species making a large spherical gall on the cork leaf snowbell *Styrax suberifolia*. This aphid has two behavioral peculiarities. First, some wingless individuals of *A. styracicola* readily fall from the gall when it is disturbed. Second, if they fall on man, they bite his skin with their stylets, causing an intense irritation of the skin (TAKAHASHI, 1930; see AOKI *et al.*, 1977). TAKAHASHI (1928, 1931), who reported the biting habit of *A. styracicola* for the first time, was not able to explain why the aphids do so. Recently AOKI *et al.* (1977) explained it by supposing that *Astegopteryx styracicola* has sterile soldiers which fall from the gall and bite man, and that predation on galls by arboreal mammals is responsible for the evolution of this behavior. They listed the following observations supporting the hypothesis: 1) The individuals that bit man were morphologically peculiar hairy aphids (AOKI *et al.*, 1977: fig. 3 D). 2) They were 2nd instar larvae, and only in this instar did a dimorphism occur. 3) Although over one hundred mounted specimens of them were examined, none had the skin of the next instar inside. But the available information on the behavior of *A. styracicola* was admittedly scanty. So I observed this aphid at Sun Moon Lake, Nantou County, Taiwan from November 21st to December 4th, 1977.

Observations

1. *Individuals biting man*

AOKI *et al.* (1977) observed that small hairy aphids, the supposed soldiers¹⁾, bit nearly immediately when they fell on the hand, and remained stationary for a while; whereas apterous adults and normal larvae kept on walking about on the hand and did not bite. In order to confirm this observation, the following experiment was carried out. Fifty soldiers and 50 apterous adults were picked out from a gall. They were placed on my hand one by one and it was recorded whether or not they bit the skin within 30 seconds, or then within a minute. The result (Table 1) showed that a clear difference in the habit of biting the human skin exists between the soldier and the apterous adult, although one adult also bit the skin.

Table 1. A comparison of the habit of biting the human skin between the soldier and the apterous adult.

	No. individuals tested	Indiv. bit within		Indiv. did not bite
		30 sec.	1 min.	
Soldier	50	40	45	5
Apterous adult	50	1	1	49

BANKS *et al.* (1968) are skeptical about biting with the stylets by *A. styracicola*. However, immediately after I observed under a magnifying lens that the apex of the rostrum of a soldier touched the skin of my hand, I felt irritation. Therefore, there is now no doubt that the aphids bite with the stylets.

2. *Individuals falling from the gall*

AOKI *et al.* (1977) predicted that the individuals that fall on man should exclusively be soldiers, except for casually fallen ones of other forms. To test this prediction the following experiment was carried out. A snowbell tree, having about 20 galls of *A. styracicola*, was chosen. Ten galls on the lower twigs were shaken from below with a metal frame tied to a bamboo pole. The frame was about

Table 2. Individuals collected by shaking the gall.

Date	No. individuals collected	Soldier	Other indiv.
1 (Nov. 22)	501	501	0
2 (Nov. 24)	438	438	0
3 (Nov. 27)	184	184	0
4 (Nov. 28)	272	272	0
5 (Dec. 1)	1015	1014	1
6 (Dec. 2)	1562	1561	1
Total	3972	3970	2

1) In the following they are simply called "soldiers".

30 cm in diameter and a paper bag was attached to it for the purpose of receiving falling aphids. All the aphids that fell into the paper bag were picked up and deposited in alcohol, and later they were identified under a dissecting microscope in the laboratory. The result (Table 2) showed that the prediction is true. Of 3972 individuals collected, 3970 were soldiers.

The two nonsoldier individuals were boiled in 10% KOH solution and mounted on a slide glass, and then identified. One was a 1st instar larva having the soldier skin inside and the other was a normal 2nd (or later?) instar larva.

3. *Individuals walking about on twigs*

TAKAHASHI (1930) mentioned that many apterous females and larvae moved out of the gall and walked about on its surface or the nearby twigs. But in the light of the soldier-hypothesis presented in this paper, it seems probable that the individuals walking about on the twigs are mainly soldiers. To examine this point, two twigs having galls were cut off and the aphids on the twigs and leaves were immediately captured. Later they were identified under a dissecting microscope in the laboratory. All the aphids collected (349 individuals) were soldiers.

4. *Individuals attacking predatory insects*

To see whether the aphids attack predatory insects and which form of individuals does so, the following experiment was carried out. Ten small aphidophagous syrphid larvae were collected from leaves of a bamboo species and individually placed on the galls put down on the earth. The result was that every syrphid larva was attacked by many aphids, and either fell from the gall or was wholly covered with the aphids and ceased wriggling. The syrphids together with the aphids attached to them were deposited in alcohol, and later they were examined under a dissecting microscope. All the aphids attached to the syrphid larvae (890 individuals) were soldiers. Most of these soldiers were biting the syrphid larva with their stylets.

It may be worth pointing out here that the gall of *A. styracicola* is thought to have a defensive effect against predatory insects which cannot masticate the gall tissue, since the gall has no large space for the predators to grow (see AOKI *et al.*, 1977: fig. 1). It is known that some syrphid larvae enter aphid galls through a very small slit and grow in the gall (e.g. AOKI, 1978). Such a strategy could not work against *A. styracicola*.

5. *Effect of the biting habit on mice*

To see whether the biting habit of *A. styracicola* is effective against mammals other than man, the aphids (mainly soldiers) were scattered on 3 caged mice (*Mus musculus*). Within a few minutes the mice began to scratch their faces and backs intensely with their fore and hind legs and mouth. It was observed that a mouse brushed away a soldier which had adhered to its ear for a while. It seems highly probable that the soldiers of *A. styracicola* can repel the mouse. But, although the mice scratched their backs, it is uncertain whether the soldiers actually bit the

hairy skin.

6. *Behavior of soldiers on the gall surface*

A gall was collected, and the behavior of soldiers on the gall surface was observed under a magnifying lens in a room. When a place on the gall surface was pecked with a pincette, the nearby soldiers became excited and walked around, raising their posterior abdominal segments. And a number of soldiers crawled out from within the gall through the slits.

In the field, too, many soldiers appeared on the surface of a gall when it was cut down on to the ground (Fig. 1).

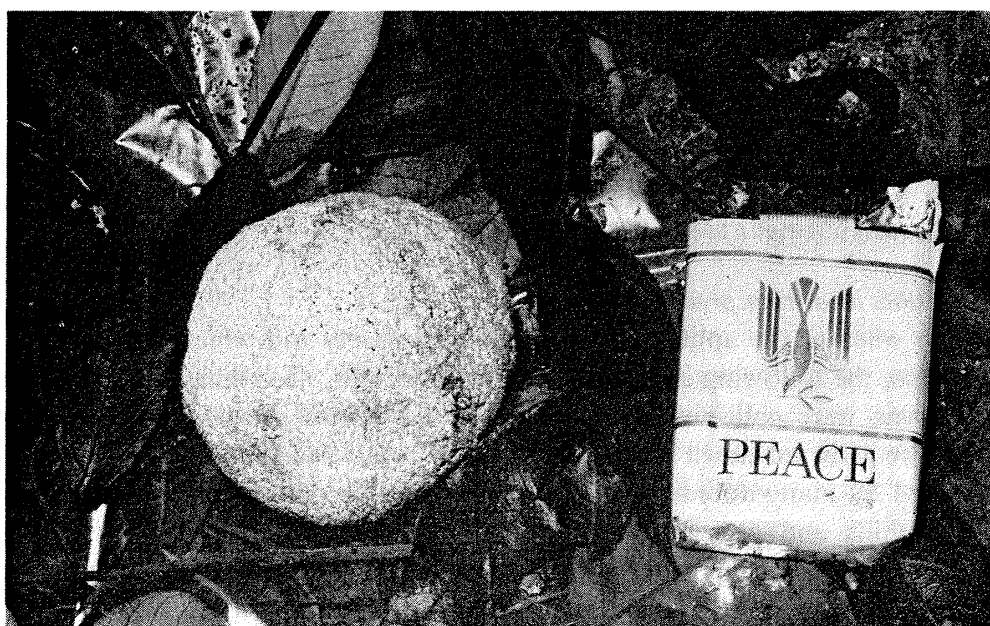


Fig. 1. An *Astegopteryx styracicola* gall. Many soldiers appear on the gall surface.

7. *Number of aphids in a gall*

A gall, about 9 cm in diameter, was collected and preserved in alcohol. Many aphids fell from the gall when it was collected. The number of aphids in the gall was estimated at 100,000 in the following manner. The gall was dissected and broken up into small pieces. The pieces, together with the aphids attached to them, were divided into roughly equal 16 samples in a dish. Then the aphids in the 9th largest sample were separated from the gall tissues, counted and identified under a dissecting microscope. This sample contained 6785 aphids, of which 3762 (55%) were soldiers.

Discussion

As it is known that at least 4 other aphid species, which have or have not special sterile soldiers, attack predatory intruders (AOKI, 1977, 1978; AOKI and

MIYAZAKI, 1978), it may not be surprising that *Astegopteryx styracicola* bites man and other animals. But at present it is difficult to decide with certainty what kind of animal is responsible for the evolution of the peculiar habits of *A. styracicola*.

Although the soldiers of *A. styracicola* can repel some predatory insects, predation by insects or other small arthropods is not sufficient to explain why the soldiers readily fall from the gall. The predators concerned should be large enough to shake the gall. They also should feed on the gall tissue, for the aphids themselves are very small and scattered in the tissue so that they are not a good food for large animals. The animals that seem to fulfil these conditions are phytophagous birds, rodents and monkeys. As birds are completely covered with feathers, the soldiers of *A. styracicola* may not be able to cause irritation to them. Rodents and monkeys, however, have naked areas of skin. If their hairs protect them from the soldier's bite, the soldiers may fall on the naked parts such as the nose. The present hypothesis presupposes that the gall of *A. styracicola* is a potential food for these arboreal mammals. Therefore, the hypothesis will be refuted if the gall contains poison.

On the other hand, if mammals or birds often feed on insect galls, the gall-making insects may have developed various devices to escape from these animals. The galls of the aphids, *Schlechtendalia chinensis* and *Nurudea shiraii*, on *Rhus javanica* contain a high percentage of tannin (TAKAHASHI, 1938, 1943). The galls of the aphid *Hamamelistes spinosus* on *Hamamelis virginiana* have many acute spines (MORDVILKO, 1935: 233). The fruit galls on *Viburnum dilatatum* made by the cecidomyid fly *Pseudasphondylia rokuharensis* become larger than the normal fruits, but they never turn red and are covered with fine white hairs (MONZEN, 1955; SUNOSE, personal communication). Are these characters merely byproducts?

The following two problems on *A. styracicola* may be worth noting: 1) No exuviae of *A. styracicola* were found within the gall. How do the aphids keep the gall clean? 2) The *A. styracicola* soldier has 2 pairs of frontal spine-like setae (see AOKI *et al.*, 1977: fig. 4C). HILLE RIS LAMBERS (1933) reports the occurrence of similar frontal setae in the 2nd instar larva of *Astegopteryx fransseni*. The function of these setae remains to be investigated.

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