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Studies on the Host Selection by Three Species of
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Ceroplastes Scales (Coccidae)

By

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Introduction

Three species of scales belonging to the genus *Ceroplastes*, viz. *C. rubens*, *C. pseudoceriferus* and *C. japonicus*, have been known in Japan. They are strongly injurious insect pests of horticulture and are commonly found in most parts of Japan except the northern and mountainous districts.

These three species of scales are attacked by some encyrtid wasps belonging to the genus *Anicetus*, of which *Anicetus beneficus* is considered as a special parasite to *Ceroplastes rubens*, *A. ceroplastis* to *C. pseudoceriferus* and *A. sp.* to *C. japonicus*. *A. ceroplastis* was reported by ISHII (1932) and TACHIKAWA (1955) to have been parasitic to *C. japonicus*, but their cases may be exceptional ones. For recent three years, the present author has tried to find similar cases, but the effort resulted in vain.

Although a single definite species only of the wasps emerged in nature from each host species, the wasps in the laboratory show the ovipositing behavior not only to their habitual host species but also to the other scales.

The ovipositing behavior of these wasps can easily be observed in a small glass tube in the laboratory. When two or three species of host scales are offered for oviposition at the same time, each species of wasps shows the characteristic tendency in the selection of hosts.

In the study on ecology and systematics of these closely related parasitic wasps, the comparison of their characteristic tendency in selecting hosts seems to present interesting and important problems. Since the author commenced the study on *Anicetus* group in 1954, he continued the effort to examine the host selecting tendency of them. In this paper, the author wishes to show the results obtained along this line.

Before going further, the author wishes to express his thanks to Prof. D. MIYADI, Dr. S. MORI, Dr. W. OHSAWA and the other members of the Research Group for Adaptive Variation for valuable discussions and criticisms during the course of this work, to Mr. T. TACHIKAWA of Ehime University for his kind identification and valuable suggestion on the systematics of these wasps, to Dr. K. YASUMATSU of

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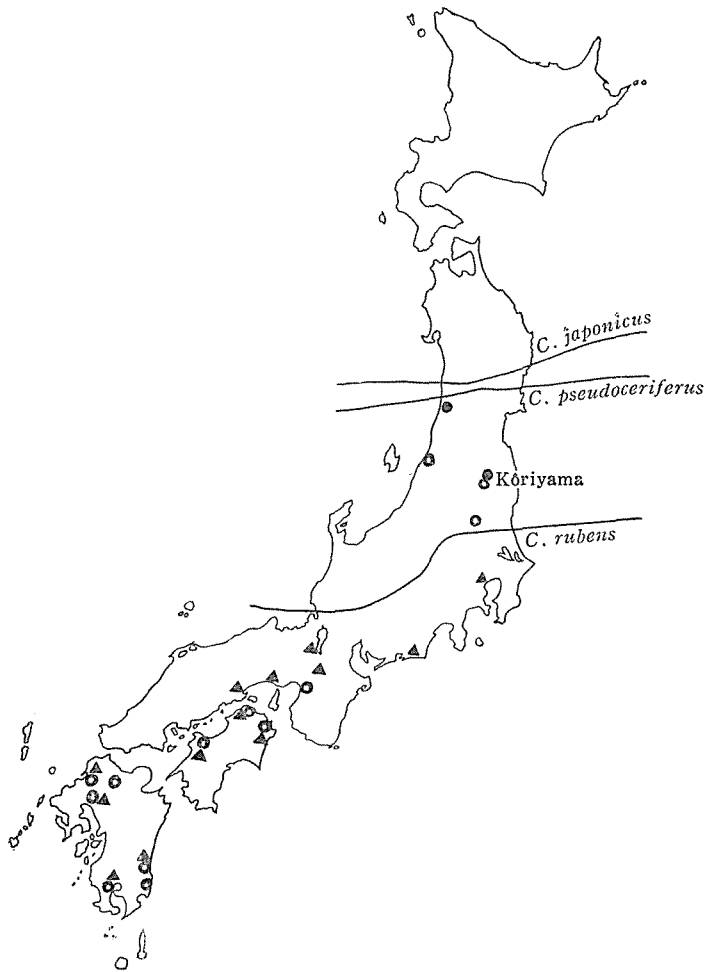


Fig. 1. Geographical distribution of *Anicetus* wasps and their hosts.

- ▲ Localities where *A. beneficus* was collected.
- Localities where *A. ceroplastis* was collected.
- ⊙ Localities where *A. sp.* was collected.

The lines show the northern boundaries of each species of host scales.

Geographical Distribution and Seasonal Occurrence of Wasps and their Hosts

Four species of encyrtid wasps belonging to the genus *Anicetus* have been recorded from Japan, of which three species are treated in this paper. Another species viz. *A. annulatus* is known as a parasite of five species of Coccidae other than the genus *Ceroplastes*.

Since the winter of 1954, many *Ceroplastes* scales were collected from several districts in Honshû, Shikoku and Kyûshû, and the parasites emerged from these scales were examined in the laboratory of Kyoto University. From these investigations the geographical distribution and the seasonal occurrence of the three species of wasps mentioned above have been clarified.

The geographical distribution of the wasps is shown in Fig. 1. From this figure, the range of distribution of each species may be summarized as follows.

A. beneficus, which was discovered in Fukuoka Prefecture in 1944, is now found in many districts of southern Japan as the result of an artificial introduction for the purpose of controlling the ruby scale, *Ceroplastes rubens*.

A. ceroplastis is distributed most widely. It is found in the greater parts of Honshû, Shikoku and Kyûshû, with the exception of northern Tôhoku district.

A. sp. was discovered by the author at Kôriyama of Fukushima Prefecture in 1956. It has been recorded only from two stations in the Tôhoku district. In spite of the extensive distribution of its host, *C. japonicus*, the distribution of this parasite species seems to be restricted within a narrow area of northern Japan.

All of these three species repeat two generations in a year, the emergent seasons of which are shown in Fig. 2. As the life span of adult females is

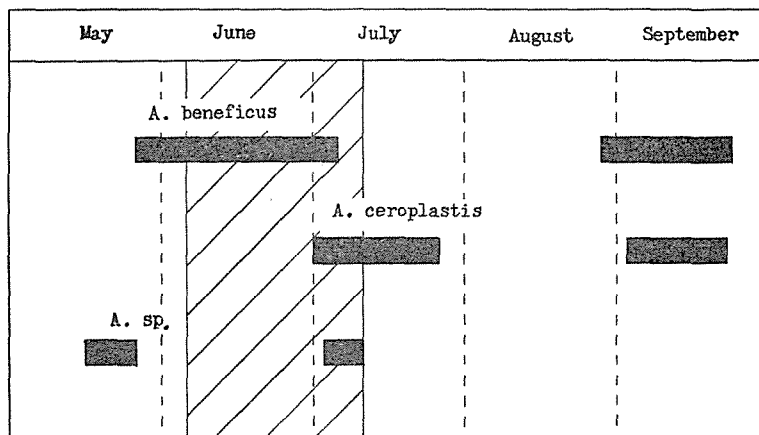


Fig. 2. Horizontal black bars show emergent periods of three species of *Anicetus* wasps. The area with oblique lines shows the season when newly hatched larvae of host scales appear.

considered to be three weeks or more, the period when the scales are attacked by the wasps may be somewhat longer than the period shown in this figure.

Experiments on Host Selection

a) *Materials and Methods*

The wasps used in the experiments were collected from the following localities.

A. beneficus: Kyoto, Tokushima, Takamatsu, Kurume, Miyazaki, Nichinan.

A. ceroplastis: Kôriyama, Ôsaka, Tokushima, Miyazaki.

A. sp.: Kôriyama.

The host scales collected from these localities were kept in glass tubes. The female wasps emerged from these scales were fed with undiluted honey for a week, and used in the experiments. These wasps can lay eggs in one or two days after emergence.

In the experiment, a test female was put in a glass tube of 7.5 cm in length and 1.5 cm in diameter, into which small twigs inhabited by three species of *Ceroplastes* scales were inserted.

The ovipositing behavior (viz. thrusting of the ovipositor into the host body) was observed during two hours, and the number of ovipositing behavior against three species of scales was recorded and compared.

b) *Results*

The experimental results described in the following tables were obtained during 1956-1957.

The author had clarified in a previous report that the host selection tendency was somewhat different according to the age of the host scales. Therefore the experiments reported here were performed by using both young and mature stages of the host scales.

The hosts to be oviposited by the wasps were prepared as follows.

Newly hatched larvae of the scales were put on the pot-planted *Euonymus japonica* THUMB. (Japanese name "Masaki"), and reared for about a week. The larvae secreted gradually the white waxy material and were soon covered with it. The body length of the scales at this stage was about 0.5 mm. They were used as the young hosts.

The mature hosts used were the adult females of each species reared up in Kyoto on the host plant of *E. japonica* or *Diospyros kaki* THUMB. (Japanese name "Kaki"), or those collected from some districts of Honshû, and Kyûshû. These scales laid their eggs in June and July, but the experiments were performed just before the oviposition.

The experimental results are shown in Tables 1-2.

From these tables, the tendency of host selection of each species may be summarized as follows.

A. beneficus: The selective tendency of this species was previously reported (OHGUSHI, 1956), and the result shown in this paper is consistent with the former.

Table 1. Showing the difference in the tendency of host selection among three species of wasps when three species of *Ceroplastes* scales of young stage were offered.

	R	P	J	—	Total
<i>Anicetus beneficus</i>					
Number of individuals	192	126	1	36	252
Number of times showing ovipositing behavior	953	375	4		1332
<i>Anicetus ceroplastis</i>					
Number of individuals	1	56	0	43	100
Number of times showing ovipositing behavior	2	244	0		246
<i>Anicetus</i> sp.					
Number of individuals	1	19	13	76	101
Number of times showing ovipositing behavior	3	42	40		85

R : Cases when ovipositing behavior was observed against *C. rubens*

P : Cases when ovipositing behavior was observed against *C. pseudoceriferus*

J : Cases when ovipositing behavior was observed against *C. japonicus*

— : Cases when no ovipositing behavior was observed

Table 2. Showing the difference in the tendency of host selection among three species of wasps when three species of *Ceroplastes* scales of mature stage were offered.

	R	P	J	—	Total
<i>A. beneficus</i>					
Number of individuals	62	0	2	36	100
Number of times showing ovipositing behavior	222	0	2		224
<i>A. ceroplastis</i>					
Number of individuals	6	63	22	130	210
Number of times showing ovipositing behavior	15	243	58		316
<i>A. sp.</i>					
Number of individuals	61	14	68	40	139
Number of times showing ovipositing behavior	220	21	208		427

Most females thrust their ovipositors into *C. rubens* (ordinary host in nature), but some of them also into *C. pseudoceriferus* and *C. japonicus*. It is interesting to note that, when the wasps attack the young host, many individuals may select *C. pseudoceriferus*.

A. ceroplastis: This species chiefly selects *C. pseudoceriferus* (ordinary host in nature). When the mature host is used, some individuals may select *C. japonicus*, but *C. rubens* never attracts this wasp irrespective of its stages of maturity.

A. sp.: The selective tendency of this newly discovered species is very interesting. The wasps of this species thrust their ovipositors into young scales of both *C. pseudoceriferus* and *C. japonicus* (which is the natural host of this species), but those of *C. rubens* are rarely attacked. On the contrary, when the mature scales are used, the wasps show ovipositing behavior equally to both *C. japonicus* and *C. rubens*, whereas *C. pseudoceriferus* is rarely attacked.

The relative tendency of host selection in these species is shown in Fig. 3.

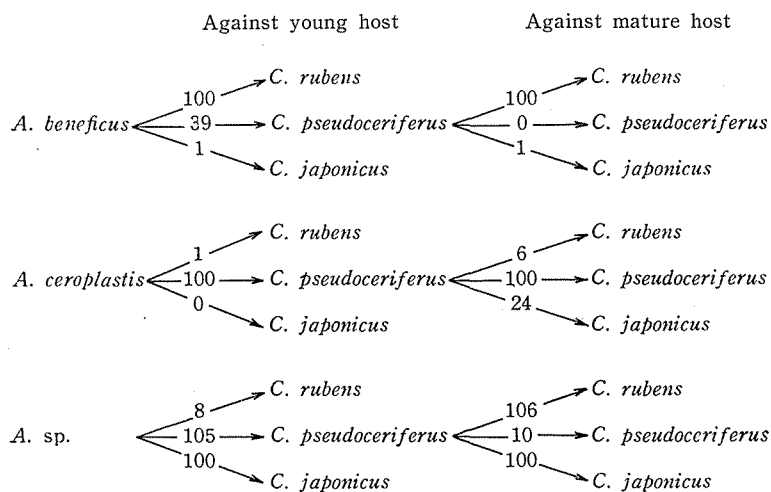


Fig. 3. Relative tendency of host selection in three species of *Anicetus*. The figures indicate the relative number of ovipositing behavior observed against each host species, when the value to the habitual host was taken as 100.

Discussion and Conclusion

From the beginning of this century, the host selection problem of insect parasites has been attacked by several investigators. Their efforts have been concentrated on the analysis of the mechanism of host finding and the problem of host suitability. The physiological mechanism of host finding has been studied chiefly by sense

physiologists, and some factors such as odor, shape and so on have been pointed out to partake of the host recognition.

In this study, the author has found that the parasitic wasps investigated show ovipositing behavior not only to their habitual hosts but also to the other species of the scales. The regular tendency in selecting hosts for oviposition is ascertained in each species of wasps.

The problem of the tendency of host selection in parasitic wasps may be approached from two points of view. One of them concerns the variability of tendencies, the other the latent host-parasite relationship between scales and wasps.

The selective tendency of *A. beneficus* is not rigid in the case of young host, but it is rather strictly determined for the mature host. On the other hand, *A. ceroplastis* shows a limited tendency for young host, but a loose choice among mature hosts. *A. sp.* is loose in the host selection irrespective of the age of the host.

From these results, we cannot find any coincident rule between the tendency of host selection of the wasps and the developmental stages of the host scales.

The latent host-parasite relations are different according to the wasp species or conditions of the hosts.

Four cases of latent relation were found, viz. *A. beneficus* to the young stage of *C. pseudoceriferus*, *A. ceroplastis* to the mature stage of *C. japonicus*, and *A. sp.* to the young stage of *C. pseudoceriferus* as well as to the mature stage of *C. rubens*. The cases of *A. ceroplastis* to *C. japonicus* and *A. sp.* to young *C. pseudoceriferus* are not fully confirmed, but the rest cases are well supported by the sufficient number of the experimental results. Among them, the case of *A. sp.* to *C. rubens* is interesting in relation to their geographical distributions. *A. sp.* is found in the Tōhoku district where *C. rubens* is not observed in the natural condition.

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