Investigations On The Hymenopterous Parasites Of Ceroplastes Rubens Maskell In Japan

Yasumatsu, Keizo
Entomological Laboratory, Department of Agriculture, Kyushu University

Tachikawa, Tetsusaburo
Entomological Laboratory College Of Agriculture Ehime University

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INVESTIGATIONS ON THE HYMENOPTEROUS PARASITES OF *CEROPLASTES RUBENS* MASKELL IN JAPAN*

KEIZÔ YASUMATSU AND TETSUSABURO TACHIKAWA

Plates 1-2

INTRODUCTION

Ceroplastes rubens Maskell has been an important pest of various economic plants in Japan for more than fifty years. Since its introduction into Japan (first found in 1897 at Nagasaki), it has spread over practically all provinces of Kyushu and Shikoku and western half of the main island, Honshu. The fact that no less than one hundred and twenty-five species of plants are attacked by this scale in Japan indicates the difficulty of its complete control by the chemical methods. Thus this scale is considered to be the third most important *citrus*-scale in Japan or the second most serious persimmon-pest in Japan, although it is of minor importance in foreign countries. Therefore the introduction of its parasitic Hymenoptera has been attempted during the years 1932 to 1938 from Hawaii and California, as the control of this scale by the introduction of its natural enemies seemed to be most promising. Four parasitic Hymenoptera, viz. *Aneristus ceroplastae* Howard, *Microterys kotinskyi* (Fullaway), *Tomocera californica* Howard and *Scutellista cyanea* Motschulsky, were introduced and liberated at Nagasaki, but without success. Meanwhile an

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elaborate investigation on the native parasites and predators has been carried out at the Nagasaki Agricultural Experiment Station, and several parasitic Hymenoptera were found. Unfortunately, however, these parasites were proved to be of little importance in checking the scale. On the basis of all available evidences, Professor Tei Ishii concluded in 1940 that the only possible method of control of this scale, therefore, would be the chemical one.

But it must be noted that the survey of the natural enemies of this scale has been performed chiefly at Nagasaki and that the horticulturists must expect some injuries to fruit trees from the application of insecticides in various ways.

In the early summer of 1946, the senior author had the good fortune to rear three species of parasitic Hymenoptera, viz. *Anicetus annulatus* Timberlake, *Microterys speciosus* Ishii and *Coccophagus hawaiiensis* Timberlake, from *Ceroplastes rubens* Maskell at Fukuoka. The percentage of parasitism of the latter two species was very low as previously examined by Dr. Ishii at Nagasaki, while that of the first mentioned species was comparatively high. Therefore, the senior author arrived at the supposition that the data are presented as local evidence of the effectiveness of this parasite in partially controlling the scale, and further recollected the word of Dr. C. P. Clausen, that one phase of biological control which has been somewhat neglected is that of the utilization of native parasites and predators. *Anicetus annulatus* Timberlake was hitherto known as a parasite of five other species of scales, and it is quite possible that the usefulness of this parasite has generally been overlooked.

In 1947, studies were made by the authors chiefly to ascertain the effectiveness of this parasite in Kyushu. Scales were collected from thirty-six localities in both Fukuoka and Oita Prefectures. The collections were made at random in each locality from various host plants, and the scales were examined daily for the emergence of the parasites. Such field collections and the results obtained would have convinced the authors that *Anicetus annulatus* Timberlake was really serving a good purpose in controlling the scales in Fukuoka Prefecture.

Before going further the authors express their hearty gratitude to Professor Teiso Esaki for his kindness rendered in the course of the present study.

PARASITES OF *Ceroplastes rubens* MASKELL REARED IN KYUSHU

Following eight species of parasitic Hymenoptera were reared from *Ceroplastes rubens* throughout the course of this investigation.

Aphelinidae

1. *Aphytis* sp.

16♀♀, Fukuoka, 6. v.—30. v. 1947; 15♀♀, Tsukumi, 24. iv. —25. v. 1947.

2. *Coccophagus hawaiiensis* Timberlake

1921 *Coccophagus lecanii* Nakayama (nec Fitch), Phil. Jour. Sci., 18: 98.
1926 *Coccophagus japonicus* Gahan, Proc. Ent. Soc. Washington, 28: 24.
1931 *Coccophagus hawaiiensis* Compere, Proc. U. S. Nat. Mus., 78, 7: 55.
1932 *Coccophagus hawaiiensis* Ishii, Oyo-Dobuts. Zasshi, 4: 151.
1940 *Coccophagus japonicus* Ishii (nec Compere), Oyo-Dobuts. Zasshi, 12: 123.

2♀♀, Fukuoka, 1946; 5♀♀, Fukuoka, 17. v.—31. v. 1947.
Distribution: Japan (Honshu: Shizuoka, Wakayama, Hiroshima. Kyushu: Fukuoka, Nagasaki, Miyazaki, Kagoshima).
Other host: ? *Ceroplastes ceriferus* (Anderson).

3. *Casca* sp.

3♀♀, Fukuoka, 14. v.—29. v. 1947; 1♀, Tsukumi, 25. iv. 1947.

Encyrtidae

4. *Microterys speciosus* shii

1923 *Microterys speciosus* Ishii, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull., 3: 70.
1928 *Microterys speciosus* Ishii, Bull. Imp. Agr. Exp. Sta., 3: 133.
1932 *Microterys speciosus* Ishii, Oyo-Dobuts. Zasshi, 4: 151.
1940 *Microterys speciosus* Ishii, Oyo-Dobuts. Zasshi, 12: 123.

5♀♀, 1♂, Fukuoka, 26. iv.—4. v. 1947.
Distribution: Japan (Honshu: Shizuoka. Kyushu: Fukuoka, Nagasaki, Kagoshima).
Other host: *Ceroplastes floridensis* Comstock.

5. *Microterys okitsuensis* Compere

1926 *Microterys okitsuensis* Compere, Univ. California Pubns., Ent., 4: 38.
1928 *Microterys okitsuensis* Ishii, Bull. Imp. Agr. Exp. Sta., 3: 137.

3♀♀, 7♂♂, Fukuoka, 30. iv.—25. v. 1947; 1♀, 1♂, Tsukumi, 26. iv.—17. v. 1947.

Distribution: Japan (Honshu: Okitsu. Kyushu: Fukuoka, Nagasaki, Tsukumi).

Other hosts: *Pulvinaria aurantii* Cockerell, *Pulvinaria psidi* Maskell.

6. *Anabrolepis bifasciata* Ishii

1923 *Anabrolepis bifasciata* Ishii, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull., 3: 106.
1928 *Anabrolepis bifasciata* Ishii, Bull. Imp. Agr. Exp. Sta., 3: 148.

1 ♀, Tsukumi, 14. v. 1947.

Distribution: Japan (Kyushu: Nagasaki, Tsukumi).

7. *Anabrolepis extranea* Timberlake

1920 *Anabrolepis extranea* Timberlake, Proc. Hawai. Ent. Soc., 4: 434.
1928 *Anabrolepis extranea* Ishii, Bull. Imp. Agr. Exp. Sta., 3: 148.

1 ♀, Tsukumi, 27. iv. 1947.

Distribution: Hawaii, Japan (Honshu: Ozuki. Kyushu: Isahaya, Tsukumi).

Other host: *Pseudaonidia paeoniae* Cockerell.

In 1920 Dr. Timberlake wrote as follows: "this certainly must be an immigrant species, but it is not yet apparent from what part of the world it was derived, although an Oriental origin is suspected."

8. *Anicetus annulatus* Timberlake

1919 *Anicetus annulatus* Timberlake, Proc. Hawai. Ent. Soc., 4: 227.
1920 *Anicetus annulatus* Fullaway, Proc. Hawai. Ent. Soc., 4: 242.
1928 *Anicetus annulatus* Ishii, Bull. Agr. Exp. Sta., 3: 149.

40 ♀ ♀, 25 ♂ ♂, Fukuoka, 1946: 1173 ♀ ♀, 722 ♂ ♂, Fukuoka, 1947: 4 ♂ ♂, Tsukumi, 25. iv.—4. v. 1947: 1 ♀, Beppu, 1947.

Distribution: California, Hawaii, Japan (Honshu: Yokohama. Kyushu: Fukuoka, Beppu, Nagasaki, Tsukumi).

Other hosts: *Coccus hesperidum* Linné, *Coccus pseudomagnoliarum* (Kuwana), *Eucalymnatus tesselatus* Signoret, *Pulvinaria* sp., *Ceroplastes ceriferus* Anderson (new host, Beppu and Kashii), *Saissetia hemisphaerica* (Targioni).

Among these parasites *Microterys speciosus* and *Coccophagus hawaiiensis* are the hitherto known natural enemies of *Ceroplastes rubens*. To determine the order of importance of these parasites, the results of the 1947 survey are set forth in Table 1.

Table 1. Percentage of parasites of *Ceroplastes rubens* observed in Kyushu in 1947.

Parasites	No. of individuals reared	Percentage
Anicetus annulatus	1870	97.04
Aphytis sp.	31	1.52
Microterys okitsuensis	12	0.59
Microterys speciosus	6	0.29
Coccophagus hawaiiensis	5	0.24
Casca sp.	4	0.19
Anabrolepis bifasciata	1	0.06
Anabrolepis extranea	1	0.06

From this table it is apparent that *Anicetus annulatus* is by far the most important parasite of *Ceroplastes rubens* and that seven other species are almost ineffective in reducing the scale populations. It is an interesting fact that the two species, *Microterys speciosus* and *Coccophagus hawaiiensis*, were found only in small numbers and have never made any increase in the level of effectiveness during the past twenty years. As to the economic status of the former species Dr. Ishii wrote in 1923 as follows: " it has already been noted that the parasite prefers to deposit eggs in full-grown female hosts, and that the latter is not killed until the greater proportion of their eggs are laid. Furthermore, the parasite usually develops only one generation per year in this host, and the percentage parasitized is very low, averaging about 3%. ...For this reason given above, and substantiated by observations and extensive counts in the field, it may be said that the parasite has very little or no effect in checking the scale." As to *Coccophagus hawaiiensis* he further wrote as follows: "... comparatively large numbers of pupae and adults were found dead in the host scale, this probably being due to premature death and drying out of the hosts, these consequently becoming so hard that the adult is unable to effect emergence. The adults of all generations prefer small immature scales in which to deposit their eggs, and particularly the adults of the first, third and fourth generations oviposit largely in such scales whose growth has not been vigorous. The above facts, together with the relating low percentage of parasitism, show that *C. hawaiiensis* (*lecanii*) is of very little value as a means of checking the increase of *Ceroplastes* *rubens.*" The authors' investigation indicates that the parasitism of these two parasites is much lower than that observed by Dr. Ishii. As economic entomologists, the authors feel no need to advance their knowledge of these seven species. Nevertheless, from the theoretical standpoint, the authors are extremely interested in the fact that the species of the Genera *Aphytis*, *Casca* and *Anabrolepis* were hitherto unrecorded from the scale insects of the Genus *Ceroplastes*.

PERCENTAGE OF PARASITISM OF *Ceroplastes rubens* BY HYMENOPTEROUS PARASITES OBSERVED IN KYUSHU

In the course of the present investigation, the percentage of parasitism was calculated by the following formula:

$$\frac{\text{Number of adult parasites emerged}}{\text{Number of scales}} \times 100.$$

The value, however, does not represent the real number of scales which were practically killed by the parasitic larvae. The larvae of the parasites which could not complete metamorphosis in the course of the postembryonic developmental period owing to some physiological reasons were not calculated in the present investigation. Consequently the value derived from the formula does not indicate an actual percentage of parasitism. Thus it is claimed that the actual value of parasitism must be estimated much higher. The results are summarized in Table 2.

Table 2. Parasitism of *Ceroplastes rubens* by Hymenopterous parasites in different localities in Kyushu observed in 1947

Host plants of *Ceroplastes rubens*	Localities*	No. of *C. rubens*	No. of parasites emerged**	Percentage of parasitism
Thea sinensis	Beppu, Oita Pref.**	114	A1 ♀	0.87
Citrus Unshu	Hikonouchi, Ts	252	0	0.00
Citrus Unshu	Nishinouchi, Ts	470	0	0.00
Citrus Unshu	Nakata, Ts	78	0	0.00
Citrus Unshu	Nishinouchi, Ts	1589	D1 ♀, F1 ♀	0.13
Citrus Unshu	Nishinouchi, Ts	294	0	0.00
Citrus Unshu	Kataura, Ts	165	0	0.00
Citrus Unshu	Shimoaoe, Ts	286	0	0.00
Eurya japonica	Nakata, Ts	3176	A1 ♀	0.03

Eurya japonica	Nakata, Ts	396	A1♂, G14♀	3.78
Thea sinensis	Nishinouchi, Ts	170	0	0.00
Thea sinensis	Hikonouchi, Ts	783	A2♂, E1♀, H1♀	0.51
Thea sinensis	Nakata, Ts	591	0	0.00
Thea sinensis	Iwaya, Ts	746	G1♀	0.13
Sakakia ochracea	Miyamoto, Ts	164	0	0.00
Camellia Sasanqua	Miyamoto, Ts	53	0	0.00
Diospyros Kaki	Nishinouchi, Ts	1764	0	0.00
Camellia japonica	Hikonouchi, Ts	58	0	0.00
Cinnamomum camphora	Miyamoto, Ts	114	D1♂	0.87
Laurus nobilis	Nakata, Ts	619	0	0.00
Fortunella japonica	Miyajidake, Fu	40	A5♀9♂	35.00
Ilex latifolia	University campus, Fu	226	A65♀43♂ C3♀	49.11
Machilus Thunbergii	University campus, Fu	171	A39♀19♂	33.91
Cinnamomum Loureirii	University campus, Fu	604	A100♀91♂	31.62
Ilex rotunda	University campus, Fu	677	A8♀2♂	1.47
Thea sinensis	University campus, Fu	567	A89♀55♂	25.39
Diospyros Kaki	Sasaguri, Fu	1667	A141♀85♂, G14♀	14.39
Citrus Unshu	Tachibana, Fu	1213	A128♀41♂, D3♀6♂	14.67
Illicium anisatum	University campus, Fu	179	A59♀27♂	48.04
Eurya japonica	Harumachi, Fu	1720	A138♀50♂, B1♀, D1♂ G2♀, H1♀	11.22
Sasakia ochracea	Sasaguri, Fu	962	A79♀64♂, B1♀, H1♀	15.07
Ilex dimorphophylla	University campus, Fu	560	A12♀17♂	5.17
Ilex integra	University campus, Fu	1307	A138♀76♂	16.37
Sasakia ochracea	Sasaguri, Fu	368	A23♀20♂, B3♀, C2♀1♂	13.31
Camellia japonica	Harumachi, Fu	1240	A104♀124♂	18.38
Laurus nobilis	University campus, Fu	1805	A45♀69♂	6.31

* Ts : Tsukumi, Oita Prefecture. Be : Fu : Fukuoka Prefecture.

A : *Anicetus annulatus*. B : *Coccophagus hawaiiensis*. C : *Microterys speciosus*. D : *Microterys okitsuensis*. E : *Anabrolepis extranea*. F : *Anabrolepis bifasciata*. G : *Aphytis* sp. H : *Casca* sp.

** Kindly collected by Mr. Tsuneo Torikata to whom the authors express their hearty thanks.

As seen from the table given above, marked differences in parasitism could be found in different localities. The parasitism at Beppu district was only 0.87 per cent and at Tsukumi district averaged only 0.27 per cent; whereas at Fukuoka district it averaged 21.1 per cent. Furthermore, the results show a high degree of parasitism in some places in Fukuoka district. The failure to find *Anicetus annulatus* in any appreciable numbers in Oita Prefecture (Beppu and Tsukumi) in the present investigation seems to be attributed to the later invasion of *Ceroplastes rubens* into that district.

The material from the University campus was collected mainly in the Botanical garden of the Faculty of Agriculture, Kyushu University. The following host plants are planted close to each other in a very limited area in the garden, and the comparison of the parasitism of *Ceroplastes rubens* on these plants seems to throw some light upon the habitat of the important parasite, *Anicetus annulatus.*

Table 3. Actual parasitism of *Anicetus annulatus* on *Ceroplastes rubens* on different host plants cultivated in a very limited area in the Botanical garden of the Faculty of Agriculture, Kyushu University.

Groups	Hosts	Host plants	Percentage of practical parasitism
A	*Ceroplastes rubens*	*Ilex latifolia*	over 49.1
	C. rubens	*Machilus Thunbergii*	over 33.9
	C. rubens	*Cinnamomum Loureirii*	over 31.6
	C. rubens	*Thea sinensis*	over 25.4
	C. rubens	*Illicium anisatum*	over 48.0
B	*C. rubens*	*Ilex dimorphophylla*	over 5.2
	C. rubens	*Ilex integra*	over 16.3
	C. rubens	*Laurus nobilis*	over 6.3

As can be seen in the table given above, *Anicetus annulatus* killed a much higher percentage of the population of *Ceroplastes rubens* on the plants of the group A than that of the group B. The highest case of parasitism observed amounted to over 50 per cent. In contrast, scales that were on the group B plants lived without appreciable damage from the parasites. The fact may be regarded as a highly important phenomenon. The questions which now arise for discussion are: (1) Why were the scales on the "A" plants more highly parasitized than those on the "B" plants? and (2) What is the factor which causes such close correlation between the activity of the parasites and the microclima of their habitat. First of all, it must be considered that the plants of the group B have much denser branches and foliage in a unit space than those of the group A. These conditions would affect the microclima on the plants in comparatively high degree. Consequently each of the groups A and B would offer some different ecological environment to these parasites. Thus *Anicetus annulatus* seemed to prefer the environment of the plants of the group A to those of B. The *Citrus*-trees may also be regarded as a representative of the group A. Similarly the fact that the plants of the group B are generally more densely covered with the sooty mold fungus, which grows on the honey dew given off by *Ceroplastes rubens*, may be of equal significance. In this case the surface of the infested plants appears to be densely covered with black dust. In 1941, Dr. S. F. Flanders published the following very interesting opinion concerning a dusty environment to insects. "A dusty environment is unfavorable to many species of insects. ... The susceptibility of the Hymenoptera to dust is correlated with specialized structures for removing dust particles from their food or from the surface of their bodies. ... The parasitic hymenopteron may pass the debris, removed from the antennae, mouth parts and other parts of the body, backward by means of each pair of legs. ... When small species of parasitic Hymenoptera, such as *Trichogramma*, come in contact with an excessive amount of dust, their movements lack coordination and they "wallo" helplessly. ... The parasites of pests not only may be more susceptible to dusts but they may be more uniformly affected than their hosts since they are largely hymenopterous or dipterous and consequently are more uniform in structure and in their feeding habits." Such a condition seems worthy of consideration. And in this connection it would be suggested that the sooty mold fungus on the infested plants does not directly affect *Anicetus annulatus* but seems to afford an unfavourable environment to this parasite. Invariably there may be numerous natural factors which tend to reduce the populations of the scales. Perhaps the most important of these are adverse climate, diseases, predacious enemies and insect parasites. But in Japan neither climatic factors nor diseases killed a conspicuous number of *Ceroplastes rubens* during the period when these observations were made. *Anicetus annulatus*, on the other hand, destroyed a large number of this scale, particulary in Fukuoka Prefecture. It was roughly estimated that more than fifty per cent of the scales were destroyed by this parasite. At any rate, a remarkable fact connected with this introduced scale is the slowness with which native parasites have transferred to the various stages of the new host. It must be noted that only in recent years *Anicetus annulatus* has become the dominant parasite of the scales in many places in N. Kyushu. In this connection Prof. Emer. Y. Tanaka* informed the senior author that the population of *Ceroplastes rubens* in his orchard has reduced prominently in recent years. Mr. I. Tateishi* of the Saga Agricultural Experiment Station has also experienced similar cases in some parts of Fukuoka and Saga Prefectures where the number of the scales was checked by the parasitic Hymenoptera. The authors think that all this evidence may represent the effectiveness of *Anicetus annulatus*. This evidence points to the possible importance of distributing the native parasite, *Anicetus annulatus*, from Fukuoka Prefecture to another, even though the species is widespread, as Dr. Clausen (1936) has already suggested.

EMERGENCE OF THE ADULT PARASITES

The emergence of such adult parasites as *Aphytis* sp., *Coccophagus hawaiiensis*, *Casca* sp., *Microterys speciosus*, *M. okitsuensis*, *Anabrolepis bifasciata* and *A. extranea* lasted from the end of April to that of May in 1947. In Tsukumi district *Anicetus annulatus* was first observed at the end of April. The dates of the emergence of the adult of this parasite observed in the laboratory of the Kyushu University are summarized in the following tables.

Table 4. Emergence of the adult *Anicetus annulatus* in Fukuoka (Observed in the laboratory).

Date	4. vi.	5. vi.	6. vi.	7.–12. vi.	13. vi.	14.–15. vi.
♀	2	1	1	137	17	209
♂	3	5	4	159	29	222
Total	5	6	5	296	46	431

Date	17. vi.	18. vi.	19. vi.	20. vi.	21. vi.	22. vi.	23. vi.	24. vi.
♀	101	105	151	141	100	46	61	36
♂	84	52	91	65	29	10	21	9
Total	185	157	242	206	129	56	82	45

* To these gentlemen the authors express their thanks for their kind informatio on the problem.

Date	25. vi.	26. vi.	27. vi.	28. vi.	29. vi.	30. vi.	1. vii.	2. vii.
♀	20	15	9	6	3	0	1	2
♂	1	0	1	0	1	0	1	0
Total	21	15	10	6	4	0	2	2

Table 5. Sex-ratio of the adult *Anicetus annulatus.*

Date	No. of females	No. of males	Sex-ratio in per cent
4. vi.–6. vi.	4	14	22.2
7. vi.–12. vi.	137	159	46.2
13. vi.–17. vi.	318	338	48.5
18. vi.–22. vi.	533	247	68.3
23. vi.–27. vi.	142	34	80.7
28. vi.–2. vii.	12	2	85.7
Total number	1146	794	

From these tables it is apparent that the emergence of the adult *Anicetus annulatus* was at its height during the middle of June when the sex-ratio is about 50 per cent. Next, the time of the emergence of the adult in each day was observed in the laboratory.

Table 6. Time of the emergence of the adult *Anicetus annulatus* in Fukuoka (Observed in the laboratory).

Date	19. vi.		24. vi.		25. vi.		26. vi.		Total in per cent		Average in per cent
Weather	Fine		Rainy		Fine		Fine				
Sex	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	
7:00– 8:00	0	11	1	1	1	0	1	0	0.49	11.37	3.88
8:00– 9:00	30	17	1	2	5	1	10	0	17.45	19.58	18.12
9:00–10:00	41	13	7	5	8	0	1	0	28.30	15.46	24.27
10:00–11:00	39	8	13	1	4	0	1	0	24.05	13.40	20.71
11:00–12:00	11	8	12	0	0	1	1	0	11.79	9.27	11.00
12:00–16:00	22	28	2	0	0	0	1	0	11.92	30.95	22.02
16:00– 7:30	0	0	0	0	0	0	0	0	0.00	0.00	0.00

From this table the following facts may be derived. The emergence of the adult begins before seven in the morning, reaches its height during the hours nine to eleven and ceases about four o'clock in the afternoon. More than eighty per cent of the adult emerges before noon, and no adult emerges during the dark hours.

OVIPOSITION OF *Anicetus annulatus* AND THE SIZE OF THE SCALES

The oviposition behavior of the female of *Anicetus annulatus* was observed very easily under the binocular microscope. When the female is ready to oviposit, she mounts on the back of a scale and examines it carefully with the tips or the underside of the antennae while walking back and forth, always orientating her body-axis almost parallel to the longitudinal axis of the scale. If the scale is in satisfactory condition, she stands on tip-toe, and raises the anterior portion of the body but lowers the tip of the abdomen until it is close to the protective wax covering of the scale. The ovipositor pierces the protective covering of wax of the host. This piercing procedure may require ten minutes or as much as fifteen minutes. The oviposition may require only a few second. Meanwhile the antennae are almost motionless and pointed downward. Sometimes the host scale exserts its anal tube as the female parasite stabs it with the ovipositor during oviposition, an indication that the scale possibly feels and is in pain during the procedure as already known in many cases. In one instance, the honey dew excrected by the anal tube of the scale became attached to the face of the ovipositing female parasite, but the parasite neither paid any attention to it nor fed on it. *Anicetus annulatus* does not distinguish between scales already oviposited on and those not oviposited on. It is not uncommon to find supernumerary eggs on the same hosts laid by different parasites or by parasites that returned to attack the same host. If the scale is large, she inserts the ovipositor into the scale in full length. If the scale is small, only the apical portion of the ovipositor is inserted. The measurements of 1558 scales from which *Anicetus annulatus* emerged are summarized as follows:

Table 7. Measurements of the protective covering of wax of *Ceroplastes rubens.*

	Minimum length	Maximum length	Average length
Longitudinal axis	1.0 mm.	4.0 mm.	2.48 mm.
Transverse axis	1.0 mm.	4.0 mm.	2.28 mm.

So far as the authors' observations goes, there are no sufficient data and observations available to substantiate the fact hat a larger parasite has a tendency to select a larger scale.

LONGEVITY OF THE ADULT PARASITES

Generally it is almost impossible to ascertain the longevity of the parasitic Hymenoptera in the field, but it is apparent that they would live much longer in the field than in confinement in glass tubes. As to the longevity of *Anicetus annulatus* Dr. Ishii (1923) gave a single record of 52 days in the female. The authors' investigations on the longevity of the same species in confinement in glass tubes in the laboratory are seen in the following tables.

Table 8. Longevity of the adult *Anicetus annulatus* that were given no food.

Longevity in days		2	3	4	5	6	10	Average
No. of individuals	♀	4	7	9	3	1	2	4.07 days
	♂	1	13	3	4	0	0	3.47 days
	total	5	20	12	7	1	2	

Table 9. Longevity of the adult *Anicetus annulatus* that were fed with water.

Longevity in days		3	4	5	6	7	8	Average
No. of individuals	♀	1	4	8	3	2	1	5.21 days
	♂	1	3	2	4	1	0	5.09 days
	total	2	7	10	7	3	1	

Table 10. Longevity of the adult *Anicetus annulatus* that were fed with honey dew dropped off by the Aphididae.

Longevity in days		3	4	7	8	9	11	14	17	18
No. of individuals	♀	0	1	1	0	3	0	0	1	3
	♂	1	0	0	1	0	1	1	0	1
	total	1	1	1	1	3	1	1	1	4

Longevity in days		20	21	24	26	31	37	38	Average
No. of individuals	♀	1	2	0	0	1	3	1	20.64 days
	♂	1	0	4	1	0	0	0	17.81 days
	total	2	2	4	1	1	3	1	

Table 11. Longevity of the adult *Anicetus annulatus* that were fed with diluted honey.

Longevity in days		11	13	14	16	17	27	30
No. of individuals	♀	0	0	1	1	1	1	0
	♂	1	1	0	0	0	0	1
	total	1	1	1	1	1	1	1

Longevity in days		32	35	36	37	39	Average
No. of individuals	♀	1	1	1	1	2	29.20 days
	♂	0	0	0	0	0	18.00 days
	total	1	1	1	1	2	

Table 12. Longevity of the adult *Anicetus annulatus* that were fed with concentrated honey.

Longevity in days		8	17	21	25	26	28	29
No. of individuals	♀	0	1	0	3	1	3	7
	♂	1	1	1	2	1	1	0
	total	1	2	1	5	2	4	7

Longevity in days		30	31	32	33	Average
No. of individuals	♀	3	1	1	1	16.90 days
	♂	0	0	0	0	21.42 days
	total	3	1	1	1	

All the material of the parasites used in these experiments were 0 to 24 hours old. From the tables given above the following facts may be derived. The longevity of the adult parasites fed with water could not be greatly prolonged as compared with those fed nothing whatsoever. The life of the adult parasites could be greatly prolonged by such a diet as honey dew dropped off by the Aphididae (about five times as long as those given no food). The individuals that were furnished with honey showed much longer adult life (sometimes about seven times as long as those without food). But the authors were not be able to detect any definite difference in the adult life fed with honey dew, diluted honey or concentrated honey. The longevity of the adult life of the other parasites that were fed with no food are summarized in the following table.

Table 13. Longevity of the adult life of seven other parasites that were fed with no food.

Aphytis sp	♀	Average	4.84 days
Microterys okitsuensis	♀		4.40
	♂		6.00
Microterys speciosus	♀		3.66
	♂		3.60
Coccophagus hawaiiensis	♀		5.50
Casca sp.	♀		3.50
Anabrolepis bifasciata	♀		3.00
Anabrolepis extranea	♀		3.00

CONCLUSION

It is a remarkable fact that during the past few years there has been a progressive decrease in the population of *Ceroplastes rubens* Maskell in N. Kyushu. A thorough analysis and survey in the infested areas of N. Kyushu definitely indicate that the increase of natural enemies is now having considerable influence on the scale population. As many as eight species of Hymenopterous parasites were recognized. Among them an Encyrtid, *Anicetus annulatus* Timberlake, especially offers possibility of reducing scale populations. At present an attempt to liberate this parasite in other parts of Japan where the percentage of parasitism of the scales by the natural enemies is very low is desirable.

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Appendix: List of known Hymenopterous parasites of the scales of the Genus *Ceroplastes*.

(This list may not be complete but contains all the species to which the senior author can refer at present)

Scales	Parasites	Localities	References
actiniformis Green	*Aneristus ceroplastae* Howard	Ceylon	Howard, Ashmead (1896), Gahan (1924, 1925), Smith, Compere (1928), Compere (1936)
africanus Green	*Anicetus africanus* Girault	N. Africa	Mercet (1925)
	Cheiloneurus angustifrons Compere	N. Africa	Compere (1938)
	Trichomasthus tenuicornis Mercet	N. Africa	Mercet (1925)
..gentinus Brèthes	*Prorhopoideus baezi* Brèthes	Argentine	Brèthes (1921)
bergi Cockerell	*Cerapterocerus bonariensis* Brèthes	Argentine	Brèthes (1922)
ceriferus (Anderson)	*Anicetus ceroplastis* Ishii	Japan	Ishii (1928)
	Cheiloneurus ceroplastis Ishii	Japan	Ishii (1928)
	Eusemion sp.	China	Silvestri (1929)
chinensis Nietner	*Scutellista* sp.	Italy	Silvestri (1919)

	Tomocera californica Howard	Spain	Mercet (1924), Smith, Compere (1928)
cirripediformis (Comstock)	*Aneristus ceroplastae* Howard	Porto Rico	Dozier (1925), Compere (1936)
	Aphycus mexicanus Howard	U. S. A.	Howard (1898)
	Plagiomerus cyaneus Ashmead	Porto Rico	Dozier (1925)
destructor Newstead	*Anicetus parvus* Compere	C. Africa	Compere (1937)
	Bothriophryne ceroplastae Compere	C. Africa	Compere (1937)
	Coccidoxenus ugandensis Compere	C. Africa	Compere (1937)
	Coccophagus amblydon Compere	C. Africa	Compere (1937)
	Coccophagus clavellatus Compere	S. Africa	Compere (1931)
	Coccophagus flaviceps Compere	S. Africa	Compere (1931)
	Diversinervus elegans Silvestri	C. Africa	Gurney (1936)
	Euxanthellus sp.	S. Africa	Compere (1936)
	Scutellista cyanea Motschulsky	C. Africa	Gurney (1936),
		Australia	Gurney (1936)
dozieri Cockerell	*Aneristus ceroplastae* Howard	Haiti, Porto Rico	Compere (1936)
	Marietta ceroplastae Howard	Haiti, Porto Rico	Compere (1936)
euphorbiae Cockerell	*Aneristus ceroplastae* Howard	Jamaica	Gahan (1924, 1925), Smith, Compere (1928), Compere (1936)
floridensis Comstock	*Microterys clauseni* Compere	Japan	Compere (1926), Ishii (1928, 1932)
	Microterys speciosus Ishii	Japan	Ishii (1928, 1932)
	Encyrtid sp.	China	Silvestri (1929)
galeatus Newstead	*Eurytoma galeati* Girault	C. Africa	Girault (1916), Gowdey (1917)
	Neomphaloidella ceroplastae Girault	C. Africa	Girault (1916), Gowdey (1917)
	Scutellista cyanea Motschulsky	C. Africa	Girault (1916), Gowdey (1917)
giganteus Dozier	*Homalopoda cristata* Howard	Haiti	Dozier (1937)
	Prococcophagus hispaniolae (Dozier)	Haiti	Compere (1936)
mimosae	*Scutellista gigantea* Berlese	E. Africa	Berlese (1917)
rubens Maskell	*Anabrolepis bifasciata* Ishii	Japan	Yasumatsu, Tachikawa
	Anabrolepis extranea Timberlake	Japan	Yasumatsu, Tachikawa
	Aneristus ceroplastae Howard	Hawaii	Timberlake (1918), Fullaway (1919)
		Fiji	Simmonds (1936)
	Anicetus annulatus Timberlake	Japan	Yasumatsu, Tachikawa
	Aphytis sp.	Japan	Yasumatsu, Tachikawa
	Casca sp.	Japan	Yasumatsu, Tachikawa
	Cerapteroceroides japonicus Ashmead	Japan	Ishii (1940)

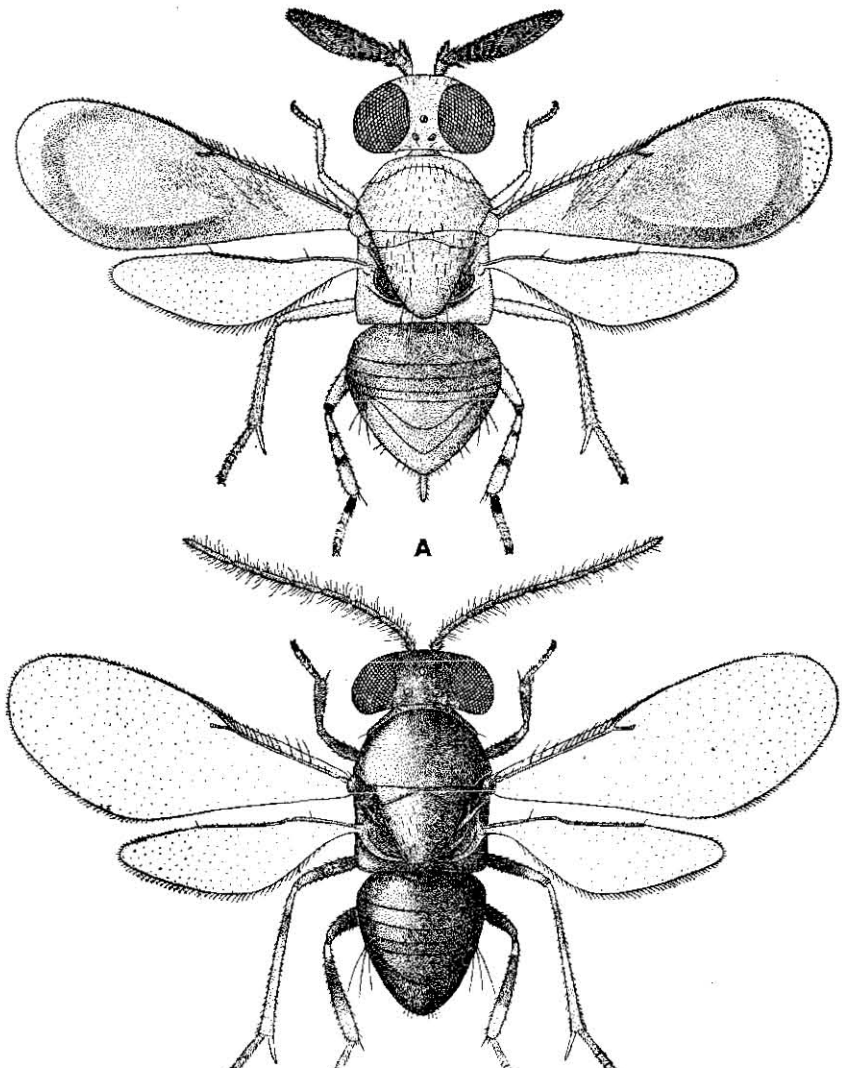
	Cheiloneurus ceroplastis Ishii	Japan	Ishii (1923, 1928, 1932, 1940), Kaburaki (1934)
	Coccophagus hawaiiensis Timberlake	Japan	Ishii (1923, 1932, 1940), Kaburaki (1940), Yasumatsu, Tachikawa
	Eupelmus sp.	Japan	Ishii (1932)
	Eusemion sp.	China	Silvestri (1929)
	Marietta sp.	Japan	Ishii (1940)
	Microterys kotinskyi (Fullaway)	Hawaii	Fullaway (1918)
	Microterys okitsuensis Compere	Japan	Yasumatsu, Tachikawa
	Microterys speciosus	Japan	Ishii (1923, 1928, 1932, 1940), Kaburaki (1934), Yasumatsu, Tachikawa
	Physcus atrithorax Girault	Australia	Girault (1939)
	Quaylea whitieri (Girault)	Hawaii	Ishii (1940)
	Tomocera californica Howard	Hawaii	Fullaway (1919), Smith, Compere (1928)
	Tomocera ceroplastis Perkins	Hawaii	Fullaway (1919)
rusci (Linné)	*Coccophagus howardi* Masi	Europe	Silvestri (1919)
	Coccophagus lecanii (Fitch)	U. S. A.	Smith, Compere (1928)
	Coccophagus scutellaris Dalman	Europe	Silvestri (1919)
	Eusemion italicum Masi	Italy	Masi (1917)
	Marietta caridei (Brèthes)	Brazil	Brèthes (1920)
	Scutellista cyanea Motschulsky	N. Africa	Picard (1914), Delassus (1924)
		S. France	Balachowsky (1927, 1930)
		Italy	Smith, Compere (1928), Widiez (1932)
	Tetrastichus gemani Brèthes	Brazil	Brèthes (1920)
	Tomocera californica Howard	Spain	Mercet (1924), Smith, Compere (1928)
vuilleti Marchal	*Coccidoxenus coelops* Waterston	C. W. Africa	Waterston (1917)
sp.	*Aneristus youngi* Girault	U. S. A.	Compere (1936)
sp.	*Aphycus mexicanus* Howard	Mexico	Howard (1898)
sp.	*Asteropaeus primus* Howard	Mexico	Howard (1898)
sp.	*Bothriophryne ceroplastae* Compere	C. Africa	Compere (1937)
sp.	*Bothriophryne dispar* Compere	C. Africa	Compere (1939)
sp.	*Bothriophryne fuscicornis* Compere	S. Africa	Compere (1939)
sp.	*Bothriophryne purpurascens* Compere	S. Africa	Compere (1939)
sp.	*Ceraptocerus inutilis* Compere	C. Africa	Compere (1937)
sp.	*Coccophagus atratus* Compere	S. Africa	Compere (1926)
sp.	*Coccophagus ispingoensis* Compere	C. Africa	Compere (1937)
sp.	*Coccophagus malthusi* Girault	S. Africa	Compere (1926)
sp.	*Coccophagus margaritatus* Compere	S. Africa	Compere (1931)
sp.	*Coccophagus nubes* Compere	S. Africa	Smith, Compere (1928)

sp.	*Diversinervus elegans* Silvestri	C. Africa	Compere (1937)
sp.	*Eupelmus coccidivorus* Gahan	Panama	Gahan (1924)
sp.	*Lecaniobius capitatus* Gahan	Panama	Gahan (1924)
sp.	*Marietta mexicana* (Howard)	U. S. A.	Howard (1895), Smith, Compere (1928)
		Mexico	Compere (1936)
sp.	*Metaphycus ferrieri* Compere	C. Africa	Compere (1940)
sp.	*Metaphycus lineascapus* Compere	S. Africa	Compere (1940)
sp.	*Microterys elegans* Blanchard	Argentine	Blanchard (1940)
sp.	*Microterys umbrinus* Compere	C. Africa	Compere (1939)
sp.	*Paraceraptrocerus africanus* Girault	S. Africa	Girault (1920)
sp.	*Tetrastichodes xenocles* Walker	Chili	Brèthes (1916)

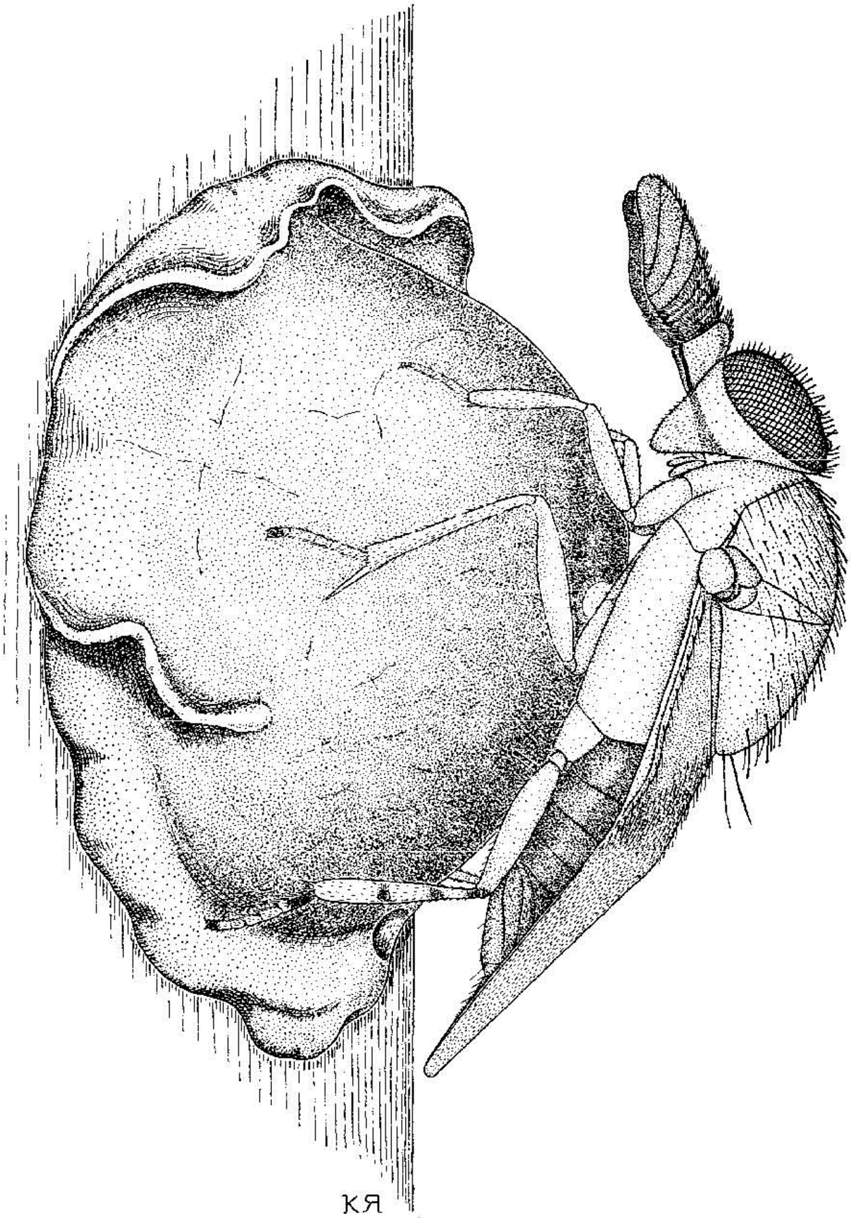
Explanation of the Plates

Plate 1. *Anicetus annulatus* Timberlake, adult.
A: Female
B: Male

Plate 2. *Anicetus annulatus* Timberlake ovipositing in the body of *Ceroplastes rubens* Maskell.



Anicetus annulatus Timberlake



Anicetus annulatus Timberlake