

Analytical Studies of Aphid Populations on a Pear-tree*

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ナシの木の上でのアブラムシ個体群の研究

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In the spring of 1957, two kinds of investigations were made by the writer to study a factor or factors acting to restrain an unlimited growth of the aphid population: one was on *Macrosiphum granarium* KIRBY in rice nurseries and the other on a few species of aphids on a pear-tree. In this paper he will treat of the latter alone, because the former will shortly appear in another journal.⁽¹⁾

In Japan pear-trees are infested with several species of aphids each year and sometimes the yield, as a result, is considerably affected by their infestation. The writer believes this will make it more significant to study the features of aphid populations on a pear-tree.

I Methods of Investigations

A pear-tree of "Yakumo" variety, which was about 2.5 metres in height and stood solely in an edge of a vegetable field at Nogi, Matsue City, was used for the present purpose. There stood another pear-tree of "Nizyusseki" variety about 3 metres away from the tree mentioned above, but in fact no colony of aphids was found on it during the period of the investigations.

Samples were taken on every third or fourth day during the period from the 25th of April to the 21st of June. The term of investigations was divided into two periods: the first was from the beginning to the 3rd of June and the second from the 6th of June to the end of the investigations.

During the first period samples were picked up from bearing spurs and during the second from long shoots.

The methods of sampling adopted were as follows:

(1) The first period—A branch of the pear-tree was chosen at random. Next a bearing spur located first or second from the tip of the branch downward was taken as a sampling unit and then the other sampling units were taken, one after one, from every tenth bearing spur down along the branch towards the stem. Thus five sampling units were obtained for each investigating day.

If five units were not obtained from one branch, the rest were got in the same way from another branch anew until the necessary number of units was filled. All leaves of a bearing spur taken as a sampling unit were gathered for examination in the laboratory.

(2) The second period—Long shoots were sampling units. The method of taking them was the same as in the first period, but in this case all the leaves were not picked up from the long shoot but only from the part secondarily growing on the long shoot.

Each leaf brought into the laboratory was examined, and if aphids were found on it they were collected and preserved in alcohol in a glass tube.

The instars of the aphids preserved were later determined by measuring their lengths of segments of antennae under a microscope.⁽¹⁰⁾ As for the aphids of the third and fourth instars it was examined whether they had wing-pads or not. (In the case of the second instar the writer could not clearly distinguish the existence of their wing-pads.)

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II Results of the First Period

All colonies of aphids recorded during the first period were those of *Toxoptera piricola* MATSUMURA, excepting one colony of *Anuraphis piricola* OKAMOTO et TAKAHASHI found on the 6th of May. *T. piricola* is one of the most injurious of aphid species that have ever injured pears in Japan. The life history of this species may be summarized as follows: eggs overwintering near buds of a pear-tree hatch early in spring, and the insects that come out injure growing leaves of the tree, forming dense colonies on them and rolling them inside. Infestation on the pear continues until June, when the aphids leave the pear for intermediate host plants, *Cyperus rotundus* L. and others. They return to pear-trees again in October or November.

When the investigations were begun on the 25th of April, colonies of *T. piricola* had already formed on some leaves of the pear-tree (Table 1).

Table 1. Results of sampling from a pear-tree at Nogi, Matsue City, during the period from the 25th of April to the 3rd of June, 1957.

Date	No. of leaves per sampling unit	No. of leaves, on which colonies of <i>Toxoptera piricola</i> were formed, per sampling unit	No. of <i>Toxoptera piricola</i> per colony	No. of apterae of <i>Toxoptera piricola</i> per colony
Apr. 25	6.8	0.2	6.00	0
29	8.2	0.4	105.00	7.50
May 2	7.0	2.0	76.00	2.70
6	5.2	0.4	18.00	0
9	6.8	0.4	11.50	0
13	4.8	0.8	60.75	2.75
17	4.2	1.2	71.67	0.33
21	4.8	0.8	39.75	1.00
24	6.0	0.6	7.00	0
27	4.8	1.0	33.00	1.40
30	4.6	0.2	6.00	0
June 3	2.6	0	—	—

Various devices of sampling have been made to estimate the population densities of aphid species (see SHANDS *et al.*⁽¹²⁾, BANKS⁽¹⁾ and NIELSON⁽⁶⁾). The writer had succeeded in estimating roughly the population densities of *Macrosiphum granarium* in rice nurseries by smaller size of samples, but in the case of *T. piricola* which form such dense colonies as on pear-leaves, it was impossible to estimate the density of their population from so small number of samples as were obtained in the present investigations. From Table 1, however, we shall be able to presume at least a general trend of the population of *T. piricola* on the pear-tree: judging both from the number of leaves infested by the aphids and from the mean number of individuals forming a colony, the population of *T. piricola* on the pear-tree did not seem to grow with advance of the season. Some years ago, as a result of studying populations of a few aphid species that injured cruciferous vegetables, the writer showed that such aphid populations as had steadily been growing suddenly increased in their size about 20 days after their establishment.⁽⁷⁾⁽⁸⁾ The reason why the population of *T. piricola* on the pear-tree failed to grow may be clarified by giving consideration to the ecological feature of the colony.

When the age constructions of colonies of *T. piricola* were observed for the first period, it was found that the mean numbers of apterous females in a colony, in general, were relatively small (the fifth column of Table 1) and that the ratios of nymphs in the third and fourth instars with wing-pads to those without wing-pads in a colony were usually very large (Figure 1).

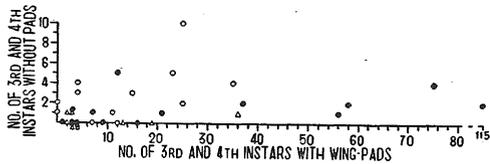


Figure 1. Relationships of the number of the third and fourth instars of *Toxoptera piricola* with wing-pads to those without wing-pads in a colony on a leaf of pear-tree during the period from the 25th of April to the 3rd of June, 1957.

- : The colony found during the period from the 25th of April to the 6th of May.
- : The colony found during the period from the 9th to the 21st of May.
- △ : The colony found during the period from the 24th of May to the 3rd of June.

The fact means that since the establishment of the population, a large portion of nymphs of *T. piricola* had developed into alates and flown off from the pear-tree, and those which had grown into apterae were too small in number to permit a vigorous growth of the population on the pear-tree.

Figure 2 represents the age distributions in such large colonies as the numbers of individuals in them exceed one hundred each. Take notice of the fact that a large portion of the colony was occupied by the nymphs with wing-pads in the latter half of the first period.

Early in June *T. piricola* left almost completely the leaves of bearing spurs of the pear-tree in which they had grown: most of them flew away for intermediate host plants and the rest moved to the secondary growths of long shoots. About at that time many of rolled leaves on which a colony had been formed were defoliated, thus the number of leaves on bearing spurs becoming, as is seen in Table 1, smaller in general. The small average number, 2.6, of the leaves picked up on the 3rd of June does not seem to be due to a sampling error.

During the first period very few natural enemies of aphids were recorded, though at the same season of the preceding year many lady beetles had been active on the same pear-tree. Only animals that might be the predators of aphids were several small spiders that spun their webs in leaves rolled by aphids. No swollen aphid attacked by parasites was discovered.

In the case of *Anuraphis piricola* only one colony was recorded from a leaf sampled on the 6th of May, which was rolled outward. The age distribution of the colony was as follows: aptera 1, the 4th instars 8 (of which 5 were ones with wing-pads), the 3rd instars 9 (of which 8 were ones with wing-pads), the 2nd instars 8, and the 1st instars 23.

III Results of the Second Period

On the 6th of June it was observed that almost all colonies of aphids had disappeared from the leaves of bearing spurs of the pear-tree, while some were found on those parts of long shoots which had come out from the first growths and stretched fresh leaves at the end of May or early in June. So since that day the method of sampling was altered as shown in the preceding section.

During the second period as many of *Aphis citricidus* KIRKALDY as *Toxoptera piricola* were collected. That this species was found injuring a pear-tree is perhaps the first case recorded in Japan, as mentioned in another paper of the writer.⁽¹⁰⁾ Both *T. piricola* and *A. citricidus* during this period formed dense colonies as in the case of *T. piricola* during the first period. Moreover, these two species had lived mingling with each other. Leaves occupied by one species were not kept off by the other, and in addition there was even a tendency that leaves preferred by one species were

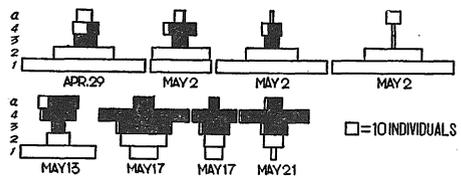


Figure 2. Age distributions in large colonies of *Toxoptera piricola*, each of which consists of one hundred or more individuals on a leaf of pear-tree, during the period from the 25th of April to the 3rd of June, 1957.

The numerals represent the first, second, third and fourth instars respectively. Letter *a* represents the adult. A blackened part means in the case of the third and the fourth instars individuals with wing-pads, and in the case of the adult, alates. A date under each figurative colony is the day when the colony was found.

Table 2. Results of sampling from a pear-tree at Nogi, Matsue City, during the period from the 6th to the 21st of June, 1957.

Date	No. of leaves per sampling unit	No. of leaves, on which colonies of aphids were formed, per sampling unit			No. of aphids per colony		No. of apterae per colony	
		Leaf with a colony of <i>Toxoptera piriicola</i> alone	Leaf with colonies of both <i>Toxoptera piriicola</i> and <i>Aphis citricidus</i>	Leaf with a colony of <i>Aphis citricidus</i> alone	<i>Toxoptera piriicola</i>	<i>Aphis citricidus</i>	<i>Toxoptera piriicola</i>	<i>Aphis citricidus</i>
June 6	8.6	1.8	0.2	0	65.44	4.00	7.78	1.00
10	6.2	1.2	0.2	0.2	24.14	5.50	0.86	0
13	4.6	0.2	0	0	19.00	—	6.00	—
15	7.8	1.0	2.8	0	21.68	146.17	0.63	3.17
18	3.6	0	0.8	0.4	23.00	22.83	2.50	1.00
21	7.0	0.4	0.8	1.4	16.83	29.36	1.00	2.27

selected also by the other, as it may be supposed from Table 2.

During this period too, it seems that the sampling error was too large to make possible the estimation of the population density, but Table 2 at least shows that there was no tendency towards a vigorous growth of the population either in the case of *T. piriicola* or in the case of *A. citricidus*.

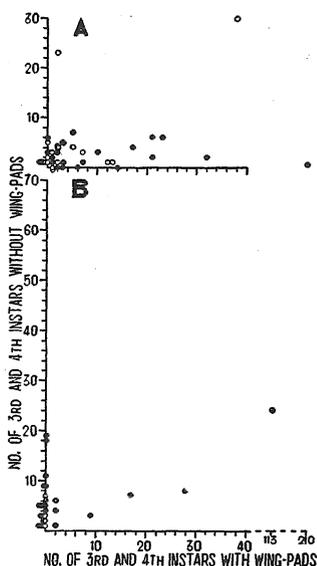


Figure 3. Relationships of the number of the third and fourth instars of both *Toxoptera piriicola* and *Aphis citricidus* with wing-pads to those without wing-pads in a colony on a leaf of pear-tree during the period from the 6th to the 21st of June, 1957.

A: *Toxoptera piriicola*. B: *Aphis citricidus*. ○: The colony found during the period from the 6th to the 13th of June. ●: The colony found from the 15th to the 21st of June.

Comparing Figure 3 with Figure 1, we can say that the ratio of nymphs of *T. piriicola* with wing-pads to ones without wing-pads in each colony there was no fundamental difference between the first and second period, and that there was a tendency that the same ratio in the case of *A. citricidus* was usually smaller than in the case of *T. piriicola* (see also Figure 4).

During the second period predators became active but no parasitism was recorded. Table 3 shows the numbers of three sorts of predators recorded from the sampled leaves. A strong tendency was seen that

Table 3. The numbers of predators recorded from sampled leaves on a pear-tree during the period from the 6th to the 21st of June, 1957.

Date	Syrphid larva	Coccinellid larva	Adult of <i>Prophylaea japonica</i>
June 6	2	2	0
10	0	0	0
13	0	0	1
15	21	4	0
18	0	2	0
21	7	0	0

predators gathered in places where high density of aphids was attained. For example, twenty-one syrphid larvae recorded on the 15th of June were entirely collected from one long shoot infested heavily with aphids. Therefore, it was impossible to estimate the population density of predators on the pear-tree from the data in Table 3.

At the latter half of this period aphids killed by predators were abundantly found on the pear-tree. There were some instances in which the whole individuals forming a colony were completely killed by predators.

After the last routine investigation on the 21st of June no observation was made of pear-tree until the 29th of the same month, when aphids killed by predators were yet noticed in abundance and few living aphids found on long shoots.

Moreover, at that day *Nippolachnus piri* MATSUMURA were observed to be establishing colonies on the old leaves of bearing spurs, but no further investigation was made into this species.

III Discussion*

In many of aphid species with plants as intermediate hosts, migration from winter hosts, on which aphids overwinter, to summer hosts, on which they reproduce vigorously, is carried out early in spring, whereas in the case of *Toxoptera piricola* aphids can remain and reproduce until early summer on the same pear-tree that they overwintered on. Most nymphs of *T. piricola* on a pear-tree, however, develop into alates even in early spring and soon after they leave there for intermediate host plants, *Cyperus rotundus* and so on, on which they can reproduce through the summer. It means that, although *T. piricola* can reproduce on a pear-tree for several generations in spring, the conditions of the tree as their host are not always favourable enough to produce apterous females in large quantities during that season. Thus it may be said that the relation of *T. piricola* to the pear-tree does not fundamentally differ from that of other aphid species to their winter host plants, from which they, in many cases, leave early in spring. It is well known that a bad weather such as a storm or a heavy rainfall is sometimes detrimental to an aphid population (for example, DUNN and WRIGHT⁽²⁾). In the spring of 1957, however, there was neither a storm nor a heavy and long rain-fall. Moreover, at least during the period from early spring to the beginning of June, natural enemies of aphids did not nearly exist on the pear-tree examined. This is to say that during this period neither weather conditions nor natural enemies were so effective as to restrain the growth of the population of *T. piricola* on the pear-tree. On the other hand, the conditions of our pear-tree as a host were unsuitable for *T. piricola*, so that they prevented the aphid population from enormously increasing on the pear-tree, because in the course of spring the greater part of nymphs of *T. piricola* on the pear-tree developed into alates, which flew off without depositing their young on the leaves on which they had developed.

Early in June *T. piricola* disappeared almost completely from the old leaves which had grown early in spring, but it was found that new colonies of *T. piricola* were forming on fresh leaves of the secondary growths of long shoots, though the production of alates was conspicuous there. At least the secondary part of a long shoot seems to be not so unfit for *T. piricola* so late as early in summer.

The secondary growths of long shoots were also infested with another species of aphid, *Aphis citricidus*. It seems that they removed from *Citrus* trees. They were reproducing, mingling with *T. piricola*, on a leaf of the pear. Both *T. piricola* and *A. citricidus* had a trend to like younger lea-

*A portion of this discussion concerning the effect of predators upon aphids was already reported in IXth Symposium in Biological Science held at Kyōto early in September, 1957.⁽⁹⁾

ves on the secondary growth of a long shoot, so it occurred frequently that colonies of both species shared in the same leaf (Table 2). The fact of co-existence of two species of aphids has already described by a few persons, and the relationship between *T. piricola* and *A. citricidus* is never an exceptional one.

As mentioned in the preceding section the ratio of nymphs in the third and fourth instars with wing-pads to ones without wing-pads in a colony was somewhat smaller in the case of *A. citricidus* than in the case of *T. piricola*. It seems to mean that early in summer conditions of the pear-tree were more favourable to *A. citricidus* than to *T. piricola*.

In the secondary parts of long shoots, predators, mainly syrphid and coccinellid larvae, decisively affected aphid populations. Although it could not be ascertained how many aphids they consumed, it was surely predators that completely destroyed the aphid populations on the pear-tree towards the end of June. Figure 4 shows the age distributions of colonies of *A. citricidus* on samples taken on



Figure 4. Age distributions of colonies of *Aphis citricidus* collected on the pear-tree on the 21st of June, 1957. The numerals and the symbol are the same with Figure 2.

the 21st of June, when the last investigation was made. Each colony was not so large, because many individuals forming it had been killed by predators, but it had a common character that nymphs in the third and fourth instars with wing-pads did not nearly exist in it. So if there were no predator the population of *A. citricidus* on the pear-tree could continue to grow towards the end of June or early in July.

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V Summary

In the spring of 1957 populations of a few species of aphids on a pear-tree of "Yakumo" variety at Nogi, Matsue City, were investigated. The term of the investigations was divided into two periods: the first was from the 25th of April to the 3rd of June, during which leaves of bearing spurs were observed, and the second was from the 6th of June to the 21st of June, during which sampling was made from the secondary growths of long shoots.

During the first period only one species, in fact, of aphid, *Toxoptera piricola*, formed its colonies on leaves of the pear-tree. The colonies had already been formed at the beginning of the investigation, but there was no tendency that the population of *T. piricola* on the pear-tree grew through the first period, though weather conditions were not unfavourable and there was no natural enemy in fact.

It was shown that the greater part of nymphs in the third and fourth instars in a colony was usually ones with wing-pads, which left the pear-tree for intermediate host plants soon after they came to maturity. This was the reason why the population of *T. piricola* did not grow through the first period.

Early in June almost all of aphids disappeared from leaves of bearing spurs, whereas new colonies of *T. piricola* and *Aphis citricidus* were formed in the secondary growths of long shoots. These two species reproduced mingling with each other.

During the second period as well as during the first, the ratio of nymphs in the third and fourth instars with wing-pads to ones without wing-pads in a colony was large in the case of *T. piricola*. The same ratio in the case of *Aphis citricidus* was smaller in general than that of *T. piricola*. It means that the population of *A. citricidus* had a potency to grow to a considerable size on the pear-tree.

Predators, however, were a decisive check factor during the second period. Larvae of syrphids and coccinellids were abundantly found in aphid colonies, and on the 29th of June it was observed that nearly all aphids of both species on the pear-tree were completely destroyed by predators.

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* In Japanese.

***In Japanese with a summary in English.