ON THE PHENOLOGY OF Chiloeorus bipustulatus (L.)*

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ABSTRACT

Field studies on the phenology of Chiloeorus bipustulatus (L.) were carried out by counting its populations in plots of citrus trees and adjacent subtropical fruit trees (avocado and mango). On citrus trees the population reached its peak in mid-summer, but on avocado and mango trees higher population was recorded much earlier. Thus, it is possible that there was a dispersal of the predator from the subtropical fruit trees to the citrus trees. In spring the larvae were dominant and by mid-summer the ratio of larvae to adults was more or less equal. The concentration of the predators in the various parts of the trees was positively correlated to the concentration of the prey, depending on the different scale insect species and their population trends in the various seasons of the year.

The polyphagous lady beetle Chiloeorus bipustulatus is by far the most important predator of citrus scale insects in Israel. The adults and their larvae prey on armored scales in all their stages and also on larvae of soft scales. To local scientists (Hecht 1936, Bodenheimer 1951) have studied the bionomics of this species, chiefly in the laboratory, but very little is known about its behaviour under natural conditions. Former field studies (Avidov and al. , 1963; Rosen and Gerson, 1965) have shown that the populations of the predator reached their peaks in citrus, groves during July, the population level in mature groves being always much higher than in younger ones. The composition of field populations of the predator in mature groves indicated the annual development of four generations on citrus in the coastal plain. A peak in larval abundance in April indicated the appearance of the spring generation, whereas a prolonged summer peak corresponded apparently to two overlapping summer generations, and a peak in October to a fourth generation.

Recently, field studies on the phenology of this predator were carried out by counting its populations in plots of citrus trees and adjacent subtropical fruit trees (avocado and mango). In the first case each plot under observation contained 45 mature trees. The most abundant species of scale insects found in this grove (central coastal area of Israel) were (in decreasing order of abundance) the following:

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on citrus

California red scale

Aonidiella aurantii (Mask).

Florida wax scale

Ceroplastes floridensis Comst.

Long-tailed mealybug

Pseudococcus adonidum (L.)

Chaff scale

Parlatoria pergandii Comst.

Purple scale

Lepidosaphes becki (Newm.)

Florida red scale

Chrysomphalus aonidum (L.)

Black scale

Saissetia oleae (Bern.)

Brown soft scale

Coccus hesperidum L.

on avocado and mango

Latania scale

Hemiberlesia lataniae (Sign.)

Long-tailed mealybug

Pseudococcus adonidum (L.)

Florida wax scale

Ceroplastes floridensis Comst.

Mango shield scale

Coccus mangiferae Green

The population on every tree was counted every two weeks (see Avidov and al., 1963). In Fig. 1 the results of these counts per tree and per month (two observations together) are summarized. This figure shows that the population trends in the two groves were different during the year. On citrus trees the population of the predator reached its peak in mid-summer. However, on avocado and mango trees the highest population was recorded in springtime during which period the predator was at its lowest ebb on the adjacent citrus trees.

It is possible that there was a dispersal of the predators from the subtropical fruit trees in the beginning of summer, during which period the normal old-leaf fall occurs (especially of the mango and the Guatemalean types of avocado). This leaf-fall, of course, causes a decrease of the prey population. C. bipustulatus was abundant from April to October. The decrease in its populations after the summer-peak was similar in both groves.

Figure 2 shows the rates of the predator's larvae and adults on citrus trees throughout the year. In winter the adults formed the whole, very small, population. In spring the larvae were dominant; by mid-summer the number of larvae and adults was more or less equal.

The total number of adults counted on citrus trees during the whole year was 2579, and the total number of larvae was 1269; the annual ratio of adults: larvae being 2:1. On the avocado and mango trees the number of the counted predators (adults + larvae) was 1646; among them 69.6% adults and 30.4% larvae. Comparing the annual results of collections, the ratio between adults and larvae was quite similar in the two adjacent groves. From the various peaks of the trends (larvae and adults) one may conclude that at least 3 generations were produced annually, but it seems that in fact there were 4 generations, two of them in summer.

Figures 3 and 4 summarize the data on the distribution of the predator's population on foliage and trunk of the trees in the various months. As can be seen in Fig. 3, in autumn and winter most of the insects were found on the foliage; during the spring the trunks were preferred, and in the summer the distribution was more or less equal in both parts of the trees. On the subtropical fruit trees (see Fig. 4) the major part of the population was found on the foliage almost throughout the year.

The dispersion of the predators, on the annual average was as follows:

	% on trunks	% on foliage
citrus trees	41.8	58.2
avocado and mango	35.7	64.3

Thus it can be seen that the average dispersion in the different groves was quite similar, and higher on the foliage than on the trunks. A comparison of percentages of the various stages of the predator in connection with its location, when counted, shows the following results:

	Citrus		Avocado and mango	
	Foliage	Trunk	Foliage	Trunk
Larvae	4.8	95.2	61.5	38.5
Pupae	20.0	80.0	33.8	66.2
Adults	90.4	9.6	74.9	25.1

Thus, in the two plots, most of the adults were found on the foliage. While in the citrus grove, most of the larvae counted were found on the trunks, the opposite was found in the subtropical fruit trees. There, in both plots, most of the pupae were found on the trunks.

It seems that the concentration of the predators in the various parts of the tree is positively correlated to the concentration of the prey, depending on the different scale insect species and on their population trends in the various seasons of the year.

Similar counts were carried out in another locality in the southern coastal area of Israel. Here the number of trees under observation was 15 in every plot. The scale-insect species were as follows (in decreasing order of abundance):

on citrus trees	on avocado trees
California red scale	Florida wax scale
Florida wax scale	Latania scale
Chaff scale	
Black scale	
Purple scale	
Brown soft scale	
Florida red scale	

In the citrus grove the California red scale infestation was very high and this species was found in large concentrations on the trunks. All the other species were in much smaller populations. The infestation of the abocado trees by scale insects was very low throughout the whole year.

The data summarized in Figure 5 show that the predator's population in this citrus grove was lower than in the first mentioned grove, C. bipustulatus being abundant especially from June to November. On the avocado trees only small numbers of the predator were found during the whole year, probably due to the very low infestation by the scale insects.

The ratio adults: larvae in the citrus trees was 2:1 and on the avocado trees 10:1.

The annual average dispersion of the predators was as follows:

	on trunks	on foliage
citrus trees	72.3	27.7%
avocado trees	11.1	88.9%

In these groves most of the predator population on citrus was found on the trunks and on avocado on the foliage. The percentage of the various stages on trunk and foliage was the following:

	Citrus		Avocado	
	Foliage	Trunk	Foliage	Trunk
Larvae	2.8	97.2	80.0	20.0
Pupae	17.6	82.4	62.5	37.5
Adults	37.5	62.5	92.6	7.4

Thus, while on citrus all stages of the predator occurred mostly on the trunk, the opposite was observed on the avocado trees.

Discussion and Conclusions

Chilocorus bipustulatus is a polyphagous predator, but prefers armored scale insects. In the coastal plain of Israel it produces 4 generations annually when feeding on diaspidid prey. This ladybeetle reaches its population peak in the citrus groves by midsummer, during which period the two first generations of the armored scales occur.

Since the populations of the California red scale are still low, in early and midsummer, this ladybeetle is capable of preventing a rapid increase of the prey population during the hot season. But the population of the ladybeetle declines in autumn and is at its lowest in winter. Thus, the California red scale is able to increase in number and then reach the peak of its population.

The populations of the chaff scale increase in the spring, reach a peak in June, and decrease afterwards (Gerson, 1967). It is during this critical ebb period, when the number of chaff scale survivors determines the size of next year's population, that Chilocorus reaches its peak and probably exerts it greatest beneficial effect.

Furthermore, it should be borne in mind that the ladybeetle produces large populations only in shaded mature citrus groves and is rare in young groves. Some species of armored scales like the California red scale, prefer young groves and are rare in dense mature groves; others, like the chaff scale, prefer opposite conditions. Thus, C. bipustulatus may be able to control the chaff scale to a much greater extent than the California red scale.

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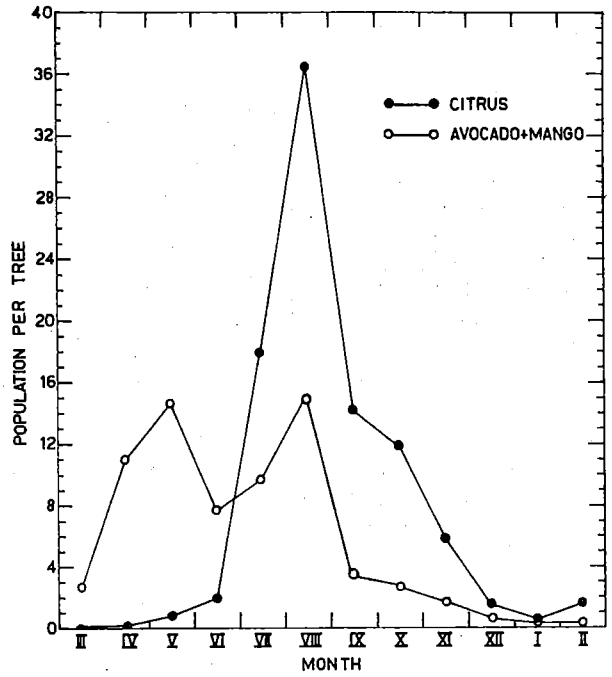

Figures

Fig. 1. Population trends of Chilocorus bipustulatus in two adjacent types of grove. - First site.

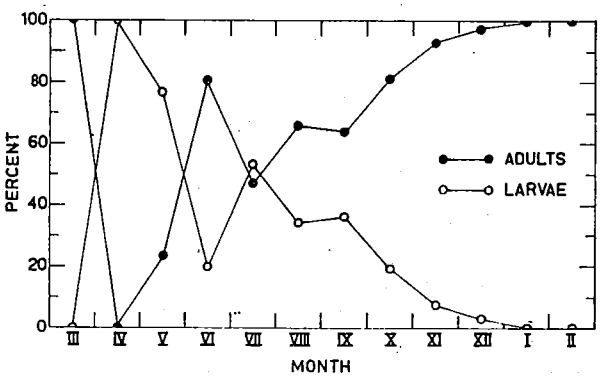

Fig. 2. Rates of Chilocorus bipustulatus larvae and adults on citrus trees throughout the year.

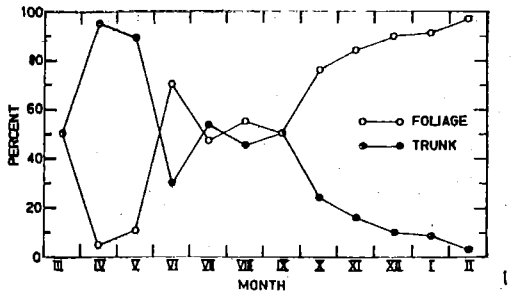

Fig. 3. Distribution of the population of Chilocorus bipustulatus on citrus trees.

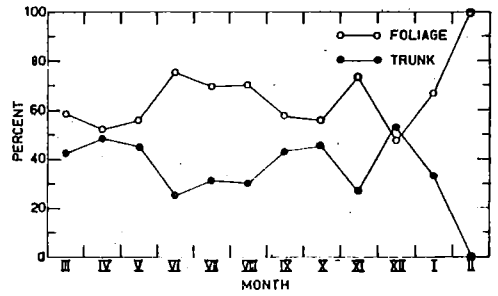

Fig. 4. Distribution of the population of Chilocorus bipustulatus on avocado and mango trees.

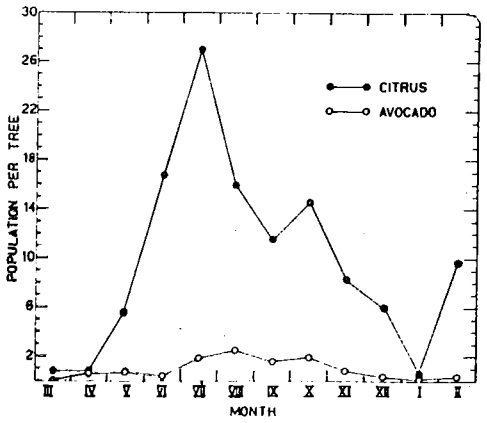

Fig. 5. Population trends of Chilocorus bipustulatus in two adjacent types of grove. - Second site.