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BIOLOGY OF THE LADYBIRD BEETLE CALVIA QUATUORDECIMGUTTATA L. (COLEOPTERA, COCCINELLIDAE)

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One of the most effective entomophages of very dangerous pests of many fruits and trees is Calvia quatuordecimguttata L. However, the biology and economic role of Calvia have been described insufficiently in the literature. Brief information on the biology of Calvia has been provided in our publications (Sem'yanov, 1965, 1968, 1973). There are also isolated reports on the predatory role of Calvia on some psyllid species (Kanervo, 1940; Chekmenev, 1966; Bushkovskaya and Titov, 1975; Poddubnyy, 1975).

Calvia is universally distributed in the European part of the USSR. It is found in apple and pear orchards, in deciduous and mixed forests, parks, and forested zones on elm, ash, alder, maple, oak, birch, and bird-cherry. The beetles hibernate in forest litter near the base of trees as well as on the fringe of deciduous and coniferous forests. Emergence from hibernation under the conditions of the Northwestern European part of the USSR takes place in the second half of April. At this time the beetles are often found in orchards on apple, and in natural cenoses on elm and ash which are damaged by psyllids, where the beetles destroy the hibernating eggs of psyllids. The ladybird beetles are found in small numbers on bird-cherry (Padus racemosa) at this time. The beginning of egg laying of Calvia usually coincides with the emergence from the eggs of the nymphs of Psylla mali Schmdb. and Psylla ulmi Frst. The eggs are laid only on trees infested with psyllids - on the stems, skeletal twigs, and branches in all parts of the crown at various covered places such as, cracks and deeper parts of the crown, forks of the twigs, and on the lower side of the branches. Most ovipositions are found on the skeletal branches of the first and second order, but we have found isolated oviposition on apple at height up to 4 m, and on elms up to 6 m.

The oviposition of Calvia is very characteristic and is easily distinguished from the oviposition of other species. The eggs are yellow-white, arranged in more or less regular rows, slightly tilted to one side. Two large spots of bright orange color, which can be observed by the naked eye, are located on the side facing upward, close to the apex of the eggs. A triangle is often formed between them, slightly on the lower side, by a third spot of smaller size. The chorion surface is covered with very minute orange colored spots. There are in the literature descriptions of the egg (Klausnitzer, 1969) and larval stages (Savoyskaya, 1964), as well as photographs of all the developmental stages (Sem'yanov, 1973).

The beetles, after emergence from hibernation and during the egg-laying period, feed upon psyllids and are very active and quite voracious. One beetle in a day may destroy 47.6 ± 3.8 nymphs of the age group I, and 38.8 ± 1.4 nymphs of the age group II of Psylla pomi.

The fertility of females depends upon the type of food on which they live. The results obtained under laboratory conditions, at 20°C and 55-60% humidity and feeding on different psyllid species and aphids, are presented in Table 1. The maximum number of eggs laid by a single female, after feeding on apple sucker, was 336 in one of the experiments.

After hatching, the larvae of the age group I remain huddled for some time, after which they move apart and begin to search actively for food, during which time they may cover a large distance (up to several meters).

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Table 1

Fertility of female Calvia after feeding on different species of aphids

Feeding object	Number of eggs laid by a single female		
	minimum	maximum	average
Psylla mali Schmdb.	198	243	219±8.2
P. alni L.	147	183	157.8±6.7
P. ulmi Frst.	113	168	142.0±10.3
Aphis pomi Deg.	106	142	122.4±4.9
Rhopalosiphum padi L.	98	128	113.6±5.8
Hyalopterus pruni Geoffr.	28	46	37.8±3.02

Table 2

Rate of development of different stages of Calvia depending on temperature

Developmental stage	Temperature				
	13°	15°	20°	25°	30°
	duration of development, days				
Egg	12	8	4	3	2
Larva	46—50	28—30	15	10	7.5
Pupa	20	12	6	4	3
Whole cycle	78—83	48—50	25	17	12.5

Pupation takes place in well covered places: deep cracks in the bark, often in the residual bark, in twisted leaves; very rarely are they on open branches and leaves.

The young beetles after wing development can also feed on different aphid species if psyllids are not available. Calvia enters hibernation slightly earlier than other coccinellids, at the end of July or the beginning of August.

Observations on the duration of different developmental stages of Calvia depending on temperature during feeding on larvae of Psylla mali and at relative humidity 55-60% are presented in Table 2. The total effect temperature, with the low threshold value of development of 10°C, is 40°C for eggs, 150°C for larvae, and 60°C for pupae.

The larvae of Calvia are quite voracious, and during the period of their development consume a large quantity of psyllids and aphids. The results on the feeding of larvae of different age groups at 20°C are given in Table 3.

The larvae have well-developed food selectivity, and in case of sufficient choice for food they prefer psyllids over aphids. Development of larvae feeding on psyllids is more uniform and rapid than of those feeding on aphids.

The lifecycles of Calvia and Psylla mali are synchronized to a great extent. Emergence of the Calvia larvae from eggs usually coincides with the appearance of the nymphs of age group I, and beginning of pupation corresponds to the wing development in Psylla. However, in some years this synchronization may be disturbed. Thus, for example, in 1966, in Leningrad District (Pushkin), egg laying in Calvia began on May 14. After this severe cold weather followed, which continued almost for two weeks and caused termination of egg laying, which was resumed after the cold weather only on June 3. At the same time, the cold weather did not have a strong influence on the developmental period of Psylla,

Table 3

Feeding capacity of Calvia larvae on different species of psyllids and aphids

Age of the Calvia larvae	Total quanity consumed per day							
	nymphs of Psylla mali				nymphs of age group I of Psylla ulmi	larvae of Aphis pomi	larvae of Rhopalosiphum padi	larvae of Hyalopterus pruni
	age grp. I	age grp. II	age grp. III	age grp. IV				
I	11±1.6	7±1.8	—	—	8±0.6	12±2.6	10±1.5	—
II	18±2.8	14±2.1	20±1.7	—	16±1.2	26±1.2	24±1.0	—
III	—	42±2.9	25±2.0	18±1.6	—	38±1.0	32±0.5	21±0.6
IV	—	—	37±3.4	28±3.2	—	42±0.6	48±0.6	30±0.5

since a larger number of the nymphs of age group I crawled into the opening buds and therefore they were exposed to the lower temperature to a lesser extent. As a result of this, a large number of the predator population could not complete their development by the time of wing formation in Psylla and, apparently, should have died. However, this did not happen. It was established by direct observation in natural conditions and especially planned laboratory experiments that the larvae of Calvia from age groups III and IV can successfully complete their development feeding on adult Psylla. Larvae of age groups I and II can not feed on winged Psylla, since because of their small size they are not able to hold the captured Psylla, and in the absence of alternate food they are destined to die.

Under natural conditions, development of Calvia was observed on a whole series of aphids and psyllids. The biocenotic relations of Calvia are shown in Fig. 1.

The developmental cycle of Psylla ulmi is very similar to that of P. mali, therefore, development of Calvia on either does not differ in any way. Emergence of nymphs from eggs in Psylla alni and ash psyllid (Psyllopsis fraxinicola?) takes place somewhat later than in the Psylla ulmi and P. mali; therefore, only that part of Calvia population which emerged from hibernation later developed on alder and ash. Emergence from the eggs in Rhopalosiphum padi is observed earlier than in the other species of aphids and psyllids (at April end—beginning of May in Leningrad district), in early spring this is the most numerous species, as a result of which, a small Calvia population develops on it, which emerges from hibernation slightly earlier than the main bulk of predator beetles. Feeding on leafhopper Alnetoidia alneti Dhlb., which was noted by us in bird-cherry (Padus racemosa), most probably is of incidental nature and is mainly observed in the larve of age group IV of Calvia in the middle and end of June when a reduction in the population density of R. padi takes place because of its migration to cereal plants. Feeding on Aphis pomi is observed, first, under low population density of Psylla pomi, and second, in the case of those Calvia larvae which emerge from late egg laying and cannot complete their development by the time of wing development in Psylla pomi.

In 1966, pupae and larvae of age group IV of Calvia were collected under natural conditions and fed on Psylla pomi, P. ulmi and Rhopalosiphum padi. The size and body weight were determined in the larvae, and water and fat contents were estimated in the pupae. The results are included in Table 4.

It can be seen from the results presented in Table 4 that the larvae feeding on psyllids have greater dimensions and weight than the larvae feeding on Rhopalosiphum. Water content of the pupae after feeding on psyllids is much less and fat content higher than after feeding on aphids. This indicates that psyllids are a more favorable food for Calvia than aphids. In the context of these results, it is easy to understand the reason for the higher fertility of female Calvia fed on psyllids than after feeding on aphids (Table 1).

Under natural conditions, Calvia always develops a single generation. Under laboratory conditions also, irrespective of temperature and day length, Calvia always gives one generation. In this context, a special experiment was planned to study the influence of photoperiodic conditions and food on induction of diapause in Calvia. The results of this experiment are presented in Table 5.

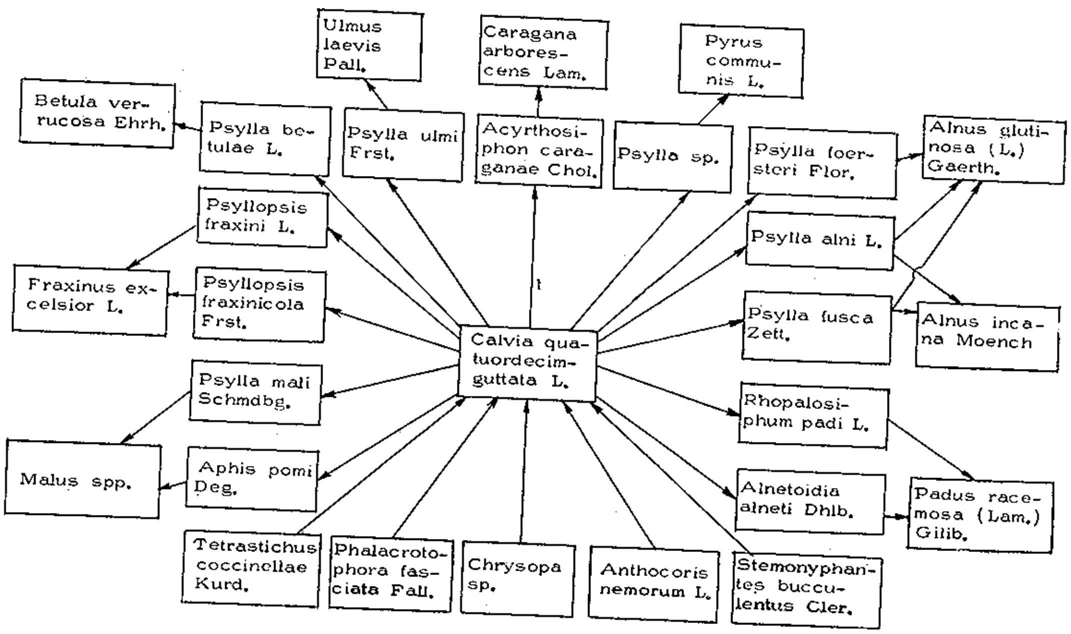

Fig. 1. Biocenotic relationships of Calvia quatuordecimguttata (L.).

Table 4

Effect of different foods on certain morphophysiological parameters of larvae and pupae of Calvia

Food object	Size (mm), and weight (mg) of larva of age group IV			Quantity in the pupa (% of dry weight)	
	length	width	weight	water	fat
Psylla pomi	9.4±0.27	2.66±0.01	20.4±1.7	61.3±7.2	11.2±0.48
Psylla ulmi	9.4±0.27	2.52±0.03	19.6±1.4	63.8±2.7	10.5±0.8
Rhopalosiphum padi	9.2±0.22	2.54±0.05	18.6±1.8	66.6±1.4	9.5±0.3

Table 5

Effect of photoperiod and food on induction of diapause in Calvia

Treat ment	Photoperiodic conditions of rearing (day length in hours)		Food		Females in diapause (%)
	Larvae and pupae	Imago	Larvae	Imago	
I	Long day, LD	20	Psyllids	Aphids	100
II	20	20	"	Psyllids	100
III	20	10 days after emergence in LD, followed by 3 weeks in SD and further again in LD	"	Aphids	100
IV					
IV	20	As in treatment III, but SD for 4 weeks	"	Psyllids	100
V	Short day, SD	After emergence, 2 weeks in SD, followed by LD	"	Aphids	100
VI	12	After emergence, 4 weeks in SD, followed by LD	"	"	100

As can be seen from the results in Table 5, irrespective of day length at which development of larvae, pupae, and imagoes took place, as well as the type of food on which imagoes and larvae were maintained, in all the cases diapause was observed in 100% insects. An active development cannot be caused even by "short-day sensibilization," although in Chilocorus bipustulatus L.), (Zaslavskiy, 1970) and monocyclic members of the northern populations of seven-spot ladybird beetle (Coccinella septempunctata L.), the short-day sensibilization eliminates diapause and causes active development (Sem'yanov, 1974). Thus, it can be concluded that photoperiodic conditions and food do not influence the induction of diapause in Calvia, and this species is genetically monocyclic.

The role of Calvia in reducing the population strength and damage of Psylla pomi is decided by a whole series of factors, among which the population density of the prey has maximum significance. According to the theory of natural balance, developed by Nicholson (1933), and based on "area of search," the search for food by the predator is necessarily of random nature. However, under natural conditions, the factor of randomness is slightly weakened. It so happens that the Calvia larvae in age group I have a sharply expressed negative geotaxy and positive phototaxy but they avoid direct solar rays. Therefore, after emergence from the eggs they immediately move upward and toward the periphery of the crown, and being concentrated at the terminals of the twigs on the lower side of leaves they move between the expanding leaves and opening petals of the buds, i.e. especially on those places where the psyllids are concentrated, which significantly increases the probability of Calvia larvae meeting the nymphs of its prey, Psylla pomi.

The ecological factors have a double effect on the population count of Calvia and its role in the population dynamics of Psylla pomi. First, the direct effect, caused by higher mortality of the beetles during hibernation under unfavorable conditions and high mortality of the larvae of age groups I and II during torrential rains and, second, the indirect effect, by destroying synchronization of the developmental cycles. For example, cold weather during the period of egg laying of Calvia causes a delay in egg laying, and this leads to a situation wherein the larvae of age group I emerging from the eggs are compelled to feed on the nymphs of the older age groups of P. pomi, sharply reducing the number of them eaten by a single larva of Calvia during the period of its development. It has been experimentally established that if the larvae of Calvia start developing simultaneously with the emergence of psyllids from eggs and feed on the nymphs of younger age groups, then during the period of their development each larva of Calvia destroys 200-400 psyllids, and if the Calvia larvae are delayed in development and feed on the nymphs of older age groups, they destroy only 60 to 100 P. pomi during the period of their development.

The economic activities of man, especially the chemical measures for insect control in early spring and during blooming of apple, have a great influence on the population dynamics of Calvia (Sem'yanov, 1973). Besides that, the Calvia population decreases as a result of activity of parasites and predators. Thus, for example, in 1966, in the environs of Pushkin, infestation of Calvia pupae by the parasitic fly Phalacrotophora fasciata Fall. on apple reached up to 18.5%. Other parasites and predators also play a certain role in reducing Calvia population (Sem'yanov and Lipa, 1967).

In Belorussia, near Gomel', in 1960, we noted the development of Calvia quinquedecimguttata Fabr. on Psylla ulmi. According to the findings of Klausnitzer (1971), C. decemguttata L. also feeds on psyllids. In British Columbia, C. duodecimmaculata Gebl. destroys Psylla pyricola Forster (McMullen and Jong, 1967).

Thus, the capacity to feed upon psyllids is a characteristic not only of C. quatuordecimguttata, but, most probably, also of the species of the genus Calvia as a whole. In this connection, members of the genus Calvia, as specialized and effective predators of psyllids, deserve universal protection.

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