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ORIGINAL ARTICLE

Features of the aggregate way of life and its importance in leaf beetles larvae (Coleoptera, Chrysomelidae) development

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The article describes the importance of the aggregate way of life of leaf beetles' larvae *G. viminalis* (Linnaeus, 1758) in the laboratory conditions. The obtained data prove that the aggregate way of life of *G. viminalis* larvae has a significant impact on the intensity of their feeding, growth and development. It is concluded that such coexistence of larvae allows them to build a defense strategy, ensuring survival in groups at early stages of development.
Key words: aggregated lifestyle; aggregation of insects; Chrysomeliade; Coleoptera; larvae

Introduction

Leaf beetles are solitary insects and spend most of their life individually. Though it is typical of them to periodically form aggregations of diverse number (from several dozens to tens of thousands of specimens). Mass aggregations of leaf beetles is an extraordinary phenomenon, and its mechanism is still poorly understood. As however, there is no single view and clear understanding of reasons for insects' aggregation in general.

Temporary aggregated states are characteristic not only of adults, but also of preimaginal phases of development in numerous Chrysomelidae (Chrysomelinae, Criocerinae, Cassidinae and Galerucinae). For example, in *Chrysomela lapponica* Linnaeus, 1758 in layings there are 15–19 eggs in general, in *Ch. populi* Linnaeus, 1758 up to 22 eggs, in *Ch. tremula* Fabricius, 1787 up to 30 eggs, in *Gastrophysa polygoni* (Linnaeus, 1758) 25–42 eggs, in *Lochmaea caprea* (Linnaeus, 1758) 19–22 eggs, in *Cassida nebulosa* Linnaeus, 1758 4–8 eggs in the laying (Guskova, 2000). Naturally, the aggregation of larvae will be observed at least at the initial stage of their development.

Several authors (Pavlov, 1985; 2009; Crowe, 1992; Palokangas and Neuvonen, 1995; Wallace and Blum, 1969; Zaitsev and Medvelev, 2009) consider the aggregations as a means of protecting young larvae from desiccation, as the liquid released by the dorsolateral glands of one larva is insufficient for humidifying and cooling its integument. Additionally, the aggregations of larvae of I-II age perform the function of protection against natural enemies, as the action of secretion (repelling) is greatly increased by the larvae crowding.

In the insects leading a group way of life, as V.A. Radkevich notes (1977), one can observe close communication of individuals through smells, sounds, specific behavior. The complicated system of signals which causes the exchange of information between the specimens leads to the formation of efficient group functioning aimed at the satisfaction of important vital needs of all its members.

We were faced with the question of whether the aggregated lifestyle influences feeding, the growth and development of larvae, and in what larvae age the group effect is the most important. In this aspect, the importance of group habitat for leaf beetle larvae is studied for the first time.

Materials and Methods

As the study object, we have chosen the larvae of *Gonioctena viminalis* (Linnaeus, 1758). It is a species of Euro-Siberian habitat, distributed in Europe, Caucasus, Kazakhstan, Siberia, North Mongolia and China (Northeast Territory) (Kippenberg, 2010). In the South Urals, *G. viminalis* inhabits small-leaved and floodplain forests, fringes of birch forests and aspen forests.

Beetles and larvae feed on leaves of *Salix phylicifolia* L. and *Populus tremula* L. (Salicaceae). The fertility is small, in general 21−25 larvae in the laying.

The study of the aggregated way of life was conducted in the laboratory conditions at the average air temperature +21±1°C, humidity 70−75 % and the daylight duration 10 h. A series of experiments was performed.

Experiment 1. Larvae of the I-st age collected in nature were placed in cages as follows: 17 larvae in the first cage (average number of larvae in the *G. viminalis* laying); 10 in the second; 5 in the third; 2 in the fourth; and one larva in the fifth. The experiment was performed in five replications. The food (leaves of *Salix phylicifolia* L.) was offered to the larvae in abundance and changed every day. Every day the weight of the eaten food, the weight and age of the larvae was recorded.

Experiment 2. The experiment involved larvae of the second age collected in nature and placed in cages as follows: 5 larvae in the first cage; 2 in the second; 1 in the third. The experiment was performed in ten replications. The conditions were the same as in the Experiment 1.

Experiment 3. The larvae of the third age collected in nature were placed in cages as in the Experiment 2, at the same conditions.

Experiment 4. The experiment involved larvae of the fourth age collected in nature and placed in cages as in the Experiments 2 and 3, at the same laboratory conditions.

The average data obtained during the experiments are provided in the summary table 1.

Results and Discussion

The aggregated way of life has a great impact on feeding of leaf beetles' larvae *G. viminalis*. So, for the entire period of development, one larva brought up in the group of 17 and 10 specimens, consumed 97 mg in average. For a larva grown up in the group of 5 specimens, the consumed food mass during the period of development was 30,1 mg in average, which is three times less.

The group way of life also influences the absolute increase in the larvae weight. Before the experiment began, the weight of the 1st age larva was 0,4□0,1 mg in average. The absolute increase in mass for a larva from the group of 17 and 10 specimens during the period of development was 20,7±4,2 mg in average. And for a larva brought up in the group of 5 specimens, the absolute increase in mass was in general 15± □ 3,7 mg.

In the solitary keeping of the larva, a disturbance in behavior was first observed, expressed in a disorderly movement through the cage, then lack of "appetite," then the larva died, before reaching the second age.

It is necessary to note that in the larvae grown up in groups (17, 10 and 5 specimens) molting took place in the same day).

Table 1. Dependence of nutrition, growth and development of *G. viminalis* larvae on their number in the group, in ages

No. of experiment	Initial number of larvae in group	Larvae age	Quantity of food consumed by one larva, mg	Average weight of one larva (initial and final), mg	Development duration (days)	Mortality, %
1	17	I	4.4±1.2	0.4 - 2.4	2	9.2±3.2
		II	12.5±3.1	2.4 - 6.4	2	3.9±1.1
		III	36.1±5.3	6.4 - 15.8	3	-
		IV	44.2±7.5	15.8 - 21.2	2	-
	10	I	4.5±1.2	0.4 - 2.5	2	5.0±1.6
		II	12.1±3.1	2.5 - 6.3	2	3.2±0.9
		III	36.2±5.3	6.3 - 15.8	3	-
		IV	44.0±7.2	15.8 - 21.1	2	-
	5	I	1.1±0.6	0.4 - 0.9	2	36.0±5.3
		II	4.5±1.1	0.9 - 3.5	2	20.0±4.2
		III	9.9±3.7	3.5 - 8.2	3	8.0±2.3
		IV	14.6±2.4	8.2 - 12.1	3	5.0±1.7
	1	I	-	0.4 - 0.3	-	100
2	5	II	10.1±1.5	1.5 - 3.7	2	18.0±4.1
		III	19.2±4.6	3.7 - 9.9	3	6.0±1.9
		IV	30.6±4.2	9.9 - 18.5	3	4.0±1.0
	1	II	1.9±0.7	1.5 - 2.1	2 - 4	60.0±6.1
		III	11.2±1.1	2.1 - 6.2	2 - 3	21.0±3.3
		IV	22.1±3.2	6.2 - 9.2	3 - 5	8.0±2.4
3	5	III	29.9±3.9	4.2 - 12.7	3	3.7.0±0.7
		IV	40.9±6.9	12.7 - 20.3	2	2.4±0.3
	1	III	32.2±4.2	4.2 - 13.5	3 - 5	3.7±0.5
		IV	43.2±7.1	13.5 - 21.3	2 - 5	2.9±0.4
4	5	IV	41.2±6.8	12.5 - 20.6	2	4.2±0.9
	1	IV	42.2±6.5	12.5 - 21.3	2 - 5	3.1±0.3

The series of experiments II, III, and IV were aimed to indicate the larvae development stage at which the group effect has the biggest importance. As a result of the experiment it turned out that the larvae taken from nature at the beginning of the second age safely feed and develop in the number of 5 specimens in the group. In the end of the fourth age they pupate, and the pupae mortality rate is 30 %, which is less than in the leaf beetles grown up from the first age in the laboratory conditions. But if we grow up the larva from the second age in solitary conditions, the picture will be completely different. They feed and grow very slowly, by the end of the second age their average weight is 9.2±4.3 mg, it is 2.3 times less than the "norm" (21.1 mg). Their mortality is high, especially in the larva of the second age – in average, 60±6.1 %. The larvae molted three times and die in the end of the fourth age or at the pupae stage.

The experiment has shown that the third and fourth age larvae taken from nature are the least whimsical and most viable. They feed intensively and gain weight both in a group and solitary. By the end of the fourth age, the average weight of each larva is 21.3±4.2 mg. Their mortality is low both in the larval and pupal phase.

Concluding remarks

Thus, the obtained data prove that the aggregated way of life of the larvae *G. viminalis* significantly affects the intensity of their nutrition, growth and development - along with the influence of abiotic factors of the environment and food quality. This coexistence of larvae, apparently, allows them to build a defense strategy, ensuring survival in groups at early stages of development.

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