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# TROPHIC RELATIONS OF LADY BEETLES (COLEOPTERA, COCCINELLIDAE) OF THE URALS

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The article contains the study of the trophic relations of the lady beetles living in the Urals. The study allocates three ecological groups depending on the peculiarities of the beetles and larvae nutrition: phytophages, micetophages, and entomophages-predators. We have revealed 66 species of lady birds-predators and two species-phytophages: *Subcoccinella vigintiquatuorpunctata* (Linnaeus, 1758) and *Bulaea lichatschovii* (Hummel, 1827). In the group of obligatory micetophages in the Urals we registered the representatives of the tribe Halyziini, it is *Halyzia sedecimguttata* (Linnaeus, 1758) and *Psyllobora vigintiduopunctata* (Linnaeus, 1758).

***Key words:*** *Coleoptera, Coccinellidae, Trophic relations, Lady beetles, Food preferences.*

## INTRODUCTION

Coccinellidae Latreille, 1807 (Coleoptera) account for 6000 species in the world fauna, belonging to 360 genera (Slipinski et al., 2011). About 2000 species are registered in Palaearctic, 167 species of 41 genera – in Russia (Korotyaev et al., 2012).

Coccinellidae are well recognizable beetles, more often known as efficient entomophages of numerous pests of agriculture and forestry. Indeed the vast majority of Coccinellidae species are predators preying on many small arthropods and naturally regulating their population. The biological features of Coccinellidae allow to use them widely to protect plants from pests, thus limiting the use of pesticides and replacing them with biological agents. Predator Coccinellidae were among the first to be used in the biological control, and due to its usage, in many cases a progress has been made in regulating the number of dangerous pests of agricultural, forest and decorative plants. However, despite the stereotype of food specialization of Coccinellidae – predation, there are species preferring plant food and even causing significant damage to agriculture, for example, *Henosepilachna vigintioctomaculata* (Motschulsky, 1858), which is a potato pest in the Far East (Russia). Other members of this family feed on mushrooms (Sutherland & Parrella, 2009). And even among predatory Coccinellidae food specialization is widely presented. Thus, the majority of Coccinellidae prefer to eat representatives of hemiptera of the suborder Sternorrhyncha (Aphidoidea, Coccoidea, Pseudococcidae, Aleyrodidae, and Psylloidea) (Hodek & Honek, 2009; Obrycki et al., 2009). There are species trophically connected solely with Formicidae (Hymenoptera) (Harris, 1921; Pope & Lawrence, 1990; Samways et al., 1997; Majerus et al., 2007) or non-insects — for example, all the species of the tribe Stethorini feed only by Tetranychidae (Biddinger et al., 2009). Thus, in the evolution of Coccinellidae there was a division of food preferences, including all the kingdoms of life (plants, fungi and animals) and trophic levels (phytophages and primary consumers). The study of the food preferences of Coccinellidae is also interesting in terms of this group phylogeny. Coccinellidae belong to a monophyletic group, Cerylonid Series (C.S.), that includes seven other Cucujoidea families: Alexiidae, Bothrideridae,

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Cerylonidae, Corylophidae, Discolomatidae, Endomychidae, and Latridiidae (Crowson, 1955; Robertson et al., 2008). The representatives of this cluster (C.S) use a wide range of natural resources in their nutrition. Nowadays Cerylonid Series is officially recognized as a new superfamily Coccinelloidea (James et al, 2015). However, the problem of the evolutionary formation of this family continues to interest many scientists. Thus, the recent studies based on the phylogenetic analysis of 62 taxons based on the ribosomal nuclear genes 18S and 28S has shown that the ancestral forms of Coccinellidae were coccidophages. Then the aphidophages and phytophages developed from them. The second transition to the phytophages developed from the aphidophages. The mycophages Halyziini also developed from the aphidophages (Giorgi et al., 2009). All these works suggest that along with the study of biological diversity, scientists are increasingly paying attention to the trophic specialization of the beetles of the family. Many aspects of this problem are studied insufficiently and require an integrated approach.

In this paper, we summarize the results of a multiyear comprehensive research of Coccinellidae of the Urals. Currently, 70 lady beetle species of 35 genera are registered in this region (Tyumaseva et al, 1984; Tyumaseva, 1997). The long-term research carried out on the biology of Coccinellidae (by the first author – since 1975–2012, by the second author – 1997–2011) and the collected material on their nutrition provides an opportunity to discuss this issue and to identify their major ecological groups depending on the food objects.

## MATERIALS AND METHODS

The collection of the entomological material was performed with classical methods: manual collection, mowing with butterfly net, shaking off the trees. All the collected material is stored in the private collection of Z.I. Tyumaseva (Chelyabinsk, Russia). The trophic relations were studied in the natural and laboratory conditions. The method of such study is described in detail by Z.I. Tyumaseva (1987) and successfully tested. In addition to our own research, we also used the published data on trophic preferences of Coccinellidae.

## RESULTS

By the peculiarities of nutrition, the Coccinellidae beetles and larvae of the Urals can be divided into three groups: phytophages, mycetophages and entomophages-predators.

Herbivorous Coccinellidae – phytophages – feed mainly on plant food: leaves of higher plants, sometimes – on their stalks, flowers or pollen. Extensive information on the biology of herbivorous lady beetles is available in the works of N.N. Bogdanov-Katkov (1927), N.A. Glushenkov (1949, 1950), N.P. Dyadechko (1954), G.I. Savoiskaya, (1983), A.N. Ivanova (1962), V.V. Shabliovskii (1964, 1966), V.N. Kuznetsov (1974). In the Urals fauna we have revealed two species of the phytophages: *Subcoccinella vigintiquatuorpunctata* (Linnaeus, 1758) and *Bulaea lichatschovii* (Hummel, 1827). These types are associated with steppe biotopes. The adults and larvae of *S. vigintiquatuorpunctata* feed on the leaves of *Salvia nemorosa, Mentha austriaca* (Lamiaceae); *Euphorbia esula* (Euphorbiaceae), *Medicago sativa, Glycyrrhiza glabra, Melilotus albus* (Fabaceae), *Trifolium pratense* (Faboideae), *Chenopodium* (Amaran thaceae), but especially prefer the leaves of *Cypsophila paniculata*, *Otites parviflora* (Caryophyllaceae) and *Asperula* (Rubiaceae). *S. vigintiquatuorpunctata* in the Urals has no economic significance, since it is not indicated on crops in the fields and gardens. The number of this lady beetle in most habitats is minor, only in some areas during the breeding season there are accumulations of beetles. Thus, in the areas close to forest shelter belts near the grain crops we caught from 80 to 127 specimen per 200 net sweeps. We also note that in Ukraine *S. vigintiquatuorpunctata* is a pest for *Medicago* (Fabaceae) and seldom – for *Beta vulgaris* (Amaranthaceae), *Brassica rapa* (Brassicaceae), *Solanum melongena* (Solanaceae) and *Solanum tuberosum* (Solanaceae) (Dyadechko , 1954), in Moldova and Central Asia – for *Medicago* (Antonov, 1975). In Belarus, it is a serious pest for *Potato* and plantations of *Sugar beet* (Semyanov, 1965).

The adults and larvae of *Bulaea lichatshovi* feed mainly on plants of the family Amaranthaceae and the genus *Artemisia* (Asteraceae). In May the beetles willingly eat the pollen of *Euphorbia* (Euphorbiaceae) and *Glycyrrhiza* (Fabaceae). Other authors also pointed out the nutrition of this species by pollen (Capra, 1947; Savoiskaya, 1983). The lady beetles-phytophages were not found on cultivated plants. However, in Kyrgyzstan, Ukraine and the North Caucasus this species causes significant harm to *Sugar beet* (Dyadechko, 1954; Kryltsov, 1954; Bronshtein, 1967).

Mycophagy is very common among the lady beetles. One should distinguish optional and obligatory mycophagy. The optional mycophagy is a common phenomenon, often found among the beetles of tribe Coccinellini (Majerus, 1994). These predators are often polyphagous and feed on pollen, nectar, honeydew, mushrooms, fruits and herbs, but specific products of animal origin (such as aphids) are necessary to complete their development (Hodek, 1973; Lundgren, 2009). From obligate mycophagous in the Urals we should note the representatives of the tribe Halyziini, it is *Halyzia sedecimguttata* (Linnaeus, 1758) and *Psyllobora vigintiduopunctata* (Linnaeus, 1758). Their beetles and larvae feed on powdery mildew (Ascomycotina: Erysiphales) which damages a variety of trees, shrubs and herbaceous plants. But mostly they prefer powdery mildew on *Trifolium, Melilotus* and *Medicago* (Fabaceae). The mycophagy of Coccinellidae is poorly studied, although in the recent years we see an increased interest to this phenomenon from the biological control (Hodek, 1973; Gordon, 1985; Samways et al., 1997; Sutherland & Parrella, 2009). The significance of lady beetles in suppressing fungal diseases of plants in the Urals has not been revealed yet.

66 Coccinellidae species in the Urals are predators. Depending on the systematic affiliation of the predominating objects of nutrition, the predators are divided into the following ecological groups: *aphidiphages*, feeding on aphids; coccidophages, feeding on coccidia; *acariphages*, feeding on plant spider mites; *polyphages,* feeding on other invertebrates of different taxonomic groups.

A significant part of of predatory lady beetles are aphidophages. Aphids have been documented as the primary food source for most members of the subfamily Coccinellinae (Slipinski, 2007). According to R.L. Blackman (1967), there are various trophic relations of aphidophages to different species of aphids: Some aphid species are edible for most lady beetles, the others are hardly edible, the third delay the development of some species or may even be toxic – such as aphids *Megoura viciae* (Buckton, 1876) and *Brevicoryne brassicae* (Linnaeus, 1758) are for lady beetle *Adalia bipunctata* (Linnaeus, 1758). Our long-term research has shown that when Coccinellidae consumed a food unusual for them, it violated their normal development cycle. The periods of their development and fertility depend on the abundance and type of food. It was found that under identical laboratory conditions at rearing larvae of *Adalia bipunctata* on the aphids *Hyadaphis tataricae* (Aizenberg, 1935) the larval stage lasts 7 days, and on the aphids *Cryptosiphum artemisiae* Buckton, 1879 – 16 days. The study of fertility of *Adalia bipunctata* has shown that when feeding the females on aphids *Therioaphis tenera* (Aizenberg, 1956) their fertility is 750 eggs in average, and on the aphids *Aphis rumicis* (Linnaeus, 1758) – 250 eggs.

The literature gives data on the voracity of lady beetles in different regions of our country. These data differ for one and the same species and depend on the abundance and quality of food as well as on the climatic conditions of the studied area. The study of the voracity of Coccinellidae revealed that the adults of *Coccinella septempunctata* (Linnaeus, 1758) eats from 120 to 176 aphid larvae of various species per day, and its larva of IV age – from 108 to 185 aphid larvae of various species. Lady beetles *Hippodamia variegata* (Goeze, 1777) and *Adalia bipunctata* eat per day from 110 to 160 and from 95 to 172 aphid larvae respectively. In the same time, the larva of IV age of *H. variegata* destroys per day from 85 to 168 aphid larvae, and the larva of IV age of *A. bipunctata* – from 72 to 83.

The selective ability of Coccinellidae is characterized by the number of specimen of the preferred aphid species, destroyed adults and lady beetles larvae per day. Thus, according to our observations, one specimen of *Coccinella septempunctata* eats in average 102 larvae of *Aphis althaeae* (Nevsky, 1929) and 44 larvae of aphids *Therioaphis trifolii* (Monell, 1882). The adult of *Coccinula quatuordecimpustulata* (Linnaeus, 1758) eats 54 specimens of *Aphis rumicis* and about 30 aphids *Titanosiphon dracunculi* (Nevsky, 1928) per day or about 168 aphids *Aphis pomi* (De Geer, 1773), and its larva of IV age – about 147 *Aphis pomi.*

In the majority of the aphidophages, the specialization in feeding on aphids is poorly expressed. Thus, *Hippodamia variegata* eats about 20 various species of aphids, *Coccinella undecimpunctata* (Linnaeus, 1758) – 12, *Oenopia conglobata* (Linnaeus, 1758) – 14 species of aphids (Mangutova, 1967). In South-Eastern Kazakhstan *Coccinella septempunctata* feeds on over 13 aphid species, in the same time destroying the larvae of Tettigarctidae, Psyllidae, Aleyrodidae, eggs and larvae of some Lepidoptera and Coleoptera (Savoiskaya, 1983). In comparatively few aphidophages the food specialization is rather well expressed. Thus, *Adalia bipunctata* eats only elm aphids *Tinocallis saltans* (Nevsky 1929) and *Exochomus jacobsoni* (Barovskij, 1927) – the inhabitants of galls on *Haloxylon ammodendron* (Chenopodioidea) (Savoiskaya, 1983).

In the absence or lack of nutrition in Coccinellidae adults and larvae the phenomenon of cannibalism is observed. At that, beetles eat their own eggs and larvae, and the larvae eat the eggs and young larvae. Cannibalism is noted mainly among the specimen of the second and third generation in the end of July and August, when the number of aphids naturally decreases.

Among Coccinellidae the acariphages are also presented, such as the members of the tribe Stethorini (Scymninae) which prey on spider mites and false spider mites (Acari: Tetranychidae and Tenuipalpidae) (Biddinger et al., 2009).

In Russia the acariphages are represented only by one species, *Stethorus pusillus* (Herbst, 1797) (Savenko, 1953; Dyadechko, 1954; Luppova, 1958; Savoiskaya, 1983; Kuznetsov, 1997). According to our observations, *S. pusillus* preys on the spider mites *Tetranychus urticae* (Koch, 1836) and has a great importance in reducing their population on *Malus, Prunus* and *Rubus idaeus* (Rosaceae), Ribes (Grossulariaceae) and vegetable crops.

The coccidophages are recorded in 4 families: Scymninae, Chilocorinae, Sticholotidinae and Coccidulinae. Several species feeding on scale insects are used in the biological control programs (Gordon, 1985; Drea and Gordon, 1990). Although the data on the trophic relations of Coccinellidae-coccidophages are far from complete, the existing material indicates the specialization of some genera of Coccinellidae-coccidophages. The representatives of the genus *Scymnus* are specific predators for mealybugs (Pseudococcidae). The majority of the representatives of the genus *Chilocorus* are trophically connected mostly with armored scales (Diaspididae). In Kazakhstan *Choilocorus bipustulatus* preys on armored scales of the genera *Adiscodiaspis, Chionaspis, Lepidosaphes, Parlatoria* (Savoiskaya, 1983). *Ch. rubidus* (Hope, 1831) is a narrow oligophage, and in the Far East develops on *Parthenolecanium corni* (Bouche, 1844). The lady beetles of this species introduced by V.N. Kuznetsov to Georgia, preyed there on soft scales (Coccidae) of the genera *Parhenolecanium, Eulecanium* (Kuznetsov, 1997) thus, the genus *Chilocorus* includes both narrow and broad oligophages, and its species can feed only on armored scales or soft scales, or on both of them. Predator Coccidae are Lady beetles of the subfamily Chilocorinae, it is *Exochomus quadripustulatus* (Linnaeus, 1758); *Parexochomus nigromaculatus* (Goeze, 1777); *P. melanocephalus* (Zoubkoff, 1833) and *P. semenowi* (Weise, 1887) In the Urals *E. quadripustulatus* feeds mainly on soft scales, and *P. melanosephalus, P. nigromaculatus* and *P. nigromaculatus* are also recorded as entomophages, as their development can proceed on Aphids.

The representatives of the subfamily Coccidulinae feed on armored scales (Diaspididae), but sometimes manifest themselves as entomophages.

The majority of species of the subfamily Scymninae feed on soft scales (Coccidae). Beetles and larvae of *Hyperaspis desertorum* (Weise, 1885) prey on ensign coccids (Ortheziidae), their feeding is recorded only on ensign coccids *Ortezia urticae* (Linnaeus, 1758). This suggests a stable relationship between the predator and victim. Some representatives of the genus *Scymnus* are specialized predators for mealybugs (Pseudococcidae).

Thus, having analyzed the trophic relations of Coccinellidae-coccidophages to their main food objects, we can allocate the groups of Coccinellidae genera – specialized predators of certain Coccoidea families. The comparative analysis of the trophic relations of Coccinellidae-aphidophages and coccidophages has shown that the coccidophages are more specialized than the aphidophages.

Coccinellidae feeding on various insects belong to the group of of polyphages. As a rule, they are specialized entomophages. In environment of the Urals, *Coccinella septempunctata* can be attributed to polyphages, because its adults eats up the aphids of 25 species on numerous trees, shrubs and herbaceous plants and also the larvae of Psyllidae and Aleyrodidae, eggs and larvae of Chrysomelidae and Coccidae, eggs of *Loxostege sticticalis* (Crambidae), *Autographa gamma* (Noctuidae) and others.

In conclusion, it should be noted that predating Coccinellidae are able to transfer to plant nutrition with pollen and nectar. Lady beetles of the genera *Coccinella* and *Menochilus*, living in India, in the absence of aphids in nature feed on mulberry fruits (Trehan & Malhotra, 1959). Hodek (1966) suggests that in several cases the phytophagy is explained by the search for the missing moisture. According to G.I. Savoiskaya (1983), the ability to partially feed on plant food appears at predators as a result of a lack of aphids and repeating from generation to generation it becomes a hereditary feature of Coccinellidae. Thus, it can be stated that Coccinellidae of Ural use a wide range food sources.

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