MODERN TRENDS IN THE DEVELOPMENT OF AGRICULTURAL PRODUCTION

PROBLEMS AND PERSPECTIVES

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The monograph presented for review is a collection of the results of actual achievements of domestic agricultural scientists, obtained directly in real conditions. The authors are recognized experts in their fields, as well as young scientists and postgraduate students of Ukraine. Research is conceptually grouped into 5 sections: modern technologies in crop production and fodder production; economy of the agro-industrial complex; breeding and breeding in the 21th century; protection and quarantine of plants; agrochemistry and soil science. The monograph will be interesting for experts in plant breeding, economics, plant protection, selection, agrochemistry, soil science, scientific workers, teachers, graduate students and students of agricultural specialties of higher education institutions, and for all those who are interested in increasing the quantity and quality of agricultural products.

Keywords: modern technologies, crop production, fodder production, plant protection, quarantine, agrochemistry, soil science, economy of agro-industrial complex.

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BIOLOGICAL PROTECTION OF APPLE-TREE FROM APPLE-BLOSSOM WEEVIL (*ANTHONOMUS POMORUM* LINNAEUS, 1758)

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In the course of critical analysis of the literature, the authors paid special attention to the elements of the integrated protection of apple plantations from apple-blossom weevil. First of all the essence of pest control in the garden is the timely and careful destruction of the hibernating stock. One of the alternatives to use the chemical pest control method is the biological method, especially it is recommended to use it in the old gardens. This fact is based on the analysis of the trophocenotic consortium connections of the phytophages of the apple garden, in which the majority of the dendrophilous species should be considered as the feeders that cause the preservation of the parasitic species populations during the years of the garden pest depressions. Another condition for the preservation of the parasitic species in the gardens is to create a forage reserve for the imago nutrition. Trophic bonds can be retained as dominant only in the absence of garden pesticides treatments or with minor treatments.

Key words: *apple-blossom weevil, harmfulness, economic threshold of harmfulness, biological protection.*

An important task of modern systems of plant protection, including fruit crops, is to develop and implement the integrated measures that preserve the crops from harmful organisms while being the safest for the environment, animals and humans. The transition to such integrated systems involves the application of the biological method of pest control, reducing the number of pesticide treatments, the ability to use the preparations of selective action together with the entomophages, etc. An important reserve in this program is the activation and use of natural resources of the beneficial insects – parasitoids and predators which limit the number of harmful insect-phytophages (Yevtushenko, 2004).

According to M.A. Filippov (1990) the biological method of pest control is a necessary component of the integrated protection, but the high agricultural technology for growing crops, the use of resistant varieties and other methods must be the preconditions.

Considering the current direction of the plantation protection strategy, that is biologization and ecologically friendly environment, it is important to develop the programs that encompass separate techniques which would take into account the natural regulatory role of useful fauna. The deeper researches are connected with determining the role of plants themselves and their varieties as factors that form the ecological environment for the life of the entomocomplex, especially the entomophages (Filippov, 1990).

Vegetative features of any variety determine not only the feeding regime of the phytophage, but also create the specific conditions for both the host plant and its entomophages. The change in the ecological situation connected with the plant variety may have a positive or negative influence on both partners or on one of them depending on the biological characteristics of the phytophage and entomophage.

Another situation is perennial, different in varietal composition fruit plantations. And if the species compositions of the entomocomplex and its biotic potential have been investigated thoroughly, the researchers paid little attention to the features and nature of the interaction of the entomocomplex with the fruit trees of different varieties. This is especially true for the study of the variety response to the efficiency of the natural entomophages and to the ratio of phytophage – entomophage when seasonal colonization of the entomophages is used.

Developing a modern strategy for the protection of fruit plantations, especially under the conditions of industrial fruit production, has proved to be the most difficult one. Some progress has been made in creating the optimum phytosanitary condition on the private plots and in the collective gardens. The extensive application of viral, bacterial and fungal biopreparations, protection and use of local entomophages, and rational application of chemical measures (taking into account the economic thresholds of the phytophages harmfulness and the criteria of the parasitoids, predators and pathogens number) became here especially important.

The role of blossoming plants for attracting the beneficial insects, increasing their life expectancy and the efficiency is well known. Extra feeding is especially needed for those entomophages which flight does not always coincide with the populating of a particular pest stage in nature.

In practice it is recommended to create the areas of concentration and extra feeding of the entomophages near the fruit plantations by sowing cultivated and wild nectariferous plants (Chernii, 2007).

Due to the increase of the trophic chain in the cenoses of the old gardens, the number of many species inclined to mass reproduction is smoothing over. The increase in the species diversity causes the stability of the garden cenosis and by most properties brings it nearer to natural forest biocenoses.

One of the major factors that reduce the species diversity and number of natural insect populations is the excessively ungrounded application of pesticides. The decrease in pesticide loading on agrocenoses that took place in the last 10–12 years has led to a significant increase in the species diversity (Krikunov, 2001; Sumarokov, 2003).

Some 20–30 year-old apple gardens are not inferior to natural and semi-natural (shelterbelt forests and parks) plantations in biodiversity. Taking into account the abundance of arable land characteristic for the region and the role of fruit plantations as “islands” of biodiversity, it makes sense to preserve some insufficiently fertile old gardens transferring them into the park plantations (Yevtushenko, 2003, 2006).

Various types of the entomophages and pathogens greatly influence the number and harmfulness of many pest species of fruit plantations. They affect the phytophages throughout the vegetation period of the trees. In fact it is possible to detect a particular parasitoid, predator or disease at any stage of the pest development. The share of the infected phytophages depends on the peculiarities of weather conditions, application of pesticides, agro-technical measures under the garden conditions, weed destruction, presence of the nectariferous plants and green-manure plants in the gardens or adjacent agricultural land and a number of other factors (Shevchenko, 2008).

The methods aimed at the use of the natural enemies play the top priority role in regulating the number of pests of fruit and berry crops.

Materials and methods

The authors have analysed literary and electronic sources from the 20th to the 21st centuries. In the course of the analysis special attention was paid to the biological methods and ways of controlling the apple-blossom weevil on fruit plantations both in Ukraine and abroad.

Results and discussion

At the pre-imago stages of development the main factors in the death of the apple-blossom weevil are the infestation of larvae and pupae with the parasitoids, larvae disease, cannibalism, destruction by predators and leafworms feeding on the same buttons, rapid opening or underdevelopment of the button.

The Hymenoptera line is one of the largest insect lines including a large number of the beneficial species. The largest number of the entomophages used for the biological destruction of harmful species belongs to the Parasitica suborder (Yevtushenko & Zabrodina, 2013).

The entomophages of the apple-blossom weevil have been studied most carefully. The main role in the regulation of this pest number is played by the membrane-winged insects. The most known species of the apple-blossom weevil entomophages and the predatory bug of the genus Anthocoris (family Anthocoridae) belong to Ichneumonidae, Braconida and Pteromalidae.

The entomophages play a certain regulative role in the apple-blossom weevil ontogenesis. Among them are the parasitoids of larvae and pupae of *Habrocytus grandis* Walk., *Tetrastichys pospjelovi* Kurd. – the primary and secondary parasitoid (the Braconidae family), *Scambus annulatus* Kiis., *S. pomorum* Ratz. (the Ichneumonidae family) as well as *Syrrhizus delusorius* Först. (the Braconidae family) which infects the beetles (3,2-12,6%).

In the 30's more than 30% of weevil larvae were infected with tachinid pimple in the gardens near Moscow. Recently as a result of the application of chemical measures the number of the beneficial insects that destroy the weevils has decreased. The adult insect feeds on the flower nectar of the umbelliferous crops (dill, parsley, carrots, etc.) as well as buckwheat, garden radish, phlox, lemon balm and many other crops.

The natural enemies are also important in some gardens of the Oriel region where they destroy up to 30-40% of the larvae and pupae of the apple-blossom weevil. She revealed the natural enemies of the apple-blossom weevil; they are the ichneumon wasps *Habrocytus tenuicornis* Foerst. (Chalcididae) and *Scambus* sp. (Ichneumonidae), the predatory bug

*Anthocoris nem*orus L. and the insectivorous birds.

From 1976 to 1980 a number of scientists studied the influence of the entomophages on the number dynamics of the apple-blossom weevil in Ukraine. Such entomophages as ichneumonids flies from the Chalcid, Ichneumonid and Braconid families and some samples of tachinids were bred from the larvae and pupae of the apple-blossom weevil. The populating of larvae and pupae with the entomophages were in the range of 8,1–21,7%. But during the years of the research a significant effect of the entomophages on reducing the number of the apple-blossom weevil has not been noticed (Yevtushenko & Zabrodina, 2013).

In the Kharkiv region the parasitoids of the apple-blossom weevil from a line of Hymenoptera were also found and identified. They are *Scambus annulatus* Kiss*., Scambus planatus* Htg. (Ichneumonidae), *Triaspis pallipes* Nees. (Braconidae), and *Habrocytus grandis* Walk. (Pteromalidae) (Yevtushenko, 2009).

Carried out in the private and bad-groomed industrial gardens (Opened Joint Stock Partnership “Berezanske”) of the Kyiv region during 1993-1998 it was found that at the pre-imago stages of development the determining factors led to the death of the apple-blossom weevil were the parasitoids of larvae and pupae; the rate of death was up to 27,9%. According to the reproductive strategy the entomophages of the apple-blossom weevil belong to the synovigenic species. The ovogenesis of the females has a cyclic character and in order to have a valuable nutrition they need to feed on carbohydrates (nectariferous plants) as well as protein (host hemolymph) throughout the whole life cycle. They are developing synchronously with the hosts. However under the most favourable conditions, the absence of the insecticide treatments and in the presence of the nectariferous plants the level of infestation of the apple-blossom weevil with the parasites is negligible. This fact is evidenced by the condition of the fruit trees growing on the territory of the Institute of Plant Physiology and Genetics. The annual rate of the population here is 90– 100%; the damage of the buds is 18– 48%, the damage of buttons is 25– 70%, and the damage of the flowers and leaves is 15 – 45%. It has been also determined that the role of the predators in the ontogenesis of the apple-blossom weevil was insignificant; on the average they destroyed from 1,6 to 5,2% of larvae and pupae.

An important factor in the death of the beetles in the spring is the death caused by the parasitoid *Syrrhizus delusorius* Först. from the Braconidae family; from 1,0 to 15,4% of the apple-blossom weevil imago were infected with it under the conditions of the Moscow region at different times.

Habrocytus grandis Walk. from the *Pteromalidae* family and *Scambus annulatus* Kiis. from the *Ichneumonidae* family are also the parasitoids of larvae and pupae of the apple-blossom weevil under the conditions of the Moscow region and Belarus. At the same time *Habrocytus grandis* Walk. dominates in the gardens where the protective measures were carried out. Under the conditions of the Moscow region the death of larvae and pupae of the apple-blossom weevil from the parasitoids reaches 23,1. In Belarus the parasitism of pre-imago stages ranged from 0,09 to 10%, and the parasitism of the imago did not exceed 0,6%.

Under the conditions of Belarus the entomophages practically don't play any role in changing the number of the apple-blossom weevil. But in some years the infestation of larvae with a complex of the parasitic membrane-winged insects from the Ichneumonidae and Braconidae families reaches 24% in some gardens. The main parasitoids of the weevil larvae in Belarus are *Scambus calobatus* Grav. and *Bracon intercessor* Nees., which fly out in June.

In Georgia the infestation of pre-imago stages with the parasitic membrane-winged insects from the Pteromalidae family is 16 – 56%, and the death of the apple-blossom weevil during the winter is 2 %.

In Poland the infestation of pre-imago stages of the apple-blossom weevil parasitoids was 3,2–5,4 %, and the main species are *Scambus annulatus* Kiis., *S. calobatus* Grav., and *S. pomorum* Ratz.

In the Netherlands the main parasitoids of the apple-blossom weevil are *Syrrhizus delusorius* Först. and *Scambus pomorum* Ratz. *Syrrhizus delusorius* Först. They were found in only six of the fifteen gardens populated by the apple-blossom weevil in the Netherlands; and in two gardens the infestation of the hibernating apple-blossom weevils reached 30%.

22,3–41,3 % of the individuals die at the pre-imago stages of the apple-blossom weevil development, and only 13,1–33,8 % of the individuals die from parasitism and predators. Taking into account the high fertility of the apple-blossom weevil and the ratio of sexes close to one, we can conclude that the main factor in reducing the number of the apple-blossom weevil is the death from the parasitoids and soil entomophages at the imago stage during the migration of the beetles to hibernation and one more factor is the unfavourable winter conditions.

The representatives of the Carabidae and Staphylinidae dominating in the soil in the leaf litter, where the apple-blossom weevil imago get migrating to hibernation or falling under the force of sharp mechanical irritations, constitute the most part of the apple-blossom weevil zoophages (Yevtushenko, 2004).

In addition the birds, especially the tomtit (*Parus mayor* L.), peck the beetles in the hibernating places and in the crown of the trees in summer.

The sparrows (*Passer domesticus* L., *Passer montanus* L.) rearing their chicks with the apple-blossom weevil larvae are of great benefit in reducing the number of the beetles in the Moscow suburbs (Yevtushenko & Zabrodina, 2013).

Both the abiotic factors and the biotic ones influence the number of the apple-blossom weevil. The optimum temperature for the egg laying is in the range of 12 – 15°C. At a temperature of 15°C the egg laying lasts 1,6 days on the average, and at a temperature of 25°C it lasts only 6 days. Therefore the prolonged spring season facilitates the egg laying process of the apple-blossom weevil and the realization of all its reproductive potential (Duan, Weber, Hirs, & Dorn, 1996). On the contrary in the years with high spring temperatures the intensive opening of the buttons causes the eggs and young weevil larvae to fall out of them. Thus, under the conditions of the Kiev region the death of the pre-imago stages of the apple-blossom weevil due to the rapid button opening reached 14,8–25,6% (Dospiekhov, 1985), in the Moscow region it reached 21,5%.

The parasitic membrane-winged insects play a certain role in regulating the number of the apple-blossom weevil (*Anthonomus pomorum* L.). 12 species of the most common entomophages of the apple-blossom weevil are known; 6 species belong to the Ichneumonidae family, 5 species belong to the Braconidae family and 1 species belongs to the Pteromalidae family. Among them 11 species are the primary parasitoids and one species may be both the primary and the secondary parasitoid. *Syrrhizus delusorius* Forst. (Braconidae) infects the adult beetles; *Habrocytus grandis* Walk. (Pteromalidae) develops on the larvae as well as on the pupae, and the remaining species are the parasitoids of the larvae. The parasitoids usually infect up to 20% of the apple-blossom weevil larvae. The trophic connections of the main entomophages *Anthonomus pomorum* L. are shown in Figure 1.

The Ichneumonidae family

Ichneumon wasps are one of the most numerous groups of parasitic membrane-winged insects in the complexes of the entomophages of many insect pests, including trophically connected ones with the fruit crops.

Most species of ihneumonids are the primary parasitoids that infect the host larvae, usually of younger age. The ichneumonids have the largest body size among all parasitic membrane-winged insects; the length of their bodies is 3–25 mm. The wings are usually well developed; rarely females (and sometimes males) are wingless. The ovipositor is short or very long. The colour of the body is usually black, often with numerous white, yellow or red spots; rarely may it be completely light.

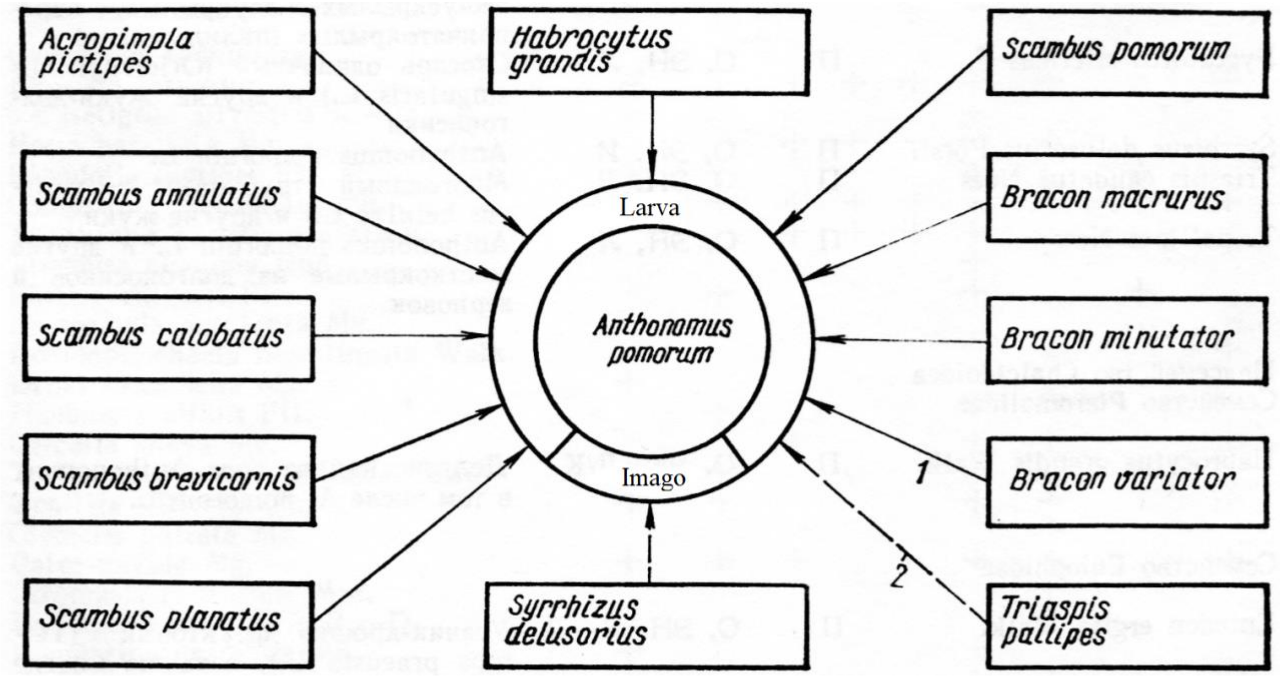


Figure 1. Scheme of trophic connections of main entomophagous species

Anthonomus pomorum L.: 1 (continuous line) – ectoparasite, 2 (dotted line) – endoparasite (Zerova, Tolkanets, Kotenko, 1992).

The ichneumonids mainly infect the larvae and pupae of other insects (the exception is the insect larvae with an incomplete transformation). During the sexual maturation the females need extra carbon and protein nutrition and perform it at the expense of the nectar and hemolymph of the hosts. Both ecto- and endoparasitoids are known among the ichneumonids, some of them are the secondary parasitoids.

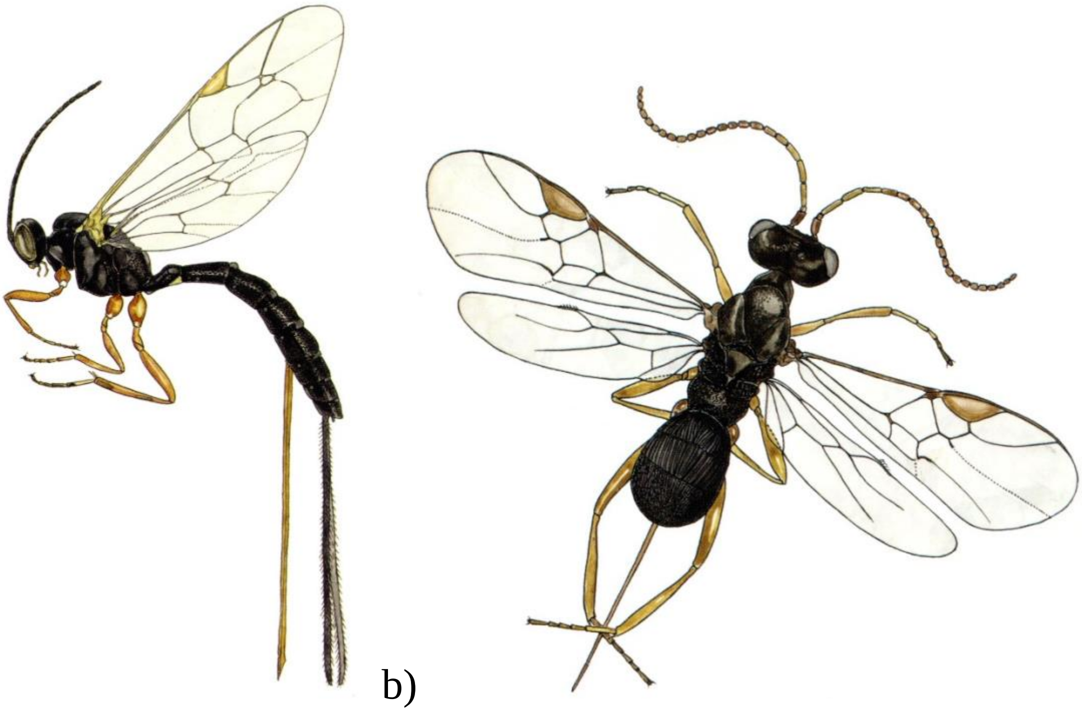
Scambus Hartig genus, 1838.

The genus is widespread in the northern hemisphere. There are 24 species in the European part; 10 of them are registered in the fruit garden agrocenosis.

The insects are slim, the length of their bodies is 4,5–12 mm. The ovipositor does not exceed the length of the body. In the fore wing the second back vein extends from the mirror between its middle and outer margin. The body is usually black; the legs are from reddish-yellow to yellow, the hind tibiae on the top are darkened.

All members of the genus are ectoparasitoids of the hidden living hosts: weevils (Curculionidae), galloforming membrane-winged insects (Cynipidae, and Tentredinidae) and various Lapidopterae (Glyphipterigidae, Gracillariidae, Choreutidae, Geometridae, and Tortricidae).

Scambus annulatus Kiss. (Figure 2a). It is distributed in the European part of the Union of Independent States except the north, in the Caucasus, Kazakhstan, Irkutsk and the Chita regions; in Central Europe and North America.



a) b)

Figure 2: a) *Scambus annulatus* Kiss.; b) *Triaspis pallipes* Nees.

Females: the vagina of the ovipositor is almost equal to the length of the abdomen. The abdomen is usually black or dark brown. The length of the body is 5 – 8 mm. The hind coxae are red. The pterostigma is yellowish with brownish margins. *Anthonomus pomorum* L., *Spilonota ocellana* F., *Choreutis pariana* Cl., *Callisto denticulella* Thunb are the ectoparasitoids of larvae.

Males: the head is accurately narrowed to its hind end. The notch on the front thighs is mat and subtly granulated.

It is a common single primary ectoparasitoid of the scaled-winged caterpillars from the families of Glyphipterygidae, Gracillariidae, Choreutidae, Geometridae, and Tortricidae, the larvae of some galloforming membrane-winged insects (Cynipidae, and Thenthredenidae) and the larvae of weevils (Curculionidae). They infect the larvae of the III–IV generations.

2–3 generations develop per year. An adult larva hibernates in a white translucent cocoon next to the host's remains. The imago flies from the beginning of May to the end of August (Zerova, Kotenko, Tolkanets, 2010).

Scambus planatus Htg. It is distributed in the southwest and south of the European part of the Union of Independent States, in the Caucasus, Irkutsk, the Chita regions, and Western Europe.

Females: the head is not narrowed to the back end. The longitudinal dorsal keels of the propodium are often significantly obliterated. The ovipositor is equal to the length of the abdomen. The body is black; the legs are reddish-yellow, the hind tibiae are whitish with a dark pattern at the base and on the top. The length of the body is 8–11 mm. It is the endoparasitoid of the larvae *Anthonomus pomorum* L., and caterpillars *Archips rosana* L., *A. xylosteana* L., *Pandemis heparana* Den. et Schiff., *Ancylis achatana* Den. et Schiff. (Zerova, Kotenko, Tolkanets, 2010).

Males: the head is almost narrowed to its hind end. The hind coxae are black. The hind tibiae are whitish with dark rings in front of the base and on the top

Braconidae family

It includes more than 15 thousand species; among them more than 2 thousand are found in the countries of the former USSR. The braconids are always present in the apple gardens and are the parasitoids of many dangerous pests.

It is one of the largest families of the ichneumon wasps. As a rule the braconids are capable of active flight, but in some species the females do not have wings or they are shortened. The body length of the braconids is from 1 to 25 (more often 2–7) mm. The body in most cases consists of a combination of black and yellow or reddish-brown colour. The ichneumonids are often completely black or brown. The braconids are the primary parasitoids of the larvae and sometimes of the adult insects from the lines of scaled-winged, sheathed-winged, two-winged, membrane-winged, bugs and net-winged. The larvae develop inside the host (endoparasitoid) or outside of it (ectoparasitoid). The larvae of ectoparasitoids and most endoparasitoids leave the host before pupation and spin a cocoon of a characteristic shape and colour near the substrate. Sometimes a cocoon hangs on a cobweb. A part of the endoparasitoids is pupating inside the mummified host. Most braconids are flying parasitoids. In many terrestrial ecosystems they are high in number and are effective natural regulators of the insect number (Zerova, Kotenko, Tolkanets, 2010).

Triaspis Haliday genus, 1835. The species of this genus parasitize in the larvae of the beetles (Bruchidae, Curculionidae, Rhinchitidae, and Scolytidae). There are 2 species in the apple gardens.

Triaspis pallipes Nees. (Figure 2b). It is distributed in the European part of the former USSR, in the Caucasus, Western Europe and China.

The first three abdominal tergits form a testa with two transverse sutures. The testa is very short, almost spherical in shape. The ovipositor is equal to the length of the abdomen and thorax taking together. The antennae have 21–24 segments. The abdominal testa is wrinkled-dashed, longitudinally crossed: the third tergit is sometimes almost smooth. The body is black; the legs and tentacles are brownish-yellow, the wings are light; the body length is 1,8–2,5 mm. It is the parasitoid of the apple-blossom weevil, other weevils and some bruchid weevils.

The common, sometimes numerous species is found both in natural ecosystems and in agrocenoses. They fly from April till October. It is an egg-larval endoparasitoid of *Coleoptera* from the Bruchidae and Curculionidae families, as well as from some Apionidae and Attelabidae families (Zerova, Kotenko, Tolkanets, 2010).

Pteromalidae family

The forms of medium size (3 mm) belong to the large family of Pteromalidae. The colour is mostly green; the ovipositor in most species is short. The host range is very wide. The primary and secondary parasitoids of many insect species from different lines are known among the pteromalids. In the fruit gardens the pteromalids are represented by almost 20 species from 10 genera; among them the effective regulators of the number of the apple trees pests are known. The species biology is very diverse (Zerova, Kotenko, Tolkanets, 2010).

Genus of Habrocytus Thoms., 1878

Their post marginal vein is longer than the radial one. The fore margin of the clypeus is even or with a slight groove. The abdomen is elongated, long, and conically sharpened to the top.

The genus includes 50 European species; among them 4 species are constantly found in the agrocenosis of the fruit garden. They are mainly the secondary parasitoids of many scaled-winged insects as well as of the blossom beetles.

Pteromalus (Habrocytus) varians (Spinola) (=grandis Walker) (Figure 3).

It is distributed in the north of the European part including the Leningrad region and in Western Europe**.**

The middle zone of the intermediate segment is found only in the centre and has a clear dotted line. The head is large, the face is long, and the length of the cheek is slightly more than the longitudinal diameter of the eye. The abdomen is equal to the length of the head and the thorax taking together or slightly longer, the body is bright green, the legs are light. The body length is 3–4 mm. The body is dark green with a metallic lustre. The distance from the fore margin of the intermediate segment to the spiracles does not exceed their diameter. The female's antennae have the rings. The male's head (view from above) lacks 3 notches. The marginal vein is 1,6–1,8 times longer than the radial one. The male's abdomen usually has a large light spot.

It is the single primary endoparasitoid of larvae and pupae of many weevils including *Anthonomus pomorum* L. It can be found everywhere from the forest stands to the farmlands (Zerova, Kotenko, Tolkanets, 2010).

Figure 3. *Pteromalus (Habrocytus) varians (*Spinola*) (=grandis* Walker)

Therefore there is a necessity for further improvement of the integrated plant protection by expanding the capabilities of the biological protection arsenal, in particular at the expense of the representatives of soil entomofauna in the garden cenoses; and the fact that in the course of their development most insects (about 90%) in any case are connected with being in the soil (during the pupa stage or during hibernation) should be taken into account (Yevtushenko, Hrama, 2007).

Conclusions

Modern systems of plant protection, including fruit crops, consist in developing and implementing the integrated measures that preserve the crops from the harmful organisms while being the safest for the environment, animals and humans. The transition to such integrated systems involves the application of a biological method of pest control, reducing the number of pesticide treatments, the ability to use the preparations of selective action together with the entomophages, etc. An important reserve in this program is the activation and use of natural resources of the beneficial insects (parasitoids and predators) which limit the number of harmful insect-phytophages.

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