MODERN OUTLOOKS OF BIOLOGICAL CONTROL OF WEED PLANTS IN THE U.S.S.R. AND THE INTERNATIONAL PHYTOPHAGOUS EXCHANGE[I)]

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The U.S.S.R. is the first European country in which phytophages have become a biological control practice against weeds.

In the fifties, large-scale experiments were already conducted on using Phytomyza orobanchia Kalt. (Agromyzidae) and Alternaria cuscutacidae Rud. to control broomrapes and dodders. Thus, the attempts were made to use indigenous species to control local weed plants. In 1930, Prof. S.Bogoyavlenskii reported, in his profound paper on biological peculiarities on Ph. orobanchia, that indigenous entomophages produced significant effects on phytophagous populations. At present, the paper by Bogoyavlenskii is of great significance because Ph. orobanchia is under study in many European countries. Good control of Orobanche has been recently achieved resulting from the introduction of central-asiatic populations of Ph. orobanchia. Any methods have not been till now developed to remove Chalcidoidea parasites from Ph. orobanchia puparia and the introduction of the phytophages is often associated with releasing new entomophages of Ph. orobanchia in addition to the indigenous ones instead of the phytophage. Puparia without parasites can, however, be obtained at growing broomrapes in a glass-house. At present, Ph. orobanchia is introduced to thousands of hectars in different southern areas of the U.S.S.R.

Our main task is, however, biological control of adventitious weed plants. In the U.S.S.R., the most troublesome quarantine weeds, including ragweeds, American dodders, Solanum sp.sp. and others, are adventitious plants. Amongst them, the weeds introduced from America spread at the greatest speed.

Therefore, we pay great attention to searching for natural enemies of American weed plants in their native land, North America.

Foci of American weeds produce a free ecological nich, these plant species often produce ecological explosions.

In addition, geographic peculiarities of our country, with diverse climatic zones and many floristic origination centres of different weed groups present, favour transferring phytophages of indigenous plants originating from Eurasia within the country. In the habitat areas of weed plants, there are hiatuses resulting from the recent introductions of the plants from their origination centres.

There is a wide range of insects, mites and nematodes injuring the most troublesome weed plant, Russian knapweed (Acroptilon (Centaurea) repens) (L.) DC.) in the Central Asia. In the South of the European part of the U.S.S.R. this weed plant is damaged only by few insect species.

In Europa, the Russian knapweed populations are more competitive than in the Central Asia and they are there the most harmful ones. We have

I) Presented at The 2nd International Symposium on Biological Control of Weeds. Rome, Italy Oct. 4-7, 1971 introduced the nematode Paranguina picridis Kir. and the mite, Aceria sp. n., (Eriophyidae)to the Crimea from the Central Asia; they suppress,in the most efficient way, the reproduction of this weed plant.

We have mechanized P. picridis treatment with using sprayers. In the Crimea the nematode infestation of Russian knapweed plants is 60% with the complete destruction of 30% plants in some tests plots.

Aceria phytophage may be introduced to North America to control Russian knapweed.

Species belonging to Eriophyidae family embracing mainly plant monophages are promising in biological control of weeds. Aceria sp. n. is a monophage of Russian knapweed. The mites feed in flower heads. The flower heads damaged are bud-shaped with their average sizes being 7 to 8 mm and maximum size II to I2 mm. The flower heads don't open in the growing period. The mites feed on the inner layer of involucre leaflets, on receptacle and mainly on distorted florets. The mite population feeding within a single flower head (the 2-nd generation) consist, on average, of 6 to 7 thousand of individuals, with their maximum number being I3 thousand and even more. Hibernating females can be easily transported.

The central-asiatic floristic centre is of great significance not only to a transference of phytophages within our country, but also to the international phytophagous exchange.

Here, the richest faunistic complex consortia of phytophages occur feeding on Halogeton glomeratus, Salsola iberica, Chondrilla, Acroptilon plants which have been distributed all over the world. Weed plants originating from deserts and mountains of the Central Asia produce readily ecological outbreaks in the sites newly colonized, e.g. on the American Continent (A. repens, S. iberica (=pestifer), H. glomeratus).

American scientists made attempts to use phytophages in control of H. glomeratus originating from the West floristic centre of Halogeton differentiation. These stenophages were not, however, able to develop on Halogeton plants from the East origination centre.

Chondrilla juncea L. introduced from East Europe has been wide-spread in North America and, at large scale, in Australia. The many of species belonging to this genus (22 out of total 27) occur in the U.S.S.R. Chondrilla origination centre seems to be located in the Eastern part of ancient Mediterranean Area. The richest fauna of specific insects occurs here on different species of this genus, this diversity declines sharply in the western direction from this region. Insect fauna on Chondrilla was studied in details by Russian entomologists in the Kazakhstan in the thirties when natural rubber plants were searched for (Emelyanova, I935, I938).

By the way, to obtain rubber from Chondrilla, latex burls produced by the burncow, Sphenoptera foveola Gebl., and not the plants themselves were used. These burls were collected near Ch.ambigua roots in Kazakh deserts.

The most promising phytophages of Chondrilla can be evidently found out for introducing them to Australia and America. Therefore, in I97I we collected S. foveola larvae in deserts to the North from the Aral Sea from May till August and dispatched them to the Australian Biological Control Unit in France.

The following insects should be taken into consideration in addition to the phytophages studied at the Australian Laboratory:

I. S.foveola Gebl. (Buprestidae). The evident strict oligophage of Chondrilla. It feeds preferably on Chondrilla ambigua Fisch., occurs also on Ch. pauciflora Ldb. and rarely on Ch. brevirostris Fisch. et Mey. As judging by the occurrence of the burncow on species belonging to different sections of Chondrilla genus in nature, this insect may readily feed on Ch. juncea.

The oviposition continue during the whole summer. Larvae move downward the stems reaching radical stem parts. The middle and old instars cause great damages to stems. They overwinter under latex burls, beetles emerge in spring. The beetles feed only on Chondrilla species.

The distribution area of species embracing the Central and West Kazakhstan and Astrakhan region, has been determined according to collections. The species seems to occur neither south wards nor east wards from this area and may be collected only in the U.S.S.R.

2. Bradyrrhoa gilveolella Tr. (Phycitidae, Lep.). This species replaces ecologically S.foveola in plain sands in steppes. It feeds on Ch. juncea, Ch.Kusnezovi Il., Ch. mujunkumensis Il., Ch. brevirostris. The flight of moths continues from May till September with intervals. Caterpillars feed on root tissues, preferably on cortical ones. Caterpillars develop in indusia reaching soil surface. Two generations arise yearly. Biological peculiarities of the species have been well studied by Russian authors. As the collections of the Zoological Institute show, the habitat area of the species embraces the West Kazakhstan, the Daghestan, the Azerbaijan and the South Ukraine (Nikolaev, Odessa, the Crimea). Outside the U.S.S.R., the species occur in the Iranian Azerbaijan.

3. Oporopsamma wertheimsteini Rbl. (=amseli Raz.)(Lep.). Caterpillars live in silky indusia on Chondrilla roots as B. gilveolella does. The habitat area is similar to that of B. gilveolella, the insect occurs in steppes.

4. Neomargarodes chondrillae Arch. (Margarodidae, Coccoidea). The coccids feed on Chondrilla roots and produce burls which are similar to those produced by S. foveola. Biological peculiarities of the species are well studied in the Kazakhstan. It is a strict oligophage of Chondrilla and occurs on Ch. brevirostris, Ch. mujunkumensis, Ch. Kusnezovi.

5. The aphid species investigated should be supplemented with two species from Chondrilla roots, namely, with Xerophilaphis chondrillae Mord. and Chomaphis chondrillae Mord. which were not described by Mordvilko.

6. Dr. J.Kerzhner has reported that his collections in the Zoological Institute comprise two undescribed species of probably specialized bugs belonging to different genera of Miridae fam. (Philini tribe) from the Volga valley and the Central Kazakhstan.

7. Dr. E.P.Narchuk reported that larvae of Aspanotrigonum cinctellum ZH. (Chloropidae, Dipt.) were found in Chondrilla roots in the Central Asia.

Salsola iberica Sennen et. Pau. (=S. pestifer A.Nels.)introduced into the U.S.A. and the South Africa is promising species to be used in biological control. In the U.S.S.R., rich fauna of strict oligophages belonging to different insect groups has been recorded on Salsola species.But almost all the oligophages have been described on shrubs and subshrubs and these insects can't usually transfer to herbaceous Salsola. This genus in divided into distinct sections, and, to control S.iberica,strict oligophages should be searched for 22 species only of Salsola section s.str. and, namely, on annual species of Salsola genus. This is one of the youngest section of the genus, it developed at the Northern frontiers of the habitat area of the genus in Eurasia and its origination centres are continental deserts.

Many insect species have been recorded on herbaceous Salsola species, but the many of them are broad oligophages and polyphages belonging to different Chenopodiaceae genera

I. Lepidoptera. Dr. M.Falkovitch studied profoundly Lepidoptera fauna on different Chenopodiaceae genera in the deserts of the Central Asia (Falkovitch, 1969). His collections resulted from rearing caterpillars on plants. In his opinion, stenophagous fauna is extremely scanty on herbaceous Salsola. For example, all Pyralidae are broad oligophages on herbaceous Salsola species, strict oligophages occur only on perennial shrubs. Broad oligophages can, however, be also used in biological control. For example, two closely related Pyralidae species, Staudingeria and Heterographis, damage leaves and shoots of some Chenopodiaceae,showing preference to herbaceous ones. Their ecological specialization is strictly attached to the plant organs being in contact with soil. Caterpillars live in branched silky-sandy tubes in sand. The development of the species is polycyclic. Last-instar caterpillars hibernate. Caterpillars are difficult to transport, but eggs can be transported.

Coleophora transcaspica Toll. (=lashkarella Toll. et Amsel) is a single moth species known at present to be specific to Salsola s. str. section. Its caterpillars live in stems of S.collina Pall., S.iberica, S.paulsenii Litv. and, probably, in those of some other species. But any pathogenic effects have not been observed on the plants.

2. Homoptera. Any specific coccids don't occur on herbaceous Salsola species.

Dr. G.Shaposhnikov considers that Chataphis tenuicauda Nevs. (a monotypic aphid genus) and Xerophilaphis salsolecearum Nevs. aphids were described on herbaceous Salsola species in the Central Asia.

3. Heteroptera. Dr. J.Kerzhner reported that Piesma salsolae Beck. (Piesmatidae) feeding on S.kali L. and related species is a single specific bug on herbaceous species. Mass occurence of tha bug is usually observed.

4. Coleoptera. Many Curculionidae species are the commonest phytophages of herbaceous Salsola in the desert of the Central Asia. This group belongs, however, to the least studied ones.

5. Diptera. Dr. E.P.Narchuk reported that larvae of Clanoneurum longicorne Beck. and those of C. cimiciforme Halid. (Ephydridae)produced mines on the shoots of herbaceous Salsola in the Central Asia.

Another genus of Chenopodiaceae family is Halogeton. In I965/66, Prof. P.Marikovskii and me, we collected little known and new phytophages of H. glomeratus C.A.Mey in the Central Asia. In our opinion, this plant is suppressed by stenophagous insects at such a strong degree that it is not capable to compete within herbaceous association and grows in the sites lacking vegetation. After being introduced to the U.S.A., H. glomeratus produce dense foci and is very troublesome on pastures.

Phytophagous fauna of H. glomeratus has been still poorly studied, but, at present, weevils (Baris), aphids and different Lepidoptera species may be tested.

Some other regions of our country are also promising for exporting phytophages. For example, extremely diverse species of plants belonging to Cynareae (Compositae)tribe occuring in the South of the European part of the U.S.S.R. and in the Southern Siberia produce an unfailing source of phytophages to be used against eurasiatic Cynareae in North America. Since I966, we have dispatched, in exchange, phytophages of weed plants from different regions of the U.S.S.R., including the Caucasus, the European part, the Central Asia, the Siberia to Canada, the U.S.A., Switzerland and some other countries.

In turn, we are especially interested in investigating consortia of American weed plants (Ambrosia, Iva, Xanthium, Cuscuta, Galinsoga, Solidago and others).

Since I969 we have introduced Tarachidia candefacta Hübn. (Noctuidae, Lep.) to Krasnodarskii and Stavropolskii areas from North America.

Long-term preliminary tests were conducted on screening Ambrosia phytophages. Great difficulties were connected with that we introduced, for the first time, alien phytophages to Europe. That's why they were tested with the particular care.

Ambrosia foci produce in Eurasia a free ecological nich which favours introducing phytophages from the native land of the weed. In Eurasia, ragweeds are not, in fact, damaged by any natural enemies (Kovalev, I97I). About ten species of sucking insects, mites and fungi transfer sometimes to ragweeds from other plants, but they never suppress significantly these weed plants.

Amongst leaf eaters, only three species of polyphagous noctuids occur sometimes on A. artemisiifolia, including Antographa confusa Steph., A. gamma L., Scotia ipsilon Hfn. But, on completing their development, the caterpillars of these species produce small-sized moths, that results undoubtedly from unsuitable food.

A. artemisiifolia is the commonest species in our country amongst three Ambrosia species (A. artemisiifolia L., A. psilostachya DC. and A. trifida L.) introduced. At present, this species occurs in the South of the U.S.S.R. from the Ukraine till the Far East with the exception of the Central Asia where it can be found only near Alma-Ata. This plant is a landscape plant in its mass distribution regionsin the Ukraine, on the Kuban and in the North Caucasus. In Krasnodarskii area, for example, all the cultivated lands are weedy in all the districts. Its distribution rates are evident as judging by its spread in the extreme South of the Soviet Far East. In 1965, it was recorded there for the first time as an uncommon species and, in five years, the plant has become a troublesome weed in the South of the Maritime Area (the Far East).

A. artemisiifolia is not only a troublesome weed plant, but it produces mass foci of human allergies.

Control of A. artemisiifolia is very difficult since the plant is widespread in all the biotopes modified with man's activity. Therefore, we consider biological control of this weed to be of particular importance.

Prior to our investigations, any attempts had not been made to apply phytophages from Ambrosia plants to biological control though ragweeds were widespread all over the world. These investigations could not be carried out without the cooperation with Canadian and American entomologists. The phytophages on Ambrosia plants were mainly collected for us in 1967/71 by the colleaques working in the Research Institute (Dr. P.Harris, Belleville, Canada), at the University of California (Dr. R.D.Goeden, Riverside) and at the Quarantine Service of the U.S.A.

The information on Ambrosia phytophages were collected by D.L.Andres, Dr. R.D.Goeden and P.Harris (1970).

From there, we obtained continuously the insects alive to be tested. We could obtain all the information available in these countries on phytophages from Ambrosia plants, while studying museum collections, published and unpublished papers, and, in such a way, an information has been collected on 270 species of insects and mites collected on Ambrosia plants, in North America (Kovalev, 1971a, 1971b).

The species of this group are, however, mainly polyphagous.

Strict oligophages were found in three insect orders, including Coleoptera, Diptera and Lepidoptera.

Coleoptera. Above 60 Coleoptera species have been collected on Ambrosia species. Leaf beetles belonging to 17 species are common enemies of ragweeds. But there are, probably, no specific Chrysomelidae species on phylogenetically young ragweeds.

31 weevil species are deeply attached to ragweeds. Smycronix stenophages may be found for biological control. But the youngest phylogenetical branch of the genus is attached to Ambrosieae. Larvae of this genus and Baris larvae are strict stenophages, tests have, however, shown that adult beetles may change their hosts.

Brachitarsus (Trigonorhinus) tomentosus Say. proves to be the most promising species, its larvae and images feed on ragweed male flowers.

Diptera. Some Diptera oligophages are not suitable for biological control because of their low harmfulness to Ambrosia plants.

Evolutionary radiation of Euaresta genus (Terphritidae)is connected with Ambrosieae. All the Euaresta species seem to develop in Ambrosia and Xanthium fruits. Tests are in progress on using E.bella Lav. to control A.artemisiifolia.

Lepidoptera. The greatest diversity of Lepidoptera feeding on Ambrosia plants makes it possible to select rather large-sized leaf eating insect species. We have conducted detailed tests of Tarachidia genus (Noctuidae). All the known host plants of this genus belong to Ambrosieae tribe. In the

South-West of North America, the origination centre of Ambrosieae tribe is situated; the most ancient Ambrosia species occur there and the greatest number of their species can be found. Here I5 Tarachidia species (out of 25 recorded) occur. Only three Tarachidia species are widespread in North America.

The distribution areas of T.candefacta and T.erastrioides Gn. coincide completely with those of their hosts, A.artemisiifolia, A.psilostachya, A. trifida.

Some tests have been conducted on host specificity of T.candefacta (Kovalev, Runeva, I970). Its specificity was tested in feeding tests including different plant genera in accordance with their taxonomic links with Ambrosieae tribe.

We consider that T.candefacta host choice is conditioned mainly with sesquiterpene lactones and, in particular, with pseudoguanolides which have been found in Ambrosia and Xanthium and are strongly different from sesquiterpenes of other Compositae.

That's why the larvae tested could feed on cocklebur leaves, but their life cycles were abnormal.

T.candefacta is one of the most promising species to be introduced to our country. In North America, T.candefacta species involves two subspecies and each of them feeds only on a single of two closely related Ambrosia species, in the South-West of the U.S.A. on A.psilostachya and in the remainder distribution area, including the South of Canada, on A.artemisiifolia. Therefore we have introduced the both subspecies to our country for controlling A.artemisiifolia and A.psilostachya. T.erastrioides is tested to control A.trifida.

According to preliminary results, the noctuid may be acclimatized till the Northern border of Ambrosia distribution area in Eurasia. The hibernation of the noctuid has been experimentally confirmed even near Leningrad, i.e. much further north than the limits of Ambrosia distribution lie.

This characteristics is of the greatest significance for acclimatizing T.candefacta on our continent. The winter resistance of pupae was assessed experimentally. Comparative assessments of the winter resistance and its fluctuation were made by electrical determination of critical supercooling points of insect body. Supercooling points of diapausing pupae are at 20--2I°C, individual pupae at -23°C. T.candefacta shows clear-cut long-day photoperiodicity. Individual diapausing pupae arise early in August and in the middle of August, 50% caterpillars diapause. The pupation associated with I00% diapausing last (third) generation takes place late in August at I4 h 20 min day length.

The optimum development time of the noctuid and the period of producing diapause have been determined while successive lots of first-instar caterpillars were released to nature each I0 days during the whole season.

A method has been developed for the mass rearing of the phytophage in a specialized rearing-cage. The phytophage is settled in nature by oviposition on napped threads stretched on metal frames. The stretched threads are similar to plant stems and their nap is like particular hairs on Ambrosia stems, that's why it stimulates oviposition. The eggs oviposited are collected together with the threads cut (Kovalev, Nayanov, I97I).

Investigations are in progress now on some other biological peculiarities of this promising phytophages.

This year, T.candefacta rearing has been difficult because of adverse effects produced with inbreeding in laboratory and insectarium. The adverse effects of inbreeding prove to arise promptly at rearing many Noctuidae species under laboratory conditions(Poitout, I969). They can be easily eliminated with introducing a new natural genetic line. When being introduced from America, each new line should, however, be tested in relation to polyhedrose virus affecting natural insect populations.

We continue screening some other phytophages of Ambrosia plants to make a complex of natural enemies in foci of the weed.

We search not only phytophagous insects and mites, but also phytophagous fungi. Preliminary tests have shown, for example, that the introduction of disease causal fungi from North America is the most promising control method against American dodders (Cuscuta sp.sp.).

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