MODERN OUTLOOKS OF BIOLOGICAL CONTROL OF WEED
PLANTS IN THE U.S.S.R. AND THE INTERNATIONAL
PHYTOPHAGOUS EXCHANGE*1)

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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 cucurbitarum Reid. to
target broomrapes and dodders. Thus, the attempts were made to use
indigenous species to control local weed crops. In 1930, Prof. A. Bogoyavlenskii
reported, in his profound paper on biological peculiarities of 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-salatic populations of Ph. orobanchia.
Any methods have not been till now developed to remove Characidia para-
sites 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 phytophages. Puparia without
parasites can, however, be obtained at growing broomrapes in a glass-
house. At present, Ph. orobanchia is introduced to thousands of hectares 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 niche, these plant
species often produce ecological explosions.
In addition, geographic peculiarities of our country, with diverse
ecliptic 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 area of weed
plants, there are histuses 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 (Arnoldia 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 Europe, the Russian knapweed populations are more competitive than
in the Central Asia and they are there the most harmful ones. We have

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introduced the nematode Paramoecia picioidia Kyr. 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. picioidia 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 monophagous Russian knapweed. The mites feed in flower heads. The flowers damaged are bud-shaped with their average sizes being 7 to 8 mm and maximum else II to 12 mm. The flower heads don’t open in the growing period. The mites feed on the inner layer of involucral 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 5 to 7 thousand of individuals, with their maximum number being 13 thousand and even more. Hibernating females can be easily transported.

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

Here, the richest faunistic complex consortia of phytophages occur feeding on Halogoron glomeratus, Salsola iberica, Chondrilla, Acrortilon 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 (spatifer), H. glomeratus).

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

Chondrilla juncea L. introduced from East Europe has been widespread 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 eastern direction from this region. Insect fauna on Chondrilla was studied in detail by Russian entomologists in the Kazakhsthan in the thirties where natural rubber plants were searched for (Emelyanova, 1935, 1938).

By the way, to obtain rubber from Chondrilla, latex burls produced by the burnow, Scehnoternera forcata Gebl., and not the plants themselves were used. The burls were collected near Ch. ambiguus roots in Kazakh deserts.

The most promising phytophages of Chondrilla can be evidently found out for introducing them to Australia and America. Therefore, in 1971 we collected S. forcata 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. forcata Gebl. (Homoptera). The evident strict oligophagous of Chondrilla. It feeds preferably on Chondrilla ambiguus Fisch., occurs also on Ch. haematocephala Lab. and rarely on Ch. brevipes Fisch. at May. As judging by the occurrence of the burnow 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 have been determined according to collections. The species seems to occur neither southwards nor eastwards from this area and may be collected only in the U.S.S.R.

2. Bradyptera silveolofla Tr. (Phyllidae, Lep.). This species replaces ecolYZg on Ch. juncea, Ch. junceol, Ch. junceolofla, Ch. junceolofla, 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 INDIA 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. Opargona eorthemistei Hol. (Sanneli Ras.) (Lep.). Caterpillars live in saliky inductive on Chondrilla roots as B. silveolofla does. The habitat area is similar to that of B. silveolofla, the insect occurs in steppes.

4. Neozanagordes chondrillae Arch. (Oxyrhopidae, Oxyrhopidae). The coxys feed on Chondrilla roots and produce burrs which are similar to those produced by S. fusca. Biological peculiarities of the species are well studied in the Kazakhstan. It is a strict oligophage of Chondrilla and occurs on Ch. brevirostris, Ch. junceolofla, Ch. junceolofla.

5. The aphid species investigated should be supplemented with two species from Chondrilla roots, namely, with Xerophilus chondrillae Nord., and Xerophilus chondrillae Nord., which were not described by Nordoiko.

6. It should be mentioned that his collections in the Zoological Institute comprise two undescribed species of probably specialised bugs belonging to different genera of Miridae fam. (Philini tribe) from the Volga valley and the Central Kazakhstan.

7. The aven of Aphanorion spinosum Zeh. (Chloridae, Dipt.) were found in Chondrilla roots in the Central Asia.

Salsola iberica Sensen et. Pau. (S. iberica 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 is 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.

1. 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 transcaucasica Toll. (*Alloclavella Toll. et Amsel) is a single moth specific to Salisola s. str. section. Its caterpillars live in stems of *Salisola Pall., Siberica, Spauladii 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 Salisola species.

Dr. J. Shaposhnikov considers that *Stathipis tenacitana Neve (a monotypic aphid species) is a specific to herbaceous Salisola species in the Central Asia.

3. Heteroptera. Dr. J. Kershner reported that *Pisma salisalae Beck, (Pismatinae) feeding on *Salisal L. and related species is a single specific bug on herbaceous species. Mass occurrence of the bug is usually observed.

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

5. Diptera. Dr. E.P. Marchuk reported that larvae of *Gannosceum longicorne Beck. and those of *Cicindeliforme Halid. (Doryphoridae) produced mines on the shoots of herbaceous Salisola in the Central Asia.

Another genus of Chamaepodidae family is Halogeron. In 1965/66, Prof. P. Markovski 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 aphidophagous 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.

The fauna of *H. glomeratus has been still poorly studied, but, at present, weevils (Bariidae) and aphids different Lepidoptera species can be tested.

Some other regions of our country are also promising for exporting phytophages. For example, extremely diverse species of plants belonging to Compositae (Compositae) tribe occurring 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 eurasian Compositae in North America. Since 1965, 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, *Eva, Xanthium, Cuscuta, Galinsoga, Solidago and others).

Since 1969 we have introduced Tarachidia candelata Hebn. (Noctuidae, Lep.) to Krasnodarstki and Stavropolaskii 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 niche which favours introducing phytophages from the native land of the weed. In Eurasia, ragweeds are not, in fact, damaged by any natural enemies (Kovalev, 1971).

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. fenni L., *Scolia ipidina Hrn. But, on completing their development, the
caterpillars of these species produce small-sized moths, that results undoubtedly from unsuitable food.

*A. artemisiaefolia* is the commonest species in our country amongst three Ambrosia species (*A. artemisiaefolia* L., *A. psilostachya* DC., and *A. trifida* L.) introduced. At present, this species occurs in the South of the U.S.S. R. 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 region in the Ukraine, on the Kuban and in the North Caucasus. In Krasnodar district, 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. artemisiaefolia* is not only a troublesome weed plant, but it produces mass food of human allergies.

Control of *A. artemisiaefolia* 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 colleagues working in the Research Institute (Fr. P. Harris, Belleville, Canada), at the University of California (Dr. R. D. Gooden, Riverside) and at the Quarantine Service of the U.S.A. The phytophages on Ambrosia plants were collected by D. L. Andrews, Dr. R. D. Gooden 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 studying museum collections, published and unpublished papers, and, in such a way, an information has been collected on 270 species of insects and sites collected on Ambrosia plants, in North America (Kovalew, 1971a, 1971b).

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

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.

19 weevil species are deeply attached to ragweeds. *Stephanitis* stenocephala may be found for biological control. But the youngest phylogenetical branch of the genus is attached to *Ambrosia*. Larvae of this genus and *Earias larvae* are strict stenocephala, tests have, however, shown that adult beetles may change their hosts.

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

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

**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 *Euphorbia* genus (*Euphorbia*). All the known host plants of this genus belong to *Ambrosia* tribe. In the
South-West of North America, the origination centre of Ambrosiinae tribe is situated. Most Ambrosia species occur there and the greatest number of their species can be found. Here 15 Tarachidia species (out of 25 recorded) occur. Only three Tarachidia species are widespread in North America.

The distribution areas of T. candefacta and T. earaefractides Gm. coincide completely with those of their hosts, A. artemisiifolia, A. pilostachya, A. trifida.

Some tests have been conducted on host specificity of T. candefacta (Kowalev, Runeva, 1970). Its specificity was tested in feeding tests including different plant genera in accordance with their taxonomic links with Ambrosia tribe.

We consider that T. candefacta host choice is conditioned mainly with sesquiterpenes lactones and, in particular, with pseudoguaniolides 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. pilostachya and in the remainder distribution area, including the South of Canada, on A. artemisiifolia. Therefore we have introduced both subspecies to our country for controlling A. artemisiifolia and A. pilostachya. T. earaefractides is tested to control A. trifida.

According to preliminary results, the noctuid may be acclimatized till the northern 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 line.

This characteristic is of the greatest significance for acclimatizing a. 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. Supercroolcing points of diapausing pupae are at -20 to -35°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 100% diapausing last (third) generation takes place late in August at 16-20 min day length.

The optimum development time of the noctuid and the period of producing diapausing have been determined while successive lots of first-instar caterpillars were released to nature each 10 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 shoots and their map is like particular hairs on Ambrosia stems. That's why it stimulates oviposition. The eggs oviposited are collected together with the threads cut (Kowalev, Baynov, 1971).

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

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 Nortiidae species under laboratory conditions (Potitou, 1969). 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 polyhedros 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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REFERENCES


