MODERN TRENDS IN THE DEVELOPMENT OF AGRICULTURAL PRODUCTION

PROBLEMS AND PERSPECTIVES

EDITED BY
S. STANKEVYCH,
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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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ENTOMOPHAGES OF SPRUCE BUD SCALE (HEMIPTERA:COCCIDAE: PHYSOKERMES) IN THE UKRAINE

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The population number of spruce bud scales within localities can be regulated by a complex of predators and parasitoids, of the predatory species, the most massive is Antribus nebulosus Forster – Anthribus nebulosus. Apart from Antribus nebulosus Forster, numerous representatives of incheumonids from the Encertidae family develop, among which representatives of the Microterys genus are most commonly spread on spruce bud scales.

In the course of our research, we have found that in spruce plantations inhabited by spruce bud scales entomophages populate females. Beyond the city limits, spruce plantations are more populated by entomophages than within the city limits. Both species of entomophages populated females in the dendrological park of Kharkiv National Agrarian University named after V.V. Dokuchaiev (49°90'N, 36°45'E) and Feldman Ecopark (50°66'N, 36°16'E). The highest inhabiting percentage of phytophages by entomophages was observed in the dendrological park of KhAU – 65 % of the examined females, of which 65 % were inhabited by Anthribus nebulosus and 45 % by Microterys lunatus. On the territory of Feldman Ecopark, 50% of the examined females were inhabited by entomophages, of which 25%

were inhabited by Anthribus nebulosus and 75% by Microterys lunatus. In the nursery garden of ornamental plants (75 Siverska St.) (49°99'N, 36°36'E), only beetles of Anthribus nebulosus were found in 55 % of the studied female specimens.

In the village of Vysoke (49°53'N, 36°07'E), Kharkiv district, in 80% of the studied females of spruce bud scales we have found only Microterys lunatus incheumonids

The lowest inhabiting percentage of phytophages by entomophages was observed in areas with severe man-caused air pollution. In the street plantations of Kharkiv Tractor Plant neighborhood (49°95'N, 36°40'E), 15 % of the studied females of spruce bud scales were inhabited by incheumonids of Microterys lunatus. Near the plant "Turboatom" (3 Energetychna St.) (49°97'N, 36°30'E) – 10 % of entomophages.

Entomophages are collected in different places of the city and region, and in laboratory conditions we have once again convinced that the number of useful insects depends on the location of spruce plantations. The more spruce trees are negatively affected by cities and people, the fewer entomophages were recorded. Our research has shown that of the two entomophage species that are most sensitive to air pollution, beetles of Anhtribus nebulosus species, their number within the city limits is minimal or completely absent.

Key words: spruce bud scales, *Physokermes,* spruce, entomophages, *Anthribus nebulosus, Microterys lunatus.*

Coniferous plantations of cities are of great aesthetic importance, and also perform important functions of air purification, saturation with phytoncides, etc. The most common coniferous plants in Kharkiv and Kharkiv region are European spruce *(Picea abies*(L.)), prickly spruce (*Picea pungens* (Engelm.)), Canadian spruce (*Picea glauca* (Moench)**)**. Street spruce plantations grow under conditions of lack of moisture and nutrient elements, high air temperature, compacted soil with poor aeration, air pollution from dust, smoke and gases (transport and industrial emissions). Plants under urban conditions are susceptible to pest attacks, among which in recent years the most dangerous are spruce bud scales (Hemiptera:Coccidae: *Physokermes*).

Route surveys conducted by us in Kharkiv and in the region in 2016-2020 revealed that 80% of spruce trees in park and street plantations and in the nursery garden (about 2000 trees were examined) are inhabited by *Physokermes piceae* Schrank, 1801 and by *Physokermes hemicryphus*

Dalman, 1826, a smaller percentage of 10% are inhabited by *Physkermes inopinatus* Danzig & Kozar, 1973.

Due to the high density of populations of spruce bud scales, their nutrition causes a slowing down in plant growth, a decrease in the accretion of the current year or its absence, a change in the colour of needles from dark green to light green or brown, defoliation and premature drying of needles. Saprophytic fungi settle on the excrement secreted by spruce bud scales. Due to the accumulation of their shoot-like products on the surface of needles, photosynthesis slows down, and the needles also overheat (Kosztarab & Kozár, 1988; Mibey, 1997; Stauffer & Rose, 1997; Melenti, 2019). Weakened spruces lose their aesthetic appearance and market value, are damaged by other insect species, are affected by pathogens (Hanson and Miller, 1984), and can even die.

The use of chemical protection in the city is prohibited, so the regulation of the pests number within localities is possible with the help of entomophages, which occupy a dominant place in the biological method of pest protection (Xu, 2002, Miller et al. 2004; Oswald 2014; Ben-Dov et al. 2015). The theoretical prerequisites of the biomethod are the introduction and acclimatization of entomophages, mass breeding and release of parasitic and predatory insects into nature, intraareal dispersal of local entomophage species, and the creation of favorable ecological conditions for improving the efficiency of local entomophages.

In many countries, much attention is paid to the study of natural enemies of phytophages: Serbia, Georgia, Turkey, Russia, Germany, Italy, and the United States (Yasnosh, 1972; Schmutterer, 1956; Sugoniaev, 1989; Dervisevic, 2019). However, in urbanized ecosystems, the active use of entomophages is practically not developed. This is primarily due to the lack of specialists in the service of urban plantation protection who are well acquainted with the ecology, biology and species composition of entomophages, as well as the lack of scientifically developed technologies and their use in urban landscaping facilities.

The use of parasitic and predatory insects is possible only on the basis of knowledge of the biological and ecological features of useful and harmful organisms, registration the complex and constantly changing interrelation between the inhabitants of biocenoses. The study of individual species and complexes of entomophages that are effective at a low number of pests is of great importance, since they are able to restrain the occurrence of mass reproduction outbreaks.

Materials and methods of research

Research methods are generally accepted. To study the species composition of entomophages, the number and biology, females of spruce bud scales were collected, entomophages were detected by dissection. Females were collected once every three days from April to May and once every five days in June, the number of females examined in one trial was 25 individuals. Species affiliation was determined using MBS-9 binoculars and determinants (Schmutterer, 1956; Kosztarab and Kozár, 1988).

Results

Entomophages are a particularly important component in urbanocenoses, where natural control is the only possible method of protection for ecological and financial reasons.

We have identified two species of entomophages of spruce bud scales – *Anhtribus nebulosus* Forster, 1770 (Coleoptera: Anthribidae) and *Microterys lunatus*, Dalman, 1820 (Hymenoptera: Chalcidoidea: Encyrtidae).

Its phenology is closely related to the life cycle of host insects – spruce bud scales. Adult beetles overwinter in protected parts of trees, or in the empty skins of spruce bud scales females. In spring, in the middle of April, beetles that have overwintered appear and additionally nourish by all stages of development of spruce bud scales (larvae, males, females) and sweet secretions of females –honey dew. Eggs are laid from early May to early June under the female's body. The larvae feed on the eggs of spruce bud scales during June – July, pupate in the female's body. Adult beetles of the new generation go to wintering in August (fig. 1). Thus, one generation is given during the year.

Females of *Anhtribus nebulosus* lay 24 to 28 eggs in the body of spruce bud scales, usually one egg per female. Embryonic development of *Anhtribus nebulosus* lasts for 2 weeks, larva that newly hatched feeds on the eggs of spruce bud scales. During its development, the larva goes through three stages (L1, L2, L3) and most often eats all the eggs of spruce bud scales, the development time of a predator is 43-49 days (Dervisevic, 2019).

As a promising entomophage of *soft scales*, *Anthribus nebulosus* was introduced in the United States at the end of the 20th century, where it was successfully acclimatized.

Fig. 1. Imago of Anhtribus nebulosus (photo by Filatov M. O.)

In most cases, one larva of *Antribus nebulosus* beetle developed in the body of females of the large spruce bud scales, in some cases 2-3 beetle larvae were found. In the case of two or more larvae development, the size of the beetles was smaller (1.5–2 times). In the small spruce bud scales, one larva of *Antribus nebulosus* always developed (fig. 2–3).

Fig. 2. Larva of *Antribus nebulosus* (photo by Filatov M. O.)

Fig. 3. Pupa of *Antribus nebulosus* (photo by Filatov M. O.)

Species of the genus Microterys are part of the taxonomic core of parasite complexes of *soft scales* of Coccidea family. Currently, 26 species of this genus are known in the Palearctic to neutralize *soft scale*s, 18 of them are endoparasites, 8 are predators on laid eggs (Sugoniaev, 1984; Triapitsyn, 1989). Despite the important role that species of the genus Microterys play in most ecosystems of the globe, including as agents of biological suppression of harmful species, information on their biology is very limited.

Incheumonid – *Microterys lunatus* Dalman. These are small insects, measuring 0.2-5 mm. The female lays eggs in the body of *soft scales*, and the larvae, like the larvae of Antribus nebulosus Forster, feed on the eggs of *soft scales* (fig. 4).

Figure 4. Imago of *Microterys lunatus* (photo by Filatov M. O.)

Species of the genus Microterys are part of the parasitoids of *soft scales*, including spruce bud scales. Most of the species of this genus are endoparasites, a small number of species are predators on laid eggs (fig. 5).

These insects play an important role as agents of biological control of harmful species, but there is little information about their biology.

Fig. 5. Larvae of *Microterys lunatus* (photo by Filatov M. O.)

The female of an incheumonid lays from one to eight eggs in each air cell in egg of *soft scales*, and several individuals of an incheumonid usually develop in one female. One larva of an incheumonid eats an average of 44 eggs of *soft scales* during its life (fig. 6).

Fig. 6. Pupa of *Microterys lunatus* (photo by Filatov M. O.)

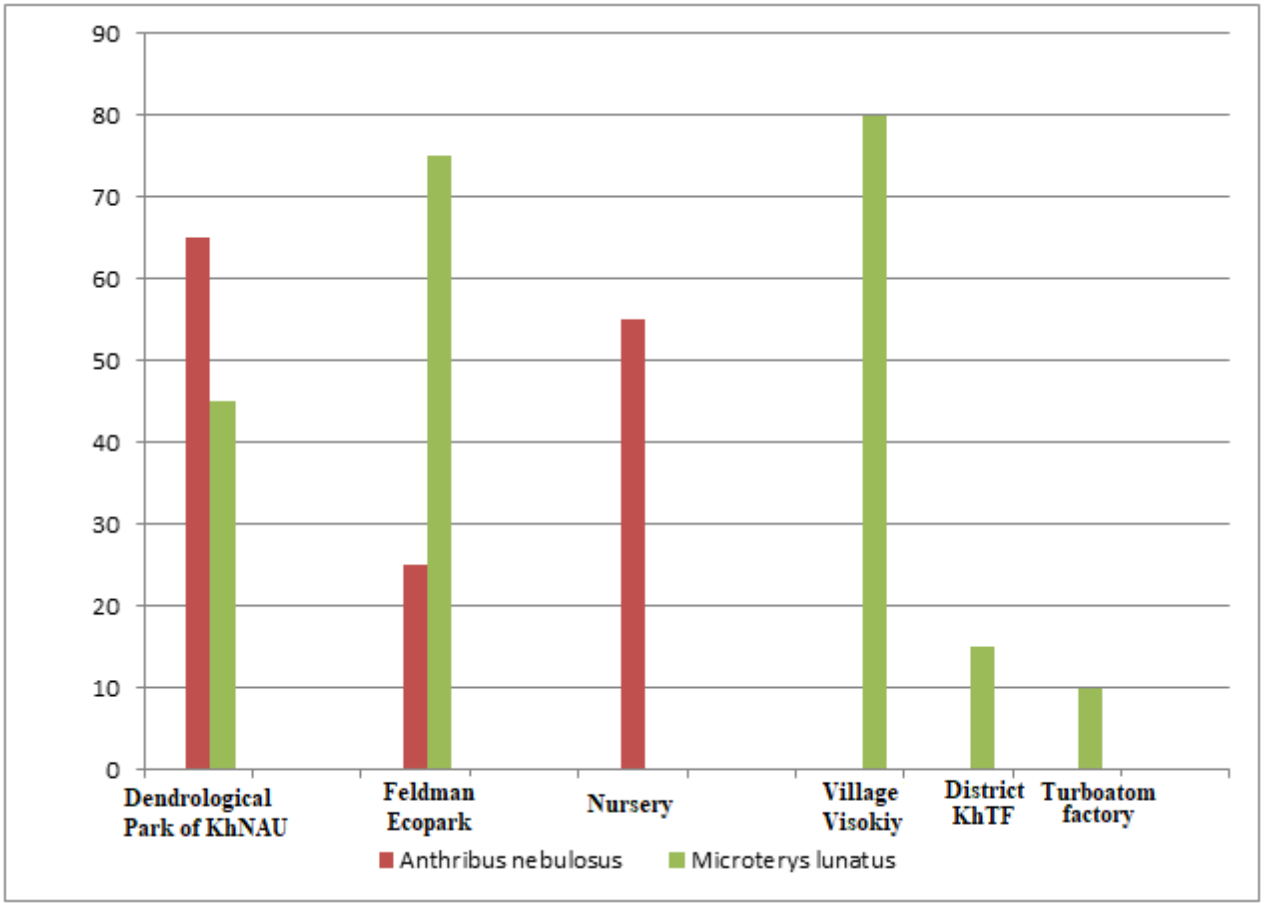

Fig. 7. The degree of inhabiting the spruce bud scales females by entomophages

Both species of entomophages inhabited females in the dendrological park of V.V.Dokuchaiev KhNAU and Feldman Ecopark. The highest percentage of phytophage inhabiting by entomophages was observed in the dendrological park of KhNAU – 65 % of the examined females, of which 65 % were inhabited by *Anthribus nebulosus* and 45 % by *Microterys lunatus* (fig. 7).

On the territory of Feldman Ecopark, 50% of the examined females were inhabited by entomophages, of which 25% were inhabited by *Anthribus nebulosus* and 75% by *Microterys lunatus* (fig. 7).

In the nursery garden of ornamental plants (75 Siverska St.), only *Anthribus nebulosus* beetles were found in 55% of the studied female specimens.

In the village of Vysoke, Kharkiv region, only incheumonids of *Microterys lunatus* were found in 80% of the studied females of the large spruce bud scales.

As our research has shown (fig. 7) the lowest percentage of inhabiting of phytophage by entomophages was observed in areas with severe man-

caused air pollution. In the street plantations on the outskirts of the Kharkiv Tractor plant, 15% of the studied females of the small spruce bud scales were inhabited by the incheumonids of *Microterys lunatus*, only in 2017 larvae of *Anhtribus nebulosus* beetles were found in the body of two females. Near the "Turboatom" plant (3 Energetychna St.) – 10% of females were also inhabited by *Microterys lunatus*, we found 2 larvae in the body of females.

Our studies have shown that of the two entomophage species, beetles of *Anhtribus nebulosus* species are the most sensitive to air pollution, their number within the city limits was minimal or they were completely absent. When creating favorable conditions: an increase in areas with flowering vegetation for incheumonids, a decrease in recreational load in park and other plantations, the location of spruce plantations remotely from highways, the number of entomophages will increase, which will allow natural regulation of the number of spruce bud scales.

Conclusions.

Spruce bud scales in Kharkiv and Kharkiv region are inhabited by two species of entomophages – *Anhtribus nebulosus* Forster, 1770 and *Microterys lunatus*, Dalman, 1820.

The degree of inhabiting varies between 10-65% in street and park plantations. A large grade of inhabiting of spruce bud scales was observed in parks, dendrological parks, the least scales inhabited spruce trees that grew along highways and street plantations. The number of useful insects depends on the location of spruce plantations. The more spruce trees are exposed to anthropogenic impacts, the fewer entomophages were recorded.

3. Our studies have shown that beetles of *Anhtribus nebulosus* species are most sensitive to air pollution of the two entomophage species, their number within the city limits is minimal or completely absent.

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