UDC 630*4:595.7(477)

© 2018 V. L. MESHKOVA

ACHIEVEMENTS AND PROBLEMS OF FOREST ENTOMOLOGY IN UKRAINE

Мєшкова, В. Л. Досягнення і проблеми лісової ентомології в Україні. *Вісті Харків. ентомол. т-ва*. 2018. Т. XXVI, вип. 1. С. 119–129.
Наведено основні результати досліджень з лісової ентомології в Україні за останні десять років. Уточнено списки шкідливих комах основних лісових порід (*Pinus sylvestris* L. і *Quercus robur* L.). Розпочато вивчення шкідників *Fraxinus* sp., *Betula* sp. та *Acer* sp. Досліджують питання сезонного розвитку місцевих і адвентивних комах, що пошкоджують лісові дерева та лісову продукцію. Приділено увагу питанням динаміки популяцій та шкідливості комах-фітофагів, їхнім асоціаціям з патогенними організмами. Підкреслено фундаментальне та практичне значення досліджень з лісової ентомології для лісового господарства. Основні завдання на найближче майбутнє включають оцінювання впливу зміни клімату на сезонний розвиток комах, їхні виживання, плодючість і шкідливість, а також балове оцінювання спроможності стовбурових комах переносити гриби, бактерій та нематод, які спричиняють відпад дерев і погіршення якості деревини. 97 назв.
Ключові слова: комахи-хвоєлистогризи, стовбурові комахи, шкідники незімкнених лісових культур, адвентивні лісові комахи, сезонний розвиток, динаміка популяцій, шкідливість, прогнозування.

Мешкова, В. Л. Достижения и проблемы лесной энтомологии в Украине. *Изв. Харьк. энтомол. о-ва*. 2018. Т. XXVI, вып. 1. С. 119–129.
Представлены основные результаты исследований по лесной энтомологии в Украине за последние десять лет. Уточнены списки вредных насекомых основных лесных пород (*Pinus sylvestris* L. и *Quercus robur* L.). Начато изучение вредителей *Fraxinus* sp., *Betula* sp. и *Acer* sp. Исследуют вопросы сезонного развития местных и адвентивных насекомых, повреждающих лесные деревья и лесную продукцию. Уделено внимание вопросам динамики популяций и вредоносности насекомых-фитофагов, их ассоциациям с патогенными организмами. Подчёркнуто фундаментальное и практическое значение исследований по лесной энтомологии для лесного хозяйства. Основные задачи на ближайшее будущее включают оценку влияния изменения климата на сезонное развитие насекомых, их выживаемость, плодовитость и вредоносность, а также балльную оценку способности стволовых насекомых переносить грибы, бактерий и нематод, вызывающих отпад деревьев и ухудшение качества древесины. 97 назв.
Ключевые слова: хвоелистогрызущие насекомые, стволовые насекомые, вредители несомкнутых лесных культур, адвентивные лесные насекомые, сезонное развитие, динамика популяций, вредоносность, прогнозирование.

Meshkova, V. L. Achievements and problems of forest entomology in Ukraine. *The Kharkov Entomol. Soc. Gaz*. 2018. Vol. XXVI, iss. 1. P. 119–129.
The main results of researches on forest entomology in Ukraine for last ten years are presented. Insect pest lists were clarified for the main forest species (*Pinus sylvestris* L. and *Quercus robur* L.). Such study of *Fraxinus* sp., *Betula* sp., and *Acer* sp. pests is started. Issues of seasonal development of native and adventive insects damaging forest trees or forest production were studied. Attention is paid to population dynamics and injuriousness of phytophagous insects, their associations with pathogenic organisms. Fundamental and practical meaning of researches on forest entomology for forest management is underlined. The main tasks for near future include evaluation of climate change influence on forest insects' seasonal development, their survival, fertility and injuriousness, as well as scoring of stem insects' ability to vector fungi, bacteria, and nematodes that cause tree mortality and decrease of timber quality. 97 refs.
Keywords: foliage browsing insects, stem insects, pests of unclosed plantations, adventive forest insects, seasonal development, population dynamics, injuriousness, prediction.

I n t r o d u c t i o n . Rich in a variety of habitats and species composition, forest ecosystems attracted the attention of classical entomologists. At the same time, forest entomology has developed as an applied science due to the need of forest and forest products protection. After the invention of effective insecticides, the main focus of research over the decades has been directed to improvement the technology of forest treatment with insecticides. However, it became clear that such 'forest protection' is dangerous for non-targeted organisms, whereas target species increase population number and resistance to poisons. Untimely use of insecticides (both within the season and the cycle of pest population gradation) leads to outbreak prolongation. Therefore, in the forest entomology of the last decades, an important place belongs to researches of the spatial and temporal dynamics of forest insect populations, their seasonal development, regional peculiarities of biology, interactions with host plants, insect competitors, entomophages, and pathogens, particularly fungi. Thorough examination of these issues shows that forest damage by insects is often considerably less than by human activity, including forest management. Therefore, forest entomologists suggested a number of modifications into recommendations on different issues of forest management which makes it possible to reduce losses, particularly from insects. The main cases where it makes sense to use pesticides include: protection of cones and seeds in seed orchards,

Meshkova V. L. Ukrainian Research Institute of Forestry and Forest Melioration named after G. M. Vysotsky,
86, Pushkinska St., Kharkiv, 61024, UKRAINE; e-mail: valentynameshkova@gmail.com

Received 01.06.2018 **Accepted 15.06.2018 by Dr. Yu. O. Guglya** **Published 26.06.2018**

seedlings in nurseries and green houses, unclosed pine plantations, felled timber, and in exceptional cases the forests themselves. As the production of forest is not only timber, but also mushrooms and berries, the issues of its protection, especially in special plantations, can also be attributed to the prerogative of forest entomology.

Therefore, applied forest entomologists pay the main attention to insects of such trophic groups:

– phytophages because of threat to forest and forest production;

– mycetophages because of threat to edible cultivated fungi;

– entomophages as the agents of forest protection;

– detritophages, necrophages, and coprophagous insects in the frame of nature protective activity.

Decision making about forest management or forest protection is based on study not only insect species composition but also the timing of tree damage during the season, population dynamics (outbreak severity, frequency and duration), prediction of insect spread and harm considering climate, microclimate and weather, forest site conditions, age, density and tree composition.

The history of forest entomology in Ukraine was repeatedly highlighted in publications (Meshkova, 1998, 2008, 2014, 2016).

The aim of this paper is a review of researches on fundamental and practical issues of forest entomology and definition of tasks for further investigation.

Materials and methods. Presented review is based on publications of Ukrainian researchers on forest entomology, mainly for the last 10 years (2009–2018).

Results and discussion. ***Species composition of forest insects*** is usually studied by specialists for individual taxonomic groups, particularly longhorn beetles — Coleoptera: Cerambycidae (Bartenev, 2009), bark beetles — Coleoptera: Curculionidae: Scolytinae (Nikulina, 2014; Terekhova, Salnitskaya, 2014), jewel beetles — Coleoptera: Buprestidae (Prokhorov, 2014).

Forest entomologists consider complexes of insect species associated with individual forest tree species (pine, oak, ash, birch), individual parts of trees (foliage, branches, stems, roots) or forest age (particularly, unclosed plantations, mature stands etc.).

This way, in clear-cuts of fresh maple-lime oak stands stem insects in the East part of Forest Steppe of Ukraine 35 insect species from 6 families were found (Kukina, 2011).

In pine stands of Low Dnieper region, 199 insect species (84 phytophagous and 64 entomophagous), including 4 species new for region, were found. Peculiarities of bioecology and phenology of 5 foliage browsing species and 24 stem species were studied (Nazarenko, 2012).

In pine stands of Kyiv and Chernihiv Polissya and also in Transtyasmin region (Forest-Steppe), 11 species of pine sawflies from 5 genera and 2 families (Pamphiliidae and Diprionidae) were identified. Among these species, *Acantholyda* sp. (*Acantholyda erythrocephala* (Linnaeus, 1758), *A. posticalis* (Matsumura, 1912), *A. hieroglyphica* (Christ, 1791)), *Diprion pini* (Linnaeus, 1758), and *Neodiprion sertifer* (Geoffroy, 1785) are rather well known. There is not enough data on *Macrodiprion nemoralis* (Enslin, 1917), *Diprion similis* (Hartig, 1834), and four *Gilpinia* spp. (*G. frutetorum* (Fabricius, 1793), *G. virens* (Klug, 1812), *G. variegata* (Hartig, 1834), and *G. laricis* (Jurine, 1807)). *G. frutetorum* amounted up to 90% in collections. Keys for pine sawflies identification by cocoons and larvae inside (eonymphs), by larvae during feeding and by egg clusters were developed (Skrylnik et al., 2014). Biological peculiarities were specified for injurious species, particularly Lepidoptera: *Dendrolimus pini* (Linnaeus, 1758), *Sphinx pinastri* Linnaeus, 1758, *Panolis flammea* (Denis et Schiffermuller, 1775), *Bupalus piniaria* (Linnaeus, 1758) and Hymenoptera: *Diprion pini*, *Acantholyda hieroglyphica*, *A. erythrocephala*, *A. posticalis*, *G. frutetorum*, and *Gilpinia virens* (Kukina, 2014).

Spread of 53 stem insect pests from 34 genera of 3 families of order Coleoptera were studied in trees of different health condition, woody debris and harvested wood in the pine stands of the Left-bank Forest Steppe of Ukraine (Skrylnik, 2015). In the pine stands of the North-Eastern Steppe of Ukraine 25 stem insects from 21 genera were identified (Kochetova, 2017).

In stands of silver birch of Kharkiv Region, 12 species of stem insects from two orders (Hymenoptera and Coleoptera) were identified. Among them 3 species are common, 1 species is usual, 5 species are rare, and 3 species are sporadic. The most of these species colonize predominantly greatly weakened trees. *Tremex fuscicornis* (Fabricius, 1787), *Agrilus viridis* Linnaeus, 1758, *Xylotrechus rusticus* (Linnaeus, 1758), and bark beetles (Scolytinae) can colonize healthy and weakened birch trees at high population density. In recently died trees, 9 species of stem insects were found, and two of them (*Agrilus viridis* and *Xyleborinus saxeseni* (Ratzeburg, 1837)) complete their development in such trees. The most of insects (10 species) colonize wood production and coarse debris (stem segments). Buprestids and occasionally longhorn beetles colonize fine wood debris (segments of branches). Birch stumps are colonized by *Dicerca furcata* (Thunberg, 1787), *Dicerca alni* (Fischer, 1824), occasionally by *Xiphydria longicollis* (Geoffroy, 1785), *Xylotrechus rusticus* (Linnaeus, 1758), *Aegomorphus clavipes* (Schrank, 1781) (Skrylnik, Koshelyaeva, 2015). Later this list was increased to 22 species

from three orders (Hymenoptera, Coleoptera, and Lepidoptera), and biological peculiarities of some species were studied (Koshelyaeva, Skrylnik, 2017).

The list of foliage browsing insects in ash (*Fraxinus* sp.) was clarified (Davydenko, Meshkova, 2017; Meshkova, Borysova, 2017). Black sawfly (*Tomostethus nigritus (*Fabricius, 1804)) was the most spread and caused severe defoliation in some years (Meshkova et al., 2013a, 2017e; Zinchenko, Kukina, 2015).

Recently, the habitats of some insects shifted in result of climate change and anthropogenic influence. Such insects are adventive in new sites and often play noticeable negative part in ecosystems, because they compete with native species. Some of them get to new regions with host plants. In this way the spruce (*Picea abies* (L.) in the east of Ukraine now is greatly infested by pests from western regions, particularly by soft scale insects — *Physokermes hemicryphus* (Dalman, 1826) and *Physokermes piceae* (Schrank, 1801) (Homoptera: Coccidae) (Melenti et al., 2017), *Ips typographus*, (Linnaeus, 1758) *I. duplicatus* (Sahlberg, 1836), *Monochamus sartor* (Fabricius, 1787) (Meshkova et al., 2014a, b).

The initial range of zigzag elm sawfly *Aproceros leucopoda* Takeuchi, 1939 (Hymenoptera) covers Japan, the east of China, the Korean Peninsula, and the Russian Far East. It was found in Luhansk Region in 2006, and its first outbreak was registered in artificial plantations of Siberian elm (*Ulmus pumila*) in Donetsk Region and Zaporizhzhia Region in 2014 (Martynov, Nikulina, 2015).

Biological and ecological peculiarities of *Anisandrus maiche* Stark, 1936 (Coleoptera: Curculionidae: Scolytinae) in Ukraine were studied (Terekhova, Skrylnik, 2012). This species from a Far Eastern fauna was first found in Ukraine in 2007. Its host plants are *Quercus borealis* Michx., *Quercus robur* L., and *Populus tremula* L.

The North American intruder *Leptoglossus occidentalis* Heidemann 1910 (Heteroptera: Coreidae) was found in different regions of Ukraine (Putshkov et al., 2012).

Ash weevil *Stereonychus fraxini* (De Geer, 1775) (Coleoptera: Curculionidae) is common in the southern regions of Europe, especially in Italy, Romania, and Moldova. In 2016–2018 it rather intensively damaged ash foliage in some forest plots in Kharkiv Region (Meshkova, Borysova, 2017).

Horse chestnut leaf miner *Cameraria ohridella* Deschka et Dimic, 1986, lime leaf miner *Phyllonorycter issikii* (Kumata, 1963), black locust leaf miners *Parectopa robiniella* Clemens, 1863 and *Macrosaccus robiniella* (Clemens, 1859), and plane leaf miner *Phyllonorycter platani* (Staudinger, 1870) have spread in forests and rural stands of Ukraine (Meshkova et al., 2014b).

However, insect identification is not enough for forest entomologists. Their main task is to determine the role of insects in the forest, to recognize if they are able to achieve high population density, to damage and to kill trees. For this purpose, the biological peculiarities of insect species in different regions are clarified. The dates of seasonal development, the places of possible aggregation are recognized, which is necessary for surveillance, assessment and prediction of insect seasonal development, trends in population dynamics, and threat for forest or forest products.

Foliage browsing insects. Researchers and practical foresters pay the greatest attention to the foliage browsing insects. On the one hand, damaged crowns in a large area attract the attention of public and regulatory authorities, and on the other hand, foliage browsing insects can be seen and assessed for the most part of their life cycle.

The lists of harmful insects have been specified for pine and oak forests, which are about 33% and 24% of all forest covered area (http://dklg.kmu.gov.ua). Such lists for other host trees are formed. The methods for survey, assessment and prediction have been developed for many of them.

Insect pests of oak in the field protective forest belts were studied (Bajdyk, Berezhnenko, 2013) as well as their trophic relations in the Left-bank Forest Steppe of Ukraine (Berezhnenko, 2014). Efficiency of insecticide treatment against ash sawfly in the field protective forest shelter belts was evaluated (Berezhnenko, 2015).

It was shown that the lists of most spread foliage browsing insects are very similar in different regions. Mean duration of their outbreaks is from three to seven years and increases from western to eastern and southern regions of Ukraine.

Phenological theory of foliage browsing insects' population dynamics is the fundamental result of the research on forest entomology. This theory makes it possible to explain the causes of differences in severity, frequency and duration of outbreaks. These causes are connected with insect seasonal development, the correspondence of dates and rates of air and soil temperature, the development of host plants and foliage browsing insects (Meshkova, 2009b, 2018).

A score for certain forest plots attractiveness for the most common foliage browsing insects was developed and tested. Such approach gives the possibility to predict the level of crown damage in separate forest subcompartments using forest inventory data, to build thematic maps of threat level, to evaluate potential focus area and its change with the change of forest age, relative density of stocking, tree species composition. An approach was implemented in Polissya (Andreieva, 2009, 2014), Forest-Steppe (Meshkova, 2009b), and Steppe

(Nazarenko, 2012; Meshkova, Kolyenkina, 2016). The lists of forest plots, where first-priority survey of pine sawflies (*Diprion pini* and *N. sertifer*) must be carried out, were compiled for respective forest enterprises.

Taking into account the changes in forest age structure, potential foci area was evaluated up to 2045 in Low Dnieper region (Meshkova, Nazarenko, 2011b). Change of forest stocking density was considered in Zhytomyr Region (Andreieva, Martynchuk, 2017). In Luhansk Region predictive algorithm for pine sawflies was clarified considering change of forest age, relative density of stocking, pine proportion in stand composition and land category of neighboring subcompartments (Meshkova, Borysenko, 2017b). The risk of pine sawflies spread increased in the case of relative density of stocking decrease and increase of subcompartment number which border with clear-cuts, burnt area or unclosed plantations.

In pine stands of Low Dnieper region, population dynamics of main pests of pine stands was analyzed by severity, incidence (probability), outbreak duration and intervals between them (Nazarenko, 2012; Meshkova et al., 2017c).

Outbreak severity was calculated as mean annual area and specific area of foci in the forest fund of mentioned forest enterprises. Specific foci area was evaluated as ratio of absolute foci area (in hectares) and pine stands area in the forest fund of mentioned enterprises (in thousand hectares) (Meshkova, 2002). Outbreak incidence (probability) in the forest fund of certain forest enterprises was calculated as the ratio of the number of outbreak years and duration of investigated period in years (in %) (Meshkova, 2009). Mean interval between outbreaks (years) was calculated as the ratio of investigated period and the number of outbreaks during this period.

Evaluation of the mean score of stand threat from given pest damage was suggested, which gives the possibility to compare outbreak dynamics in the forest fund of different forest enterprises not taking into account the absolute values of foci area (Meshkova et al., 2017c).

It was shown that severity, frequency and duration of outbreaks of pine sawflies have increased as compared with previous decades in many regions (Andreieva, 2014; Meshkova, Davydenko, 2011; Meshkova, Kolyenkina, 2016).

However, similar insect population number can cause different defoliation of trees, and similar defoliation can be or not to be the cause of tree mortality. These relations depend on ecological conditions, initial defoliation, and health condition of the tree (Meshkova, 2013). For separate cases of forest site conditions respective probability of pine mortality was evaluated (Kolenkina, 2014; Meshkova, Kolyenkina, 2016). Peculiarities of renewal of radial increment of trees in the foci of pine sawflies are investigated depending on stand age, growth class of trees, and defoliation level (Koval, Andreieva, 2009).

In the 'Standards of the quantitative indicators of the harmful insects impact pine and oak health condition in the plain part of Ukraine and mountainous Crimea' (2014, compilers V. L. Meshkova, S. G. Gamajunova, L. V. Novak, I. M. Koval, O. M. Kukina, S. V. Nazarenko, Yu. Ye. Skrylnik, I. M. Sokolova, O. V. Zinchenko, M. S. Kolyenkina, I. V. Porokhnyach, I. O. Bobrov, K. V. Davydenko, T. V. Kucheryavenko, S. O. Eroshenko, A. I. Aristova, Zh. I. Berezhnenko, L. M. Koval) critical population density was evaluated for 18 pine pests and 13 oak pests considering foliage phytomass in stands and initial health condition (for Polissya, Forest Steppe, Low Dnieper region, and Crimea). Similar tables were calculated for ash stands (Meshkova et al., 2015a, c).

Use of insecticides against foliage browsing insects remains the main way of their suppression.

Entomopathogenic viruses are known to play important role in population dynamics of forest insects (Meshkova, 2010). In Ukraine, three viral preparations are used for forest protection. They are Virin-NSH to control *Lymantria dispar* (Linnaeus, 1758), Virin-ZSP to control *Diprion pini* and Virin-RSP to control *N. sertifer*. However, this control measure is not always successful. It depends on insect biology and seasonal development, phase of insect outbreak, dates of treatment and weather conditions. In favorable conditions, epizooty develops in several stages and viral infection disseminates in the forest. Virus application is the less effective in years of intensive population growth. After treatment in a year of culmination, the development of outbreak shifts one year later but its amplitude is lower than in the control plots. Treatment with virus in a year after culmination of outbreak provides outbreak collapse two years earlier than in the control plots (Meshkova, 2010).

Weather conditions and *N. sertifer* phenology was analyzed in the Low Dnieper region. It was proved that the treatment of pine stands with virus preparation against *N. sertifer* larvae must be carried out after the date of stable transition of air temperature over 10 ºC (flowering of pine, apricot, oak, blackthorn, dandelion, Norway maple are phenological indicators). Treatment of stands in the 2nd and 3rd decades of May is risky, and in the 1st decade of June is unreasonable (Meshkova, Nazarenko, 2011a).

Usually only larvae of Lepidoptera and Hymenoptera are considered as foliage pests which are able to cyclic population dynamics. However, in some years Chrysomelidae and Curculionidae (Coleoptera) increase their populations and cause high foliage damage.

Peculiarities of seasonal development of *Chrysomela populi* Linnaeus, 1758, *Ch. tremulae* Fabricius, 1787, *Xanthogaleruca luteola* (Muller, 1766), *Agelastica alni* (Linnaeus, 1758), and *Altica quercetorum* Foudras, 1860 were investigated. All stages of *Altica quercetorum* were found the most early, and all stages of *Agelastica* were found the latest (Meshkova et al., 2016).

Among foliage pests the role of leaf miners increases in last decades (Meshkova, Mikulina, 2009, 2011, 2012a, b, 2013; Meshkova, Nazarenko, 2012). In green stands of Kharkiv Region peculiarities of biology and space and temporal dynamics of horse chestnut, lime and black locust miners are investigated. Relations between foliage damage and insect population density are evaluated. Influence of foliage damage by horse chestnut miner on radial increment of wood and generative organs of horse chestnut is evaluated numerically (Koval, Mikulina, 2012). Some species of *Aesculus* L., *Tilia* L., and *Robinia* L. were relatively resistant to horse chestnut, lime and black locust miners (Meshkova et al., 2013b). Fourteen eulophid parasitoids are found, particularly 5 from horse chestnut miner, 9 from lime miner, and 6 from black locust miners. Methods of assessment and foliage protection are developed taking into account peculiarities of seasonal development and spatial distribution of insects-leaf miners. Technical and economical effectiveness of insecticide treatment against horse chestnut miners are evaluated (Mikulina, 2012).

Insect pests in unclosed plantations. Pine plantations are artificial ecosystems, where forest environment only begins to form, and therefore plants are vulnerable to any damage or infection. All parts of transplants (seedlings) can be damaged by insects. For last decades, several recommendations were development for such stands protection from insects, especially 'Recommendations on forest plantations protection from root pests', 'Recommendations on forest plantations inspection on insect pests' (2008). 'Recommendations on assessment of pest influence on forest plantations condition in burnt area' (2014, compilers V. L. Meshkova, O. M. Kukina, S. V. Nazarenko, Yu. Ye. Skrylnik, I. M. Sokolova, O. V. Zinchenko, M. S. Kolyenkina, I. V. Porokhnyach, I. O. Bobrov, K. V. Davydenko, T. V. Kucheryavenko, S. O. Eroshenko, A. I. Aristova, L. M. Koval) include general characteristics of insects and pathogens in unclosed pine plantations, description of symptoms and signs of foliage, buds, shoots, branches, stem and root damage, the principles of damage assessment, and respective examples.

Seasonal development of *Acantholyda hieroglyphica* in unclosed pine plantations was studied (Koval, 2016). The dates of swarming of the small banded pine weevil *Pissodes castaneus* (De Geer, 1775) (Coleoptera: Curculionidae) were clarified (Meshkova, Eroshenko, 2015).

In pine forests in Siverskiy Donets River valley, 10 species of stem insects which damage unclosed pine plantations were revealed. Large pine weevil *Hylobius abietis* (Linnaeus 1758) and bark beetles *Hylastes ater* (Paykull, 1800), *Hylastes opacus* Erichson, 1836, *Hylastes angustatus* (Herbst, 1793), and *Hylurgus ligniperda* (Fabricius, 1787) are the most spread and dangerous of them. Biological and ecological peculiarities of these species have been studied (Sokolova, 2012, 2016).

Existent methods of assessment have been perfected and the new ones have been developed. Parameters of spread and injuriousness of stem insects of unclosed Scots pine plantations were considered depending on forest site conditions (Meshkova et al., 2015d). Rating system has been developed to predict the threat of these insects for pine plantations of different forest enterprises of the region. The methods of unclosed plantations protection from stem pests and the dates of treatment have been substantiated. Effectiveness of such treatment has been evaluated (Meshkova, Sokolova, 2017).

Mentioned large pine weevil and bark beetles can also damage natural regeneration of pine, but they are more dangerous in plantations which usually cover several hectares with plants of single species and age. These insects are attracted to clear-cuts and infest the stumps and wood debris, and then the adults of new generation damage transplants during maturation feeding. Some specimens of these species hibernate as larvae and other as adults. Therefore, there are several phenological groups during the season. For example *H. ater* can develop in any of five patterns: mother generation that hibernates in adult stage (1) and in larval stage (2); daughter generation, that is the progeny of the first group (two generations per season: the main (3) and sister brood (4)), and the progeny of the second group (one generation per season (5)). The most threat from this pest to transplants reveals from the beginning of vegetation period to the end of June, and less one in the second part of summer and up to October (Meshkova, Sokolova, 2017).

Stem pests. Stem pests of living trees include sucking insects (mainly Homoptera and Heteroptera) and bark and wood boring insects (mainly Scolytinae, Buprestidae, Cerambycidae). They can cause tree mortality and therefore they are physiological pests. Stem pests of felled or windthrown trees destroy timber and are useful for forest and harmful for forest management, because the timber loses quality and price.

Economical aspects of in time felling of pine trees colonized by stem pests were studied in Polissya. The spread of stem pests and blue-stain fungi in harvested pines was analyzed monthly, particularly in the upper,

middle and lower parts of trees. It has been calculated that the cost of timber of felled trees reduced after two seasons by a factor of 2.42, or by 142.1 % (Andreieva, Martynchuk, 2018).

Sucking pests are dangerous for young trees and weakened mature trees.

Single-species pine plantations in large area are vulnerable for specific pests like pine weevils (Sokolova, 2016) and later for pine bark bug *Aradus cinnamomeus* Panzer 1806 (Heteroptera: Aradidae).

Detailed study of pine bark bug in Novgorod-Siverske Polissya (Bobrov, 2016; Meshkova, Bobrov, 2011, 2012, 2018) show, that this insect has two-year life cycle in the region. Odd-year population of pine bark bug dominated in all investigated stands, although the specimens of even and odd generation can be found each year. Peculiarities of seasonal development of pine bark bug, parameters of its spread and injuriousness in pure pine and mixed pine and birch stands were investigated, particularly in the complex foci with other insect pests. Numerical score was suggested for prediction of pine bark bug spread and area of potential focus considering forest site conditions and stand age. Measures on prevention of spread of pine bark bug foci and stand protection have been developed, including optimal time of early thinning, enrichment of forest litter with foliage of different trees, fertilizing, treatment with insecticides and fungal preparation Boverin.

The role of pine bark bug decreases with stand age, and bark beetles' role increases. They usually infest dying out parts of tree (particularly lower branches), but sometimes increase their population in the stands weakened by unfavorable environmental conditions or catastrophic phenomena (fire, windstorm). As the most part of forest stands is planted, human activity becomes the most important cause of tree weakening (Meshkova, 2009a).

Researches on forest management influence on the spread of stem pests (Meshkova et al., 2009) resulted in development of several recommendations, particularly 'Methodical recommendations for the survey of forest stem pest foci' (2011, compilers V. L. Meshkova, S. G. Gamajunova, L. V. Novak, O. M. Kukina, S. V. Nazarenko, Yu. Ye. Skrylnik, I. M. Sokolova, M. S. Kolyenkina, G. M. Galiv, K. V. Davydenko, V. I. Kucheryavenko, V. V. Chudak, I. V. Malitsky), a supplement to 'Sanitary rules of Ukraine', and other recommendations, with a special emphasis on timing of thinning and clear felling considering the possibility of stem insects spread.

Stem pests of deciduous stands were studied with an emphasis on English oak (*Quercus robur* L.) (Kukina, 2011, 2013). Numerical score is given to physiological and technical injuriousness of these species. Biological peculiarities of the most abundant species (Meshkova, Kukina, 2011) and dependence of their distribution, survival and rate of development from temperature and relative humidity of colonized substrate have been investigated. Dynamics of health condition of trees on the border of clear-cut after felling in different seasons as well as their colonization by oak borer (*Agrilus biguttatus* (Fabricius, 1776)) have been analyzed. Population indices of *Scolytus intricatus* (Ratzeburg, 1837) (Coleoptera: Scolytidae) at colonization of coarse woody debris were estimated (Meshkova, Kukina, 2010). The threat of spread of oak borer was predicted in the stands near the border of clear-cuts (Meshkova, Kukina, 2013). Methodical approaches to investigation of stem pests' biology and models for prediction of their seasonal development have been developed. Measures to minimize injury from stem pests in the oak clear-cuts are suggested (Meshkova, Kukina, 2011).

In pine stands of different regions of Ukraine the same species are the most abundant and spread (Zinchenko, 2014; Skrylnik, 2015; Andreieva, 2016; Kochetova, 2017). *Tomicus piniperda* (Linnaeus, 1758), *T. minor* (Hartig, 1834), *Ips sexdentatus* (Borner, 1776), *I. acuminatus* (Gyllenhal, 1827), *Acanthocinus aedilis* (Linnaeus, 1758), *Monochamus galloprovincialis* (Olivier, 1795) infest both standing and felled (trap) trees, and *Phaenops cyaneus* (Fabricius, 1775) was found mainly in standing trees.

Biological peculiarities of these insects have been studied (Meshkova et al., 2012; Aristova, 2014; Kochetova, 2017).

T. piniperda dominates in the focus of root rot, *I. sexdentatus* and *T. minor* in fire damaged stands and *T. minor* in the foci of foliage browsing insects. It was proved that dynamics of maturating feeding of pine shoot bark beetles depends both on the cause of stand weakening and on category of tree health condition (Zinchenko, 2014). Peculiarities of colonization of living and felled (trap) trees of different categories of health condition by stem pests, distribution of pine trees by health condition and mortality were determined for pine stands, weakened by ground fire, in the foci of foliage browsing insects and root rot (Meshkova, Zinchenko, 2013). Algorithms for prediction the threat of trees colonization and mortality in stands damaged by fire, root rot, and foliage browsing insects, have been developed. Methods of trap trees use in the pine stands are improved (Zinchenko, 2014; Kochetova, 2017).

Numerical score of physiological, technical and general injuriousness was evaluated for 53 stem pests of Scots pine taking into account their ability to colonize viable trees, to damage them during maturating feeding, to vector the pathogens and to decrease timber quality. *M. galloprovincialis* appeared to be the most injurious pest (Skrylnik, 2013b, 2015). Numerical score of pine stem pests injuriousness was adopted for the North-Eastern

Steppe of Ukraine considering into account their occurrence and compared with similar scale for the Left-bank Forest-Steppe (Kochetova, 2017). It was shown, that injuriousness of stem pests varies in different regions, in living and felled trees. Physiological injuriousness of *M. galloprovincialis* can be scored as 4–15 points, of *I. sexdentatus* and *I. acuminatus* as 4–5 points. Depending on preferences to colonize the different parts of stem, technical injuriousness of *M. galloprovincialis* is 12–13.8 points, of *I. sexdentatus* 3.9–4.5 points, and of *I. acuminatus* 2.8–3.6 points. By general injuriousness, adjusted for insect occurrence, *I. acuminatus* can be low or moderately harmful in Kharkiv Region and non-harmful or low harmful in Luhansk Region. *I. sexdentatus* can be moderately harmful in Kharkiv Region and non-harmful or low harmful in Luhansk Region (Meshkova, 2017).

Stem pests' injuriousness increases because of their association with pathogens, particularly with fungi (Davydenko, Meshkova, 2012; Meshkova, Davydenko, 2012) or nematodes (Davydenko et al., 2015). Due to internship in the Department of Forest Pathology of the Swedish Agriculture University, fungi associated with *H. ligniperda* (Coleoptera: Curculionidae) (Davydenko et al., 2014) and *I. acuminatus* (Davydenko et al., 2017) were investigated. It was proved, that *I. acuminatus* vectors a species-rich fungal community including pathogens such as *Diplodia pinea* (Fr.) Dyko et B. Sutton and *Ophiostoma minus* (Hedgc.) Syd. et P. Syd. Pathogenicity tests showed that *O. minus* was the most virulent causing dieback in seedlings of Scots pine.

Measures of harvested timber protection from stem pests are substantiated taking into account their spread, phenology, and injuriousness.

Classification of stem pests by swarming dates was suggested consistent with phenological periodization by the dates of stable transition of air temperature over 5, 10, 15 °C and respective phenological indicators (Skrylnik, 2011, 2013a).

The dates of timber moving out from forest, slash removal, trap trees lying out and debarking, as well as insecticides treatment were determined for forest and timber protection from stem pests (Meshkova et al., 2015e; Skrylnik, 2015).

Sums of positive temperatures and duration of development were evaluated for different stages of the most abundant stem pests, especially *A. aedilis* (Meshkova et al., 2017a), *I. acuminatus*, *I. sexdentatus*, and *Orthotomicus proximus* (Eichhoff, 1867) (Meshkova et al., 2015b, 2017b), *M. galloprovincialis* (Meshkova et al., 2017d), *T. minor* and *T. piniperda* (Meshkova et al., 2015e; Kochetova, 2017). It was confirmed that most of studied stem pests develop in one generation per year. Only *I. acuminatus*, *I. sexdentatus* and *O. proximus* have two basic generations and a sister generation (Kochetova, 2017; Meshkova et al., 2017b).

In pine stands decline of recent years *I. acuminatus* is the first bark beetle to infest the trees (Meshkova, Borysenko, 2017a; Andreieva et al., 2018). This species has advantages due to multivoltine development and ability to complete development in rather thin branches of wood debris after felling. The second ability is the most pronounced in Polissya, where branches slowly lose moisture. The beetle forms 'spots' of infestation. During outbreak, 'spots' area increases and the distance between them decreases. An algorithm for forecasting the risk of bark beetles spread was developed using GIS. It considers forest site conditions, stand characteristic and neighboring subcompartments (Meshkova, Borysenko, 2017b).

The highest role in bark beetles foci spread belongs to forest species composition (single-species pine stands are infested first of all) and their age (mainly over 70 years old). Relative density of stocking is by itself a less important risk factor than its sudden decrease. In 31.1% of pine forest area, the foci formed near the border of main felling or clear sanitary felling. Due to the availability of digitized cartographic materials and forest inventory databases, the algorithms for prediction of foliage browsing insects and bark beetles foci were included into information system of forest protection. Information on pest foci dynamics is displayed in Geoportal 'Forests of Ukraine'. It will help to upgrade the accuracy of prediction, to evaluate the optimal area of survey and control measures against insect pests (Meshkova, Borysenko, 2017b).

It was shown that the best way to protect timber from stem insects is to fell trees in winter and to remove them from forest before vegetation beginning. In an exceptional case, harvested timber must be treated with insecticides (Meshkova et al., 2011), particularly with Konfidor Maxi WG, BI-58 CE, Zolon 35 CE (Kochetova, 2017).

Insecticide treatment in optimal dates is the most important in forest protection from foliage browsing insects (Meshkova, Nazarenko, 2011a), stem pests (Skrylnik, 2015), and pine bark bug (Bobrov, 2016).

These dates depend on air temperature, especially in spring. The earlier beginning of vegetation period leads to increase of the number of generations for multivoltine insects and acceleration of semivoltine insects development (Meshkova, 2009b).

The results of researches on forest entomology (not counting exclusively faunistic researches) in Ukraine of the last 10 years are presented in 10 PhD theses (O. Kukina, O. Andrejeva, S. Nazarenko, I. Mikulina, M. Kolyenkina, O. Zinchenko, Yu. Skrylnik, I. Bobrov, I. Sokolova, A. Kochetova), over 200 papers and four

monographs (Meshkova, 2009; Meshkova, Kolyenkina, 2016; Meshkova, Sokolova, 2017; Meshkova, Bobrov, 2018).

These results reflected in 'Recommendations on forest plantations protection from root pests', 'Recommendations on forest plantations inspection on insect pests' (2008), 'Methods of stem pests foci inspection' (2011), 'Quantitative parameters of foliage browsing insects influence on oak and pine condition in the plain part of Ukraine', 'Recommendations on assessment of pest influence on forest plantations condition in burnt area' (2014), 'Provisional recommendations on priority measures in pine forests damaged by bark beetles' (2017).

Since 2015 native and adventive insects damaging different forest tree species are studied, particularly in *Fraxinus excelsior* L., *Betula pendula* Roth., *Acer platanoides* L. etc. Such infestation, together with fungi and other pathogenic organisms which infest foliage, stems or roots, leads to forest decline.

'Methodological guidelines for survey, assessment and prediction of pest spread in the plain part of Ukraine' and 'Recommendations for a comprehensive forest-pathological survey of stands for the detection of new pests and their impact on forest health condition' are planned to develop in the next years and to implement into forest enterprises, quarantine, and environment protection activity.

C o n c l u s i o n s . The main issues of research on forest entomology for the last ten years included refinement of insect species composition of different host trees, biological and phenological peculiarities of native and adventive insects damaging forest trees or forest production, population dynamics and injuriousness of phytophagous species, insect associations with pathogenic organisms. The lists of pine and oak pests are quite complete, attention is paid to ash, birch, and maple pests study.

The results of research have fundamental and practical significance, because they explain and predict spatial and temporal population dynamics of forest insects and are the basis for the normative documents of the forestry sector.

Investigation of climate change influence on forest insects' seasonal development, their survival, fertility, and injuriousness remains an important task. Another important task is the scoring of stem insects' ability to vector fungi, bacteria, and nematodes, which cause tree mortality and decrease timber quality.

R E F E R E N C E S

Andreieva, O. Y. 2009. Prediction of pine sawflies foci in the forests of Central Polissya. *Scientific Herald of NULES of Ukraine. Series: Agronomy*, **132**, 135–141. [in Ukrainian].

Andreieva, O. Y. 2014. Spread of pine sawflies in the stands of Central Polissya. *Herald of Zhytomyr National Agroecological University*, **1** (41), 3, 140–145. [in Ukrainian].

Andreieva, O. Y. 2016. Stem pests in the foci of pine stands decline in Zhytomyr Forest Enterprise of Zhytomyr Region. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 3–9. [in Ukrainian].

Andreieva, O. Y., Guzii, A. I., Vyshnevskyi, A. V. 2018. Spread of bark beetles foci in pine stands of Volodymyretske Forest Enterprise. *Scientific Bulletin of UNFU*, **28**(3), 14–17. [in Ukrainian].

Andreieva, O. Y., Martynchuk, I. V. 2017. Dynamics of the threat of pine sawflies foci spread with a change of forest stocking density. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 11–17. [in Ukrainian].

Andreieva, O. Y., Martynchuk, I. V. 2018. Economical aspects of felling the trees colonized by stem pests in the pine stands of Polissya. *Scientific Bulletin of UNFU*, **28**(2), 31–36. [in Ukrainian].

Aristova, A. I. 2014. Colonization of trap trees by *Acanthocinus aedilis* (Linnaeus, 1758) in the Northern Steppe of Ukraine. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 7–14. [in Ukrainian].

Bajdyk, G. V., Berezhnenko, Zh. I. 2013. Insect pests of oak in the field protective forest belts of the training & scientific production centre 'Doslidne pole' of Kharkiv National Agrarian University named after V. V. Dokuchajev. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **10**, 22–28. [in Ukrainian].

Bartenev, A. F. 2009. *Longhorn beetles of the Left-Bank Ukraine and Crimea*. KhNU, Kharkiv, 1–418. [in Russian]. ISBN: 9789666235636.

Berezhnenko, Zh. I. 2014. Trophic relations of lepidopterous foliage browsing insects in the field protective forest belts of the Left-bank Forest Steppe of Ukraine. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 15–22. [in Ukrainian].

Berezhnenko, Zh. I. 2015. Efficiency of insecticide treatment against ash sawfly in the field protective forest shelter belts. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 17–20. [in Ukrainian].

Bobrov, I. O. 2016. *Spread and injuriousness of pine bark bug in the stands of Novgorod-Siverske Polissya*: PhD Thesis (06.03.03 — forest sciences and forestry). Kharkiv, 1–22. [in Ukrainian].

Davydenko, K., Meshkova, V. 2017. The current situation concerning severity and causes of ash dieback in Ukraine caused by *Hymenoscyphus fraxineus. In:* Vasaitis, R., Enderle, R., eds. *Dieback of European Ash (Fraxinus spp.): Consequences and Guidelines for Sustainable Management*. SLU, Uppsala, 220–227.

Davydenko, K. V., Meshkova, V. L. 2012. Methodical aspects of evaluation of pathogenic influence of Ophiostomatoid fungi, associated with bark beetles, on *Pinus sylvestris* L. seedlings. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **11**, 57–63. [in Ukrainian].

Davydenko, K. V., Skrylnik, Yu. Ye., Meshkova, V. L. 2015. Stem nematodes in declining stands of Scots pine in Volyn' Polissya. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 32–37. [in Ukrainian].

Davydenko, K., Vasaitis, R., Menkis, A. 2017. Fungi associated with *Ips acuminatus* (Coleoptera: Curculionidae) in Ukraine with a special emphasis on pathogenicity of ophiostomatoid species. *European Journal of Entomology*, **114**, 77–85.

Davydenko, K., Vasaitis, R., Meshkova, V., Menkis, A. 2014. Fungi associated with the red-haired bark beetle, *Hylurgus ligniperda* (Coleoptera: Curculionidae) in the forest-steppe zone in eastern Ukraine. *European Journal of Entomology*, **111**, 561–565.

Kochetova, A. I. 2017. *Stem pests of pine and their control in the places of timber harvesting in the stands of the North-Eastern Steppe of Ukraine*: PhD Thesis (16.00.10 — entomology). Kharkiv, 1–22 [in Ukrainian].

Kolenkina, M. S. 2014. *Spread of foci of pine sawflies in the East Ukraine and their influence on forest condition*: PhD Thesis (06.03.03 — forest sciences and forestry). Kharkiv, 1–20. [in Ukrainian].

Koshelyaeva, Y. V., Skrylnik, Yu. Ye. 2017. Biological peculiarities of *Xyleborus saxeseni* Rotz, 1837 in silver birch (*Betula pendula* Roth). *Fauna of Ukraine on the birder of 20–21 centuries. New concepts of zoological researches (Kharkiv, 12–16 September 2017).* Kharkiv, 39–40. [in Ukrainian].

Koval, I. M., Andreieva, O. Y. 2009. Influence of *Neodiprion sertifer* Geoffr. outbreak on dynamics of Scots pine radial increment in Polissya. *Forestry and Forest Melioration*, **116**, 62–69. [in Ukrainian].

Koval, I. M., Mikulina, I. M. 2012. Dendrochronological research of common horse chesnut damaged by the horse-chestnut leaf miner in Forest-Steppe zone. *Scientific Bulletin of UNFU*, **22**(10), 40–45. [in Ukrainian].

Koval, L. M., 2016. Seasonal development of *Acantholyda hieroglyphica* (Christ, 1791) (Pamphiliidae: Hymenoptera) in unclosed pine plantations. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 24–29. [in Ukrainian].

Kukina O. M. 2011. *Prediction of distribution and development of stem insect pests in the oak clear-cuts of the East part of Forest Steppe of Ukraine*: PhD Thesis (16.00.10 — entomology). Kharkiv, 1–20. [in Ukrainian].

Kukina, O. M. 2013. Peculiarities of oak trees colonization by oak bark beetle (*Scolytus intricatus* Ratzeburg, 1837; Coleoptera: Scolytidae). *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **10,** 98–103. [in Ukrainian].

Kukina, O. M. 2014. Foliage browsing insects of Chihirin pine forest. *Forestry and Forest Melioration*, **124**. 177–184.

Martynov, V. V., Nikulina, T. V. 2015. Population surge of zigzag elm sawfly (*Aproceros leucopoda* (Takeuchi, 1939): Hymenoptera: Argidae) in the Northern Cis-Azov Region. *Russian Journal of Biological Invasions*, **8**(2), 135–142.

Melenti, V. O., Lezhenina, I. P., Melenti, D. O. 2017. The use of chemical protection to limit the population of the soft scale insects — *Physokermes hemicryphus* Dalman, 1826 and *Physokermes piceae* Schrank, 1801 (Homoptera: Coccidae) on the spruce). *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 104–109. [in Ukrainian].

Meshkova, V. L. 1998. The role of Kharkov scientists in development of forest entomology. *The Kharkov Entomological Society Gazette*, **6**(2), 175–180.

Meshkova, V. L. 2002. *History and geography of foliage browsing insects outbreaks*. Maydan, Kharkiv, 1–244 (In Ukrainian).

Meshkova, V. L. 2008. Development of A. I. Ilyinsky ideas in the forest entomology of Ukraine. *Reading of the memory of Andrei Ilyinsky (VNIILM, 18 March, 2008)*. Moscow — Pushkino (2009), 18–33. [in Russian].

Meshkova, V. L., Davydenko, K. V., Kukina, O. N., Sokolova, I. M., Skrylnik, Yu. Ye. 2009. Methodological aspects of stem insects research. *News of the Saint Petersburg State Forest Technical Academy*, **187,** 201–209. [in Russian].

Meshkova, V. L., Mikulina, I. M. 2009. Spread of horse-chestnut leafminer (*Cameraria ohridella* Deschka and Dimic, 1986: Lepidoptera: Gracillariidae) in the green stands of Kharkiv Region. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **8**, 105–109. [in Ukrainian].

Meshkova, V. L. 2009a. Entomological problems in clear-cuts and fire-sites in the pine stands of Forest Steppe and Steppe of Ukraine. *Bulletin of the Moscow State University of Forest. 'Forestry Bulletin'*, **5**(68), 72–79. [in Russian].

Meshkova, V. L. 2009b. *Seasonal development of foliage browsing insects*. Novoye slovo, Kharkiv, 1–396. [in Russian]. ISBN: 9789662046694.

Meshkova, V. 2010. Natural and artificial epizooties of virus diseases of forest insects in Ukraine. *In:* Gninenko, Yu. I., Zhang Yong, eds., *Recent developments in research and application of viruses in forest health protection*. VNILLM, Pushkina-Beijing, 59–72.

Meshkova, V. L., Kukina, O. N. 2010. Population indices of *Scolytus intricatus* (Ratzeburg, 1837) (Coleoptera: Scolytidae) at colonization of coarse woody debris. *News of the Saint Petersburg State Forest Technical Academy*, **192**, 167–174. [in Russian].

Meshkova, V. L., Bobrov, I. O. 2011. Seasonal development of pine bark bug populations in the fresh poor forest site conditions. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **9**, 102–109. [in Ukrainian].

Meshkova, V., Davydenko, K. 2011. Foliage browsing insects outbreaks in Ukraine before and after global warming. *In*: Delb, H., Pontuali, S., eds. *Biotic Risks and Climate Change in Forests. Proceedings of the Working Party 7.03.10 Methodology of Forest Insect and Disease Survey in Central Europe, 10th Workshop (Freiburg, Germany, 20–23 September 2010).* FVA, Freiburg, 18–25. (Berichte Freiburger Forstliche Forschung. Bd. 89)

Meshkova, V. L., Kukina, O. M. 2011. Injuriousness of xylobionts in the oak clear-cuts in the Left-Bank Ukraine. *News of the Saint Petersburg State Forest Technical Academy*, **196**, 238–245. [in Russian].

Meshkova, V. L., Mikulina, I. M. 2011. Seasonal development of *Phyllonorycter robiniella* Clem. (Lepidoptera, Gracillariidae) in the green stands of Kharkiv. *Forestry and Forest Melioration*, **119,** 176–183. [in Ukrainian].

Meshkova, V. L., Nazarenko, S. V. 2011a. Evaluation of optimal dates of treatment of stands with viral preparation against *Neodiprion sertifer* Geoffr. in the Low Dnieper region. *Proceedings of the Forestry Academy of Sciences of Ukraine*, **9**, 143–146. [in Ukrainian].

Meshkova, V. L., Nazarenko, S. V. 2011b. Prediction of foliage browsing insects foci spread in Doslidne forestry of the Steppe branch of URIFFM. *Forest Journal*, **2**, 40–47. [in Ukrainian].

Meshkova, V. L., Skrylnik, Yu. Ye., Zinchenko, O. V. 2011. Larvae density and colonization level of pine logs by *Monochamus galloprovincialis* after treatment with insecticides. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **9**, 110–115. [in Ukrainian].

Meshkova, V. L., Bobrov, I. O. 2012. Infestation of 6–12-years old forest plantations by pine bark bug (*Aradus cinnamomeus* Panz) depending on forest site conditions and mixture scheme of tree species. *Proceedings of the Forestry Academy of Sciences of Ukraine*, **10**, 139–143. [in Ukrainian].

Meshkova, V. L., Davydenko, K. V. 2012. Ophiostomatoid fungi vectored by bark beetles *Hylastes* spp. in pine plantations of the Left-bank Ukraine. *News of the Saint Petersburg State Forest Technical Academy*, **200,** 106–113. [in Russian].

Meshkova, V. L., Mikulina, I. M. 2012a. Spatial and temporal dynamics of lime miner populations in green stands of Kharkiv Region. *Scientific Herald of NULES of Ukraine*, **171**(3), 159–166. [in Ukrainian].

Meshkova, V. L., Mikulina, I. N. 2012b. Seasonal development of invasive miner moths in green stands of Kharkov. *In: Ecological and Economical Sequences of Dendrophylic Insect Invasions: Proceeding of All-Russian Conference with International Participation. (Krasnoyarsk, 25–27 September 2012).* Krasnoyarsk, 168–171. [in Russian].

Meshkova, V. L., Nazarenko, S. V. 2012. *Phyllonorycter platani* (Staudinger, 1870) (Lepidoptera: Gracillariidae) in Kherson Region. *The Kharkov Entomological Society Gazette*, **20**(2), 63–64. [in Russian].

Meshkova, V. L., Zinchenko, O. V., Aristova, A. I. 2012. Population indices of European bark beetle (*Ips sexdentatus* Boern.) in pine stands of Lugansk Region. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **11**, 145–152. [in Ukrainian].

Meshkova, V. L. 2013. Approaches to evaluation of injuriousness of foliage browsing insects. *Ukrainian Entomological Journal*. **1**(6), 79–89. [in Ukrainian].

Meshkova, V. L., Davydenko, K. V., Berezhnenko, Zh. I. 2013a. Foliage browsing insects in ash (*Fraxinus* sp.) in green stands of Kharkiv Region. *In:* Puzik, V., ed. *Plant Protection in 21st Century: Problems and Prospects of Development: Proceedings of Internet Scientific Conference of Students, Post-graduate Students and Young Scientists.* KhNAU, Kharkiv, 71–74. [in Ukrainian].

Meshkova, V., Mikulina, I., Shatrovskaja, V. 2013b. Host specificity of some Gracilariid leafminers. *In: Recent Developments in Research and Application of Viruses in Forest Health Protection.* China Forestry Publishing House, Beijing, **1**, 13–27.

Meshkova, V. L., Kukina, O. M. 2013. Prediction of the threat of spread of oak borer (*Agrilus biguttatus* F.) in the stands near the border of clear-cuts. *Proceedings of the Forestry Academy of Sciences of Ukraine*, **14**, 157–160. [in Ukrainian].

Meshkova, V. L., Mikulina I. M. 2013. Seasonal development of horse-chestnut leafminer, *Cameraria ohridella* Deschka et Dimić, 1986 (Lepidoptera: Gracillariidae) in the green stands of Kharkiv. *The Kharkov Entomological Society Gazette*, **21**(2), 29–37.

Meshkova, V. L., Zinchenko, O. V. 2013. Colonization by stem insects the pine stands weakened by different causes. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **10**, 126–131. [in Ukrainian].

Meshkova, V. L. 2014. Advance and tasks of forest protection in Ukraine. *Herald of Volga State University of Technology. Series 'Forest Ecology. Nature Management'*, **2**(22), 5–20. [in Russian].

Meshkova, V. L., Skrylnik, Yu. Ye., Tovstukha, O. V. 2014a. Stem insect pests in wind damaged pine stands and priorities for sanitary felling. *Proceedings of the Forestry Academy of Sciences of Ukraine*, **12**, 172–176.

Meshkova, V. L., Turenko, V. P., Bajdyk, G. V. 2014b. Adventive injurious organisms in the forests of Ukraine. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 112–121. [in Ukrainian].

Meshkova, V. L., Eroshenko, S. A., 2015. Dates of swarming of the small banded pine weevil *Pissodes castaneus* (De Geer, 1775) (Coleoptera: Curculionidae) in the North-Eastern Steppe of Ukraine. *The Kharkov Entomological Society Gazette*, **23**(2), 59–63. [in Ukrainian].

Meshkova, V. L., Berezhnenko, Zh. I., Kukina, O. M. 2015a. Critical population density of foliage browsing insects in pedunculate oak (*Quercus robur*) and European ash (*Fraxinus excelsior*) in the Left-bank Forest-Steppe. *Proceedings of the Forestry Academy of Sciences of Ukraine*, **13**(1), 139–143.

Meshkova, V. L., Kochetova, A. I., Zinchenko, O. V. 2015b. Pine engraver beetle *Ips acuminatus* (Gyllenhal, 1827): Insecta: Coleoptera: Scolytinae in the North-Eastern Steppe of Ukraine. *The Kharkov Entomological Society Gazette*, **23**(2), 64–69. [in Ukrainian].

Meshkova, V. L., Kukina, O. M., Berezhnenko, Zh. I. 2015c. Prediction of severity of stand damage by winter moth in the Left-bank Forest Steppe. *Scientific Herald of NULES of Ukraine. Series 'Forestry and Ornamental Horticulture'*, **219**, 176–181. [in Ukrainian].

Meshkova, V. L., Sokolova, I. M., Koval, L. M., Kochetova, A. I., Yeroshenko, S. O. 2015d. Spread and injuriousness of stem insects in unclosed Scots pine plantations in pine forests in Siversky Donets river valley depending on forest site conditions. *Forestry and Forest Melioration*, **127**, 177–186.

Meshkova, V. L., Zinchenko, O. V., Skrylnyk, Yu. Ye., Aristova, A. I. 2015e. Timeline (or timeframe) of development of pine stem pests in the Left-bank Ukraine. *News of the Saint Petersburg State Forest Technical Academy*, **211,** 59–67. [in Russian].

Meshkova, V. 2016. Some recent results of long-term investigations in the permanent sample plots of URIFFM. *Proceedings of the Shevchenko Scientific Society. Ecological collection. Modern Problems of Forest Ecology and Biodiversity Research. In memoriam of Docent Andrij Pjasec'kij*, **46**, 33–45.

Meshkova, V. L., Bajdyk, G. V., Berezhnenko, Zh. I. 2016. Peculiarities of seasonal development of leaf beetles (Chrysomelidae) in the field protective forest belts of Kharkiv Region. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 70–78. [in Ukrainian].

Meshkova, V. L., Kolyenkina, M. S. 2016. *Mass propagation of pine sawflies in the stands of Luhansk Region*: monograph. Planeta-Print, Kharkiv, 1–180. [in Ukrainian].

Meshkova, V. L. 2017. Evaluation of harm (injuriousness) of stem insects in pine forest. *Scientific Bulletin of UNFU*, **27**(8), 101–104.

Meshkova, V. L., Borysenko, O. I. 2017a. Dynamics of pine engraver beetle-caused forest decline in Teterivske Forestry Enterprise. *Forestry and Forest Melioration*, **131**, 171–178.

Meshkova, V., Borysenko, O. 2017b. GIS-based prediction of the foliage browsing insects' outbreaks in the pine stands of the SE 'Kreminske FHE'. *Proceedings of the Forestry Academy of Sciences of Ukraine*, **15**, 112–118.

Meshkova, V. L., Borysova, V. L. 2017. Damage causes of European ash in the permanent sampling plots in Kharkiv Region. *Forestry and Forest Melioration*, **131**, 179–186.

Meshkova, V. L., Sokolova, I. M. 2017. *Stem pests of unclosed pine plantations in Siversky Donets river valley*. Planeta-Print. Kharkiv, 1–160. [in Ukrainian].

Meshkova, V. L., Kochetova, A. I., Skrylnik, Yu. Ye., Zinchenko, O. V. 2017a. Seasonal development of the timberman beetle *Acanthocinus aedilis* (Linnaeus, 1758) (Coleoptera: Cerambycidae) in the North-Eastern Steppe of Ukraine. *The Kharkov Entomological Society Gazette*, **25**(2), 40–44.

Meshkova, V. L., Kochetova, A. I., Zinchenko, O. V., Skrylnik, Yu. Ye. 2017b. Biology of multivoltine bark beetles species (Coleoptera: Scolytinae) in the North-Eastern Steppe of the Ukraine. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **1–2**, 117–124.

Meshkova, V. L., Nazarenko, S. V., Kasych, T. G. 2017c. Dynamics of European pine sawfly foci area in the stands of Low Dnieper region in 2010–2017. *Forestry and Forest Melioration*, **130**, 215–222.

Meshkova, V. L., Skrylnik, Yu. Ye., Zinchenko, O. V., Kochetova, A. I. 2017d. Seasonal development of the pine sawyer beetle (*Monochamus galloprovincialis*) in the north-eastern steppe of Ukraine. *Forestry and Forest Melioration*, **130**, 223–230.

Meshkova, V., Kukina, O., Zinchenko, O., Davydenko, K. 2017e. Three-year dynamics of common ash defoliation and crown condition in the focus of black sawfly *Tomostethus nigritus* F. (Hymenoptera: Tenthredinidae). *Baltic Forestry*, **23**(1), 303–308.

Meshkova, V. 2018. Resistance and tolerance of forest stands to insects in terms of host and forest site preferences. *In:* Gninenko, Yu. I., Zhang Yong, eds. *Recent Advances in the Researches and Application of Viruses in Forest Health Protection and Entomophages*. VNILLM, Pushkino-Beijing, 52–64.

Meshkova, V. L., Bobrov, I. O. 2018. *Pine bark bug in the stands of Novgorod-Siverske Polissya: monograph*. Planeta-Print, Kharkiv, 1–182. [in Ukrainian].

Mikulina, I. M. 2012. *Biological background of broadleaved trees protection from adventive moths-miners in green stands of Kharkov Region*: PhD Thesis (16.00.10 — entomology). Kharkiv, 1–20. [in Ukrainian].

Nazarenko, S. V. 2012. *Ecological background of prediction and control of populations of injurious pine insects in Low Dnieper region*: PhD Thesis (16.00.10 — entomology). Kharkiv, 1–20. [in Ukrainian].

Nikulina, T. V. 2014. *Bark beetles (Coleoptera: Curculionidae: Scolytinae) of South-Eastern Ukraine (fauna, geographic distribution, biological features)*: PhD Thesis (03.00.24 — entomology). Kyiv, 1–20. [in Ukrainian].

Prokhorov, O. V. 2014. *The jewel beetles (Coleoptera, Buprestidae) of the Forest-Steppe and Steppe of Ukraine*: PhD Thesis (03.00.24 — entomology). Kyiv, 1–20. [in Ukrainian].

Putshkov, P. V., Gubin, A. I., Popov, G. V., Kalesnik, V. I., Syzhko, V. V. 2012. The North American intruder *Leptoglossus occidentalis* Heidemann (Heteroptera: Coreidae) settled down in Ukraine. *Ukrainska Entomofaunistyka*, **3**(3), 1–3.

Skrylnik, Yu. Ye. 2011. Phenological peculiarities of flight of xylophagous insects of *Pinus sylvestris* L. in the Left bank Forest steppe of Ukraine. *The Kharkov Entomological Society Gazette*, **19**(1), 47–56. [in Ukrainian].

Skrylnik, Yu. Ye. 2013a. *Acanthocinus aedilis* (Linnaeus, 1758) in the pine stands of the Left-bank Ukraine. *Forestry and Forest Melioration*, **122**, 129–137. [in Ukrainian].

Skrylnik, Yu. Ye. 2013b. Injuriousness of longhorn beetles (Coleoptera, Cerambycidae) in the pine stands of the Left-Bank Ukraine. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **10,** 148–159. [in Ukrainian].

Skrylnik, Yu., Zinchenko, O., Kukina, O., Sokolova, I. 2014. Keys for determination of pine sawflies species in Kyiv and Chernihiv Polissya and Forest-Steppe of Ukraine. *Forestry and Forest Melioration*, **125**, 198–205.

Skrylnik, Yu. Ye. 2015. *Injuriousness of stem insects in the pine stands of the Left-bank Forest-Steppe of Ukraine*: PhD Thesis (06.03.03 — forest sciences and forestry). Kharkiv, 1–20. [in Ukrainian].

Skrylnik, Yu. Ye., Koshelyaeva, Ya. V. 2015. First results of study the stem insects of silver birch (*Betula pendula* Roth.) in the Kharkiv Region. *The Kharkov Entomological Society Gazette*, **23**(1), 54–58. [in Ukrainian].

Sokolova, I. M. 2012. Trophic relations of phytophagous insects of pine stands of Kharkiv Region. *The Bulletin of Kharkiv National Agrarian University. Series 'Phytopathology and Entomology'*, **11**, 104–114. [in Ukrainian].

Sokolova, I. M. 2016. *Spread and injuriousness of stem insects of unclosed Scots pine plantations in pine forests in Siversky Donets river valley*: PhD Thesis (06.03.03 — forest sciences and forestry). Kharkiv, 1–23. [in Ukrainian].

Terekhova, V. V., Salnitskaya, M. A. 2014. Annotated list of bark beetles species (Coleoptera: Curculionidae: Scolytinae) of the Forest-Steppe zone of the Left Bank Ukraine. *The Bulletin of Kharkiv National University named after V. N. Karazin. Series Biology*, **20**(1100), 180–197. [in Russian].

Terekhova, V. V., Skrylnik, Y. Y. 2012. Biological peculiarities of the alien for Europe *Anisandrus maiche* Stark (Coleoptera: Curculionidae) bark beetle in Ukraine. *Russian Journal of Biological Invasions*, **3**(2), 139–144.

Zinchenko, O. V. 2014. *Effect of stem pests on growth and condition of pine stands of the Left-Bank Forest Steppe*: PhD Thesis (06.03.03 — forest sciences and forestry). Kharkiv, 1–20. [in Ukrainian].

Zinchenko, O. V., Kukina, O. M. 2015. Some biological peculiarities of ash black sawfly *Tomostethus nigritus* Fabricius, 1804 (Hymenoptera: Tenthredinidae)**.** *The Kharkov Entomological Society Gazette*, **23**(2), 70–74.

Ukrainian Research Institute of Forestry and Forest Melioration named after G. M. Vysotskiy