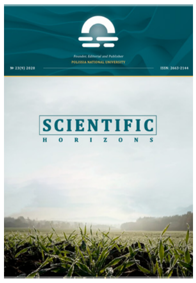
SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua

*Scientific Horizons*, 23(12), 46-57




UDC 574.476+632.7.04/.08

DOI: 10.48077/scihor.23(12).2020.46-57

# Violation of the Structure of the Forest Biocenosis Under the Action of Stem Pests and Methods of Controlling Their Numbers

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***Article's History***:

Received: 01.10.2020

Revised: 22.11.2020

Accepted: 18.12.2020

***Suggested Citation***:

Lohinova, S., & Khaietskyi, H. (2020). Violation of the structure of the forest biocenosis under the action of stem pests and methods of controlling their numbers. *Scientific Horizons*, 23(12), 46-57.

**Abstract.** The study of the forest ecosystem as an integral part of the erosion preventive system is related to a number of issues. The forest is the most powerful and effective tool in the prevention of soil erosion, droughts, and hot winds, as well as an environmental stabilising factor in general. Human forestry activities in the fight against the drying of coniferous plantations from an outbreak of mass reproduction and spread to large areas of stem pests under the influence of a complex of ecological and climatic factors, is one of the serious factors disrupting the structure of the forest biocenosis. The search for alternative solutions to the localisation of this problem requires a detailed study of the behaviour of the most common bark beetles of coniferous trees in climatic and environmental conditions that developed during 2011-2020. During the period of active temperatures in 2019, namely from the second decade of April to the third decade of October, work on stationary supervision and laboratory field work was carried out to solve the problem of localisation of stem pests of Polissya and Forest-steppe pine plantations. Methods of laying out trap trees and pheromone traps were used. In practice, the pest did not inhabit trap trees and only a few representatives in very small numbers and entomophages fell into traps. Instead, it inhabited healthy trees where the catchers were located. It was established that from the scientific and practical standpoint, the studied regularity of pine drying centres is clearly confined to highways and timber roads, as well as the area of distribution of relevant species of stem pests and weakening zones of pine stands in some areas for other reasons. It is proved that to preserve the ecological potential of coniferous plantations and reduce the negative impact of xylophagous insects, it is necessary to design preventive and biological methods of control of the main stem pests of coniferous trees

**Keywords**: entomophages, coniferous plantations, stationary supervision, pheromone monitoring, Polissya, Forest-steppe



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## INTRODUCTION

Scientists seek to solve the problem of pine engraver beetle foci on coniferous plantings, but for millions of years of its existence and constant development, nature has created its own strategies for anatomical and chemical protection [1-6] and methods of controlling to maintain the balance of its processes [1; 7-9]. People always interfere and disrupt this balance by creating artificial plantings to meet their own needs. Ecological and climatic factors [2; 3] contribute to mass reproduction and, as a result, to an increase in the population of harmful insects. For their part, coniferous plantations, weakened due to high temperatures and other important factors, are subject to destructive effects and, as a result, are a good food base for coniferous pests. Controlling stem pests of coniferous plantations is one of the important aspects of preserving their ecological potential.

During 2018, in the forest stands of the Polissya zone, namely Zhytomyr Regional Department of Forestry and Hunting (hereinafter – Zhytomyr RDFH) foci of Ips engraver beetle were found on an area of 28.8 thousand hectares. Due to the pressure of natural factors regulating the pest population (entomophage activity, improvement of climatic and hydrological conditions of common pine growth, etc.) and measures taken to improve the sanitary condition at the beginning of 2019, the area of plantings damaged by bark beetle in Zhytomyr RDFH decreased to 5.8 thousand hectares or by 7.2 times compared to 2017 [10-12].

As is shown in the analysis of mensurational characteristics of pine stands that died as a result of damage by stem pests of the bark beetle family and were eliminated by continuous sanitary cutting, high-quality pine stands of 60-120 years old that grew in fresh conditions (B2, C2) are most damaged. The general trend in age is the inability of the root system of premature and mature pine stands to transform (adapt) under changing climatic factors [10-13]. The situation that has developed with the drying of pine stands in the region can lead to such negative changes in forestry [14-17]:

– reduction of cutting volumes of developing forest stands;

– reduction of the overall density of forest stands;

– provided that the trend of drying continues, the age structure of stands will change with a further decrease in the volume of estimated felling.

The problem of mass drying of coniferous plantations caused by stem pests has a global nature [7; 18; 19]. The study of the features of damage by coniferous pests, the dynamics of their number and dissemination of species has been covered in a number of scientific publications of both Ukrainian and foreign experts in this field. In particular, by V.L. Meshkova [20], M.M. Padiy [13], M.M. Rimsky-Korsakov [21], P.A. Gaichenya [22], E.G. Mozolevska [23], B.J. Benz [21], R. Linakowski [24], E. Christiansen [25], B. Vermelinger [26], Y. Yamaoka [27], J. Muller [28], J.A. Byers [29; 30], T. Noma [31]. Foreign scientists' studies on this issue are the result of a deep study of features of the development and reproduction of stem pests on coniferous trees against the background of modern ecological and climatic changes [32].

To preserve the ecological potential of coniferous plantations and determine methods of controlling stem pests, it is necessary to study in more detail the features of populations of this group of pests, their dissemination, behaviour, and nutrition features of imago of different generations based on the results of stationary monitoring, pheromone monitoring of pests and their natural enemies.

The main objectives of this paper are:

1) study of the development features of bark beetle pest populations, their dissemination, behaviour, and nutrition features of imago of different generations;

2) pheromone monitoring analysis of pests on coniferous trees (*Ips accuminatus, Blastophagus minor, Ips sexdentatus, Ips typographus*) and their natural enemies within Polissya and Forest-steppe;

3) study of the reasons for the expansion of the harmful insects' food base;

4) design of preventive methods and methods of controlling the main stem pests of coniferous trees to preserve their ecological potential.

*The purpose of the study* is the development and scientific substantiation of strategic methods for controlling the main stem pests of coniferous trees in order to preserve their ecological potential.

## MATERIALS AND METHODS

To substantiate the features of the development of bark beetle populations, obtain objective quantitative data reflecting the state of damaged plantings and the dynamics of the pest population, methods of exploratory forest pathological examination, stationary monitoring, and detailed forest pathological examination of stem pest foci were used [33]. Ground exploratory (visual) survey is carried out along computation lines (clearances, forest roads and trails, and sometimes route lines that are set by compass in such a way as to enter all sections with the advantage of the main forest-forming species). All areas, the damage of which is reported in forestry, are also inspected, in particular: in forest management materials; in the record book of pests and diseases, in alarm sheets and the acts of their inspections which are formed by forestries, informing about the emergence of the pests and diseases foci in the forest; in the acts of surveys for the current and previous years, their results; in cartographic materials characterising the sanitary condition of plantations, the spread of pests and diseases, forest protection measures and their effectiveness; in materials of the autumn inventory. Computation lines and detected foci of pests and diseases are plotted to the duplication of the forest plantation plan. The results of the survey enter the journal of forest pathologies.

Stem pests are also divided into two phenological groups according to the time of a forest stand attack or unprotected products: spring and summer. Among the most common stem pests, the spring group includes lesser pine shoot beetle, Ips engraver beetle, six-toothed bark beetle, spruce bark beetle. The summer phenological group consists of secondary and related generations of the Ips engraver beetle, six-toothed bark beetle, spruce bark beetle. Detailed monitoring is carried out from the moment of detection of an outbreak of mass reproduction to its complete attenuation due to the death or improvement of plantings. Detailed control of stem pests is divided into two stages:

1) accounting for the condition of plantings and current pathological decline;

2) accounting for the number and state of populations of the most important harmful insects.

When determining the phase of the focus, the researchers were guided by the ratio of trees of different state categories, the amount of current pathological loss and the number of stem pests, comparing them with the same indicators inherent in a healthy forest. With detailed supervision, biological control is carried out over the development and overall survival of individual most dangerous pest species, for which data from the analysis of model trees, current surveys are used, control trap trees are laid out, or beetle catch data is evaluated with pheromone traps. Especially dangerous is the second generation of spruce bark beetle, six-toothed bark beetle, Ips engraver beetle, and others.

The use of pheromones for monitoring is advisable in the general system for detecting foci of forest stem pests and monitoring their development. Since pheromones are biologically active substances, there is a danger of provoking the emergence of new foci. They should be used strictly in accordance with the instructions, recommendations of manuals, and under the strict control of the Forest Pathology Service. During laboratory and field studies, to determine the concentration of bark beetles and emergence periods during the growing season of 2019 (from April to October), the method of "trap (model) trees" and laying out "pheromone traps" IBL-3 (Ipsodor pheromone dispenser) was used. During the application of these methods, mass collection of material in the form of pest imagos and entomophages was carried out, which led to partial localisation of the focus in the study area.

## RESULTS AND DISCUSSION

***Features of the development of bark beetle foci***

During the survey of spruce and pine stands in Polissya and Forest-steppe, it was identified that recently they have been functioning in radically changed forest-growing conditions, as evidenced by the analysis of a complex of characteristics of habitats and the actual state of vegetation. During field work, certain patterns of distribution and development of foci have also been established. In the vast majority of cases, drying spreads from the focus in the northern and western directions. The first younger generation is quite healthy and strong, which allows it to spread over a long distance (from 3 to 30 km). Due to this, it is impossible to predict the territory of dissemination of the population (Fig. 1).

***Figure 1**. Drying of pine stands damaged by Ips engraver beetle*

The second younger generation is somewhat weaker and usually inhabits adjacent plantings. It was established that in the vast majority of cases, the spread of the focus mostly coincides with the western and northern directions (up to 30-40 m from the wall of an existing focus), in the eastern and southern directions it is less frequent and less intense (up to 5-10 m) [10-12; 32; 34-35].

The zone of active dissemination of the focus is characterised by the predominance of trees of the third-fourth state categories, the crown of which is at the initial stage of drying and is characterised by a change in the colour of the needle-foliage (blanching of colour intensity, flavescence), branch fall and "shorn shoots" under the crowns of trees, frass on the stems of freshly populated trees as a result of the vital activity of the Ips engraver beetle and pine shoot beetle, as well as frass of spruce bark beetle in the spruce stands [10-12; 32-35].

A branch fall in the area of active focus dissemination under the projection of the crown of freshly populated trees and Ips engraver beetle imago present in it indicates a high concentration of the pest in the plantings. The identified feature should be taken into account by forest protection workers during the examination and planning of appropriate sanitary and health measures (Fig. 2).

***Figure 2***. *Branch fall in the zone of active focus dissemination under the projection of the crown of freshly populated trees and Ips engraver beetle imago present in it*

Features of development of Ips engraver beetle foci:

1. Ips engraver beetle and other stem pests are in constant symbiosis with a number of pathogenic fungi [36], which, getting into the wood tissues of living trees, lead to their drying out and a rapid decrease in the commercial quality of wood. That is, in addition to irreversible environmental losses, forestry and the state suffer large material losses.

2. The process of pine stands drying does not stop, so it is gaining signs of an ecological disaster. According to forecasts of scientists, forest protection specialists, and foresters, the area of damaged plantings will only increase in the coming years. This is confirmed by the results of analysis of forest pathological examinations and entomological samples for determining quantitative and qualitative indicators of populations of such stem pests: Ips engraver beetle, six-toothed bark beetle, lesser pine shoot beetle in pine forest stands of Zhytomyr, Khmelnitsky, and Vinnytsia regions.

3. One of the main criteria for assessing the qualitative state of the stem pest population is the reproduction energy, which makes it possible to characterise the dynamics of development and spread of stem pest foci. Thus, according to the authors' own analysis of model trees, the reproduction energy of the Ips engraver beetle ranges from 1.4 (average) to 2.3 (strong) in the spring and summer period. In the autumn and winter period, it averaged up to 1.9, which corresponds to an average degree and allows stating that at the time of the examination, the foci of this type of pest have certain signs of decreasing activity. Additionally, this fact is confirmed by the average length of the collective feeding tunnels. Thus, if in previous years the average length was from 12 to 16 cm, in some places up to 20 cm, already at the end of 2018, the average length decreased to 4-6 cm (short tunnels), which allows talking about a decrease in the fertility of females. There is also a certain decrease in the number of females per 1 mating chamber – from 8-12 pcs. in previous years, up to 4-6 pcs. at the end of 2018. In general, these are favourable signs of a decrease in

quantitative and qualitative indicators of Ips engraver beetle populations. But at the same time, the negative effect of stem pest foci also manifested itself with the onset of the growing season in 2019, taking into account the previous scale of drying out and the accumulation of a large amount of pests in previous years. The overall qualitative and quantitative state of the populations of these pests is influenced by a number of factors, both related to economic activity, and biotic and abiotic – climatic conditions of the autumn and winter period of 2018-2019, the activity of diseases, entomophages [10-12; 32; 34; 35].

***Results of pheromone monitoring***

Also, during the year, laboratory and field work was conducted to solve the problem of foci localisation by laying out trap trees and pheromone traps IBL-3 (Ipsodor pheromone dispenser) in plantings bordering with those damaged by bark beetles. Pheromone surveillance did not reflect the real picture of the pest's vital activity in plantings – in practice, bark beetles did not inhabit trap trees and only a few representatives fell into traps in very small numbers. Instead, it populated healthy trees where pheromone traps were located. The fact is that at the time of laying out trap trees and traps, the population of stem pests was in the active phase of the outbreak – qualitative and quantitative indicators were actively growing, and, as a result, the beetles were disoriented, and the presence of pheromone in the traps was minor, compared to its concentration in the air. A similar situation developed in Polissya and Forest-steppe for all representatives of the bark beetle family (Fig. 3-8).

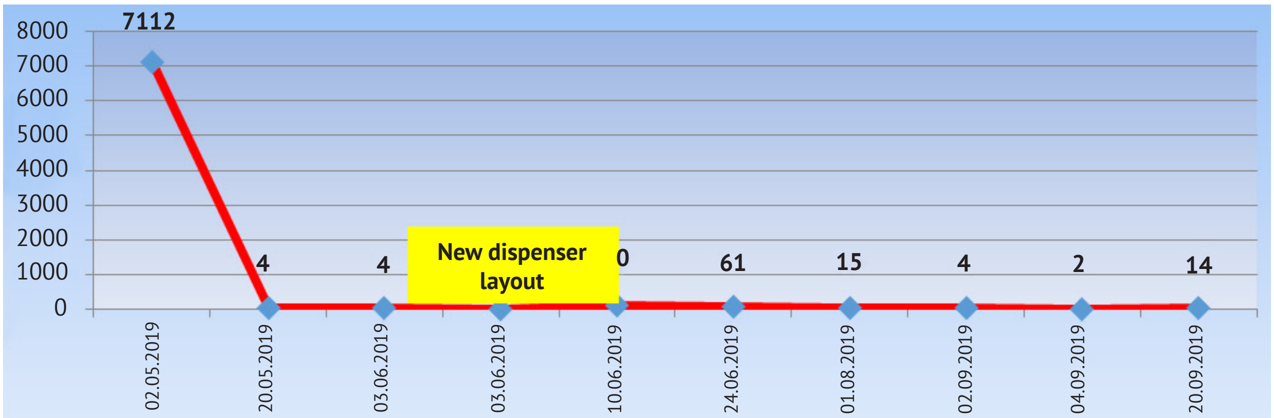


***Figure 3**. The results of pheromone monitoring on the occurence of Ips engraver beetle imago (Ips acuminatus). State enterprise "Malynske LG", Malynske forestry as of 01.10.2019*

***Source**: developed by the authors based on their own research*

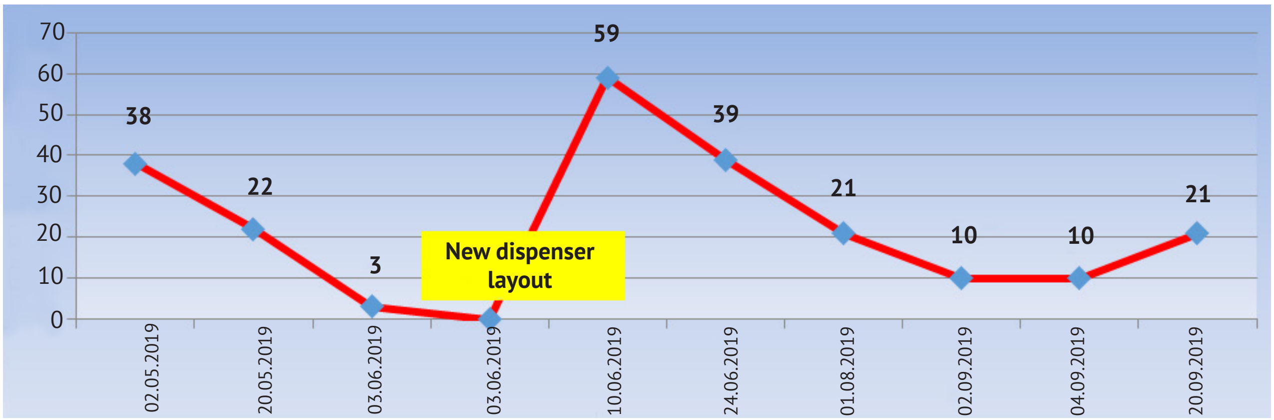


***Figure 4**. The results of pheromone monitoring for the occurence of six-toothed bark beetle imago (Ips sexdentatus). State enterprise "Malynske LG", Malynske forestry as of 01.10.2019*

***Source**: developed by the authors based on their own research*

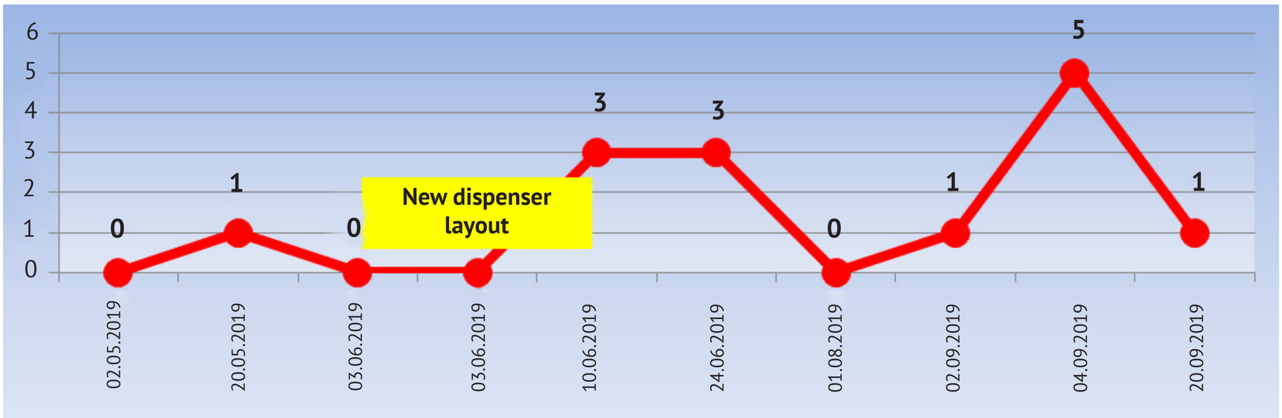


*Figure 5*. The results of pheromone monitoring for the occurence of ant beatle imago (Thanasimus formicarius). State enterprise "Malynske LG", Malynske forestry as of 01.10.2019

***Source***: developed by the authors based on their own research

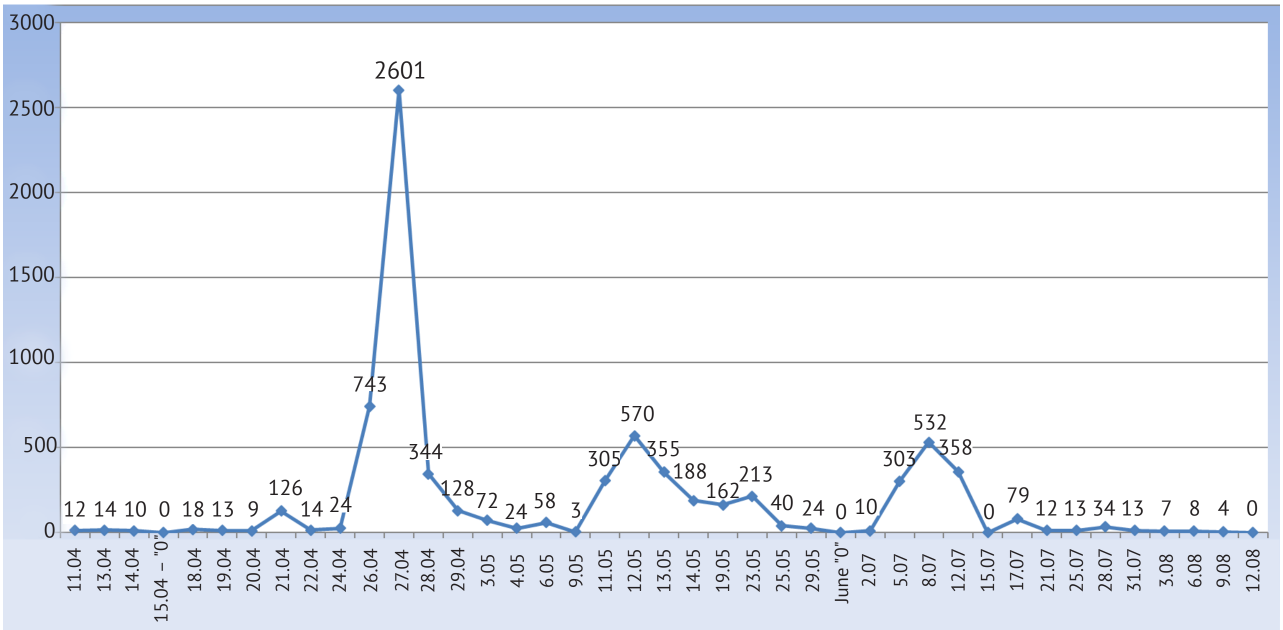


*Figure 6*. The results of pheromone monitoring on the occurence of Ips engraver beetle imago (Ips acuminatus). State enterprise "Slavutske LG", Golytske and Komarovske forestries as of 20.08.2019.

***Source***: developed by the authors based on their own research

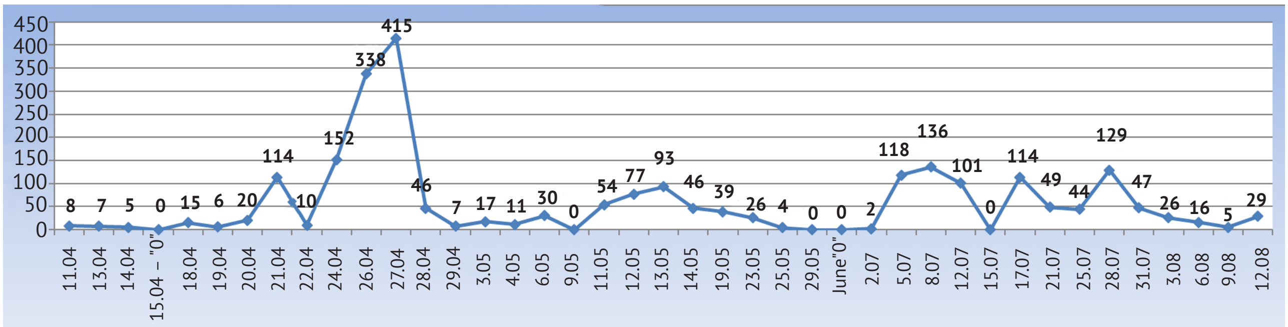


*Figure 7*. The results of pheromone monitoring for the occurence of six-toothed bark beetle imago (Ips sexdentatus). State enterprise "Slavutske LG", Golytske and Komarovske forestries as of 20.08.2019

***Source***: developed by the authors based on their own research

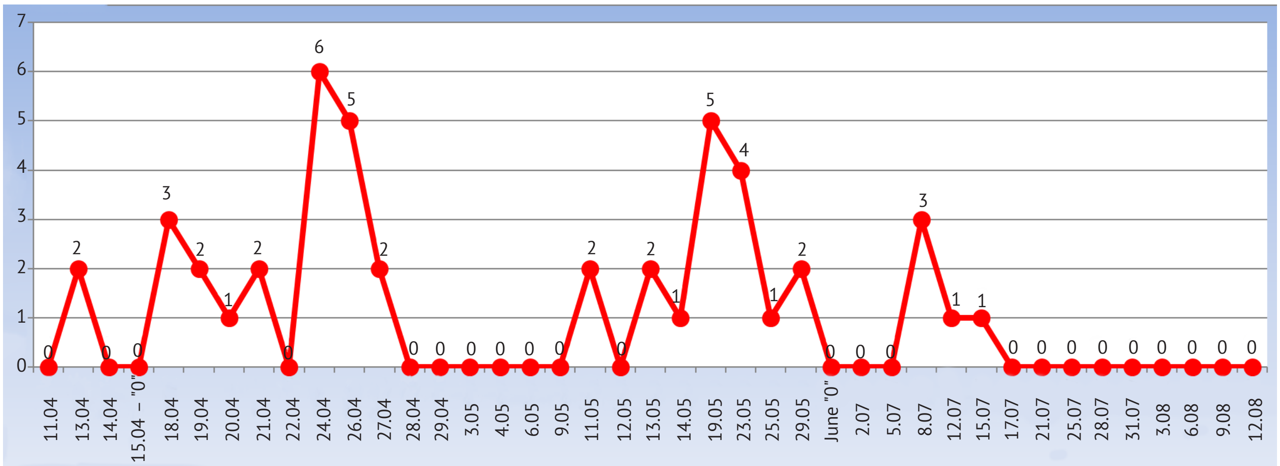


***Figure 8****. The results of pheromone monitoring for the occurence of ant beatle imago (Thanasimus formicarius). State enterprise "Slavutske LG", Golytske and Komarovske forestries as of 20.08.2019*

***Source****: developed by the authors based on their own research*

Another important factor is the indicator of the number of entomophage imago – ant beetle (*Thanasimus formicarius*) – per unit of drying pine forest area and the frequency of occurrence of the species (constant presence) in all drying foci. It was established that the greatest number and frequency of occurrence is observed in the drying foci of pine forests affected by bark beetles.

After analysing the general forest pathological and sanitary conditions of coniferous plantations, a certain pattern of occurrence of pine drying foci was identified, which are concentrated along highways and roads laid in the forest and along which the harvested wood is transported. Furthermore, the distribution area of the main types of stem pests lies within pine stands weakened by specific harmful factors. These are the following types of stem pests: Ips engraver beetle (*Ips acuminatus*) and the lesser pine shoot beetle (*Blastophagus minor*). They are characterised by the attack of the tree crown top. They are most common in the plantings of eastern and south-eastern Zhytomyr region. In these plantings, the crowns of trees are weakened by chronic foci of needle-eating insects, snowbreaks, and suffer from overheating of the thin bark zone of tree stems of plantings thinned as a result of selective sanitary cutting. The northern and north-western parts of the region "suffer from root rot (pine fungus and honey mushroom), changes in the hydrologic regime due to frequent droughts, mining, and fires, have a weakened root system and crown, are distinguished by the simultaneous type of pest colonisation, and are damaged mainly by the six-toothed bark beetle (*Ips sexdentatus*), in combination with the above" [34].

Signs of degradation of pine stands "due to the dissemination of stem pests with subsequent damage by tracheomycosis is the intensive nature of drying of the forest stand (group and entire), the spread of drying from South to North, that is, first of all, trees die on the most exposed to light edges, forest walls, and cutting areas, as well as trees that are adjacent to the active drying foci from the North. The areas of drying foci vary from 0.1 to 2.0 ha" [34]. Thus, the ultimate cause of drying out of scots pine trees is a complex of factors, namely the reproduction and spread of stem pests (mainly bark beetles) and pathogens of tracheomycosis (ophiostomy fungi), which are their integral part [10]. The species composition and rate of reproduction of forest insects depend on the quality and physiological state of plantings and forestry, on climate fluctuations, on the volume of insect predators and parasites, on the presence of insectivorous birds, and a number of other environmental conditions.

### *The state of the forest biocenosis in the context of an outbreak of mass reproduction of stem pests*

The main conditions and factors affecting the life of insects and the development of biocenoses are divided into two main groups:

1) abiotic factors – temperature, humidity, light, soil conditions [1];

2) biotic factors – the influence of the surrounding organic world.

For each type of insect, and especially for each stage of their development, there is a certain favourable temperature, or optimum, according to which the vital activity of an organism (nutrition, metabolism, vagility, reproductive activity) is most intense. The more the temperature deviates from the optimum, the less favourable it becomes for physiological processes in insect's body. This explains the ability of bark beetles to produce several generations a year instead of one, but there are exceptions. Thus, for example, a lesser pine shoot beetle always gives one generation. This constancy of the cycle is explained by the species specificity of the insect, which has historically developed under the influence of natural selection.

Humidity, which is present in the bark and wood of a tree, affects the development and metabolism of insects that live in the wood. The dryness of the environment increases the loss of water by evaporating it from the surface of the body of an insect imago, or by breathing movements through the spiracles, especially during an increase in temperature. The limits of optimal humidity in different insects and their stages are different: some bark beetles develop well on the sunlit sides of tree stems not avoiding strong drying of the damaged tree (Ips engraver beetle, six-toothed bark beetle); other species need shaded sides with a high moisture content for their development (lesser pine shoot beetle) and quickly die when the bark dries up [14; 18]. The influence of climate on the dissemination of insects is quite substantial. Heavy precipitation and lack of sunny days limit the development of insects. Most species appear in large numbers during droughts and begin to disappear during the rainy season, especially when the latter are accompanied by a decrease in temperature.

The relation of pests to tree species and the nature of the forest stand may vary:

– polyphage group;
– selective;
– a single-species group.

Stem pests of coniferous species can change their belonging to groups depending on the insect's habitat and changes in external conditions, especially if there is insufficient food supply during mass outbreaks; for example, the spruce bark beetle (a single-species group) often inhabits pine trees if there is not enough spruce suitable for its development. Quite often, there is a competition between species for existence, which sometimes has a strong impact on the number of this species, its reproduction, and further existence in the biocenosis. But predatory, parasitic beneficial insects (entomophages), and insectivorous birds have a greater impact on the number of pests. Only ants of one anthill destroy up to 100 thousand insects per day. One of the serious factors that disrupt the structure of the forest biocenosis is human economic activity. Improper forestry activities directly lead to the development of harmful entomofauna.

Strip cuttings, which were practised in the past, were almost always accompanied by an increased attack of pests on them. A similar pattern is observed during selective cutting when most of the stock is excessively cut down, and thereby the growth conditions of the remaining forest stand are being dramatically changed. The number and dissemination of harmful insects are increasing most rapidly in forests, where cutting operations are continuously conducted without compliance with sanitary requirements. If timber harvest and felling residues are left in the forest for the summer period, the attacks of harmful species increase sharply. In such conditions, many species of bark beetles and longhorn beetles, which usually inhabit felled forest, attack growing trees.

It is worth remembering that in mixed forests, the mass spread of pests is less frequent, and the resistance of such complex forest stands affected by insects is much greater. Therefore, artificial clean plantings (especially coniferous monocultures) periodically suffer from the reproduction of harmful insects [34].

## CONCLUSIONS

The above data of exploratory forest pathology survey, stationary, and pheromone monitoring allow designing preventive and other methods of controlling the main stem pests of coniferous trees in order to preserve their ecological potential, namely:

1. Create a single national electronic database for accounting for foci of forest pests and diseases with the possibility of its constant updating, filling, and correcting data by representatives of forest pathology enterprises.

2. All cuttings in plantings damaged by stem pests of the bark beetle family must be carried out before April 1 (before the emergence of stem pests). The cut timber must be barked, the bark and felling residues burned since the vast majority of the pest (wintering) is concentrated under the bark of trees. The order of cutting should be as follows:

– first of all – plantings damaged in the second half of the year, where the largest mass of the pest is concentrated (this will also help preserve the technical quality of forest products);
– plantings damaged at the beginning of the year;
– dead standing trees of previous years.

3. Provide for a set of measures to prevent the movement and storage of unbarked (untreated with pesticides) forest products in the period from April 1 to November 1. Strictly prohibit the uplift of bark to the territory of forest stands from the facilities of processing and storage of forest products.

4. Implement a set of measures for introducing the use of pheromone preparations against Ips engraver beetle, six-toothed bark beetle, and lesser pine shoot beetle into forestry production in order to control their number.

5. Introduce machines and mechanisms into forestry production for disposing of felling residues in cutting areas.

6. Conduct experimental treatment of forest stands

with insecticides using aerosol technology (GARD) and motor sprayers of the "SOLO" and "STIHL" types to reduce the number of stem pests and mycosis vectors in the foci (during the period of emergence and additional nutrition).

7. Consider the possibility of using drone aircraft to quickly detect foci of drying out and other damage, determine their coordinates and previous areas using GIS technologies.

8. Use of stationary fire-preventing video surveillance to detect foci of drying.

9. Develop guidelines for forestry of pine stands damaged by stem pests based on the accumulated experience of recent years, supported by the results of experiments.

## REFERENCES

[1] Ivanytskyi, S.M., & Shchyrba, H.R. (2005). *Soil science*. Ternopil: Zbruch.

[2] Halik, O.I., & Basiuk, T.O. (2014). *Guidelines for climate information of Ukraine.* Rivne: NUVHP.

[3] Getmanchuk, A., Kychylyuk, O., Voytyuk, V., & Borodavka, V. (2017). The regional changes of climate as primary causes of strong withering of pine stands in Volyn Polissya. *Scientific Bulletin of UNFU*, 27(1), 120-124.

[4] Zaiachuk, V.Ya. (2008). *Dendrology*. Lviv: Apriori.

[5] Jenkins, M.J., Hebertson, E., Page, W.C., & Jorgensen, A. (2008). Bark beetles, fuels, fires and implications for forest management in the Intermountain West. *Forest Ecology and Management,* 254, 16-34.

[6] Franceschi, V.R., Krokene, P., Christiansen, E., & Krekling, T. (2005). Anatomical and chemical defenses of conifer bark against bark beetles and other pests. *New Phytologist*, 67, 353-376.

[7] Nikiforuk, A. (2012). Beetlemania. *New Scientist*, 1-2(14), 62-65.

[8] Baburina, N.A., & Ivanov, V.S. (2015). Occurrence of bark beetles of different types in various of the woods of the leningrad region. *ISJ Theoretical & Applied Science*, 04(24), 162-165.

[9] Collins, B.J., Rhoades, C.C., Hubbard, R.M., & Battaglia, M.A. (2011). Tree regeneration and future stand development after bark beetle infestation and harvesting in Colorado lodgepole pine stands. *Forest Ecology and Management,* 261(11), 2168-2175.

[10] Bolyukh, O.H., & Pryianchuk, I.V. (2018). *Review of the dissemination of pests and diseases in 2018 and forecast their development for 2019 in the forest plantations of Zhytomyr RFHA*. Vinnytsia: DSLP "Vinnytsialisozakhyst".

[11] Stehniak, V.D. (2018). *Review of the spread of pests and diseases in 2018 and the forecast of their development for 2019 in the forest plantations of Vinnytsia RFHA*. Vinnytsia: DSLP "Vinnytsialisozakhyst".

[12] Tarasevych, O.V., Zborovska, O.V., & Zhukovskyi, O.V. (2015). *Report on research work on the topic: "Study of forest pathological processes in drying pine plantations of SE "Chervonoarmiiskyi lishosp APK" for 2015" (final)*. Kharkiv: PF UkrNDILHA.

[13] Khramtsov, N.N., & Padyi, N.N. (1965). *Stem forest pests and their control*. Moscow: Lesnaya promyshlennost.

[14] Guidelines for the supervision, accounting and forecasting of mass reproductions of forest stem pests. (1975). Moscow: Lesnaya promyshlennost.

[15] Pashenova, N.V., & Baranchikov, Yu.N. (2014). The most dangerous species of ophiostomy fungi in the coniferous forests of Siberia. In *VIII Readings in the memory of O.A. Katayev.* Retrieved from https://docplayer.ru/28146024-Naibolee-opasnye-vidy-ofiostomovyh-gribov-v-hvoynyh-lesah-sibiri.html.

[16] Resolution of the Cabinet of Ministers of Ukraine No. 555 "On Approval of Sanitary Rules in the Forests of Ukraine". (1995, Jule). Retrieved from https://zakon.rada.gov.ua/laws/show/555-95-%D0%BF#n9.

[17] Tyshchenko, V.P. (1986). *Insect physiology.* Moscow: Vysshaya Shkola.

[18] Kostyn, Y.A. (1964). *Stem pests of coniferous forests of Kazakhstan*. Alma-Ata: Academy of Sciences of the Kazakh SSR.

[19] Bent, B.J., Regniere, J., Fettig, C.J., Hansen, E.M., Hayes, J.L., Hicke, J.A., Kelsey, R.G., Negrón, J.F., & Seybold, S.J. (2010). Climate change and bark beetles of the Western United States and Canada: Direct and indirect effects. *BioScience*, 60(8), 602-613.

[20] Mieshkova, V.L. (2010). *Methodical recommendations for the examination of foci of forest stem pests*. Kharkiv: UkrNDILHA.

[21] Rymsky-Korsakov, M.N., & Guseva, V.I. (Eds.). (1949). *Forest entomology*. Moscow: Hoslesbumyzdat.

[22] Haichenia, P.A., Serykov, O.Ya., & Fasulati, K.K. (1970). *Trunk pests of the forest (pictorial identification)*. Kyiv: Urozhai.

[23] Mozolevskaia, E.H., Kataev, O.A., & Sokolova, E.S. (1984). *Methods of forest pathological examination of stem pests and forest diseases*. Moscow: Lesnaya promyshlennost.

[24] Linnakoski, R., de Beer, Z.W., Ahtiainen, J., Sidorov, E., Niemelä, P., Pappinen, A., & Wingfield, M.J. (2010). Ophiostoma spp. associated with pine- and spruce-infesting bark beetles in Finland and Russia. *Persoonia*, 25, 72-93.

[25] Christiansen, E., Warning, R.H., & Berryman, A.A. (1987). Resistance of conifers to bark beetle attack: Searching for general relationships. *Forest Ecology and Management*, 22, 89-106.
[26] Wermelinger, B. (2004). Ecology and management of the spruce bark beetle Ips typographus – review of recent research. *Forest Ecology and Management*, 202, 67-82.
[27] Yamaoka, Y., Wingfield, M.J., Takahashi, I., & Solheim, H. (1997). Ophiostomatoid fungi associated with the spruce bark beetle Ips typographus f. aponicus in Japan. *University of Tsucuba library*, 101(10), 1215-1227.
[28] Muller, J., Bubler H., Gobner, M., Rettelbach, T., & Duelli, P. (2008). The European spruce bark beetle Ips typographus in a national park: From pest to keystone species. *Biodiversity and Conservation*, 17(12), 2979-3001.
[29] Byers, J.A. (1989). Chemical ecology of bark beetles. *Experientia*, 45, 271-283.
[30] Byers, J.A., Zhang, Q.H., & Birgersson, G. (2000). Strategies of a bark beetle, Pityogenes bidentatus, in an olfactory landscape. *Naturwissenschaften*, 87, 503-507.
[31] Noma, T., Colunga-Garcia, M., Brewer, M., Landis, J., Gooch, A., & Philip, M. (2010). European spruce bark beetle Ips typographus. *Michigan State University's Invasive Species Factsheets*, 1, 1-2.
[32] Kavun, E.M., & Lohinova, S.O. (2017). Dynamics and distribution of major pests of Norway spruce and scots pine in the conditions of Vinnytsia and Zhytomyr regions. *Agriculture and Forestry*, 5, 174-182.
[33] Vorontsov, A.I. (1982). *Forest entomology*. Moscow: Vysshaya Shkola.
[34] Kavun, E.M., & Lohinova, S.O. (2017). Geographic and ecological aspects of distribution stem pests of coniferous trees species in delimitations of Zhytomyr and Vinnytsia regions and their dynamics. *Agriculture and Forestry*, 6(2), 120-128.
[35] Lohinova, S.O. (2018). Prediction of mass reproduction of stem pests of coniferous trees in Ukraine and its relevance. *Agriculture and Forestry*, 11, 142-151.
[36] Shevchenko, S.V., & Tsyliuryk, A.V. (1986). *Forest phytopathology*. Kyiv: Vyshcha shkola.

## СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ

[1] Іваницький С.М., Щирба Г.Р. Грунтознавство. Тернопіль: Збруч, 2005. 228 с.
[2] Галік О.І., Басюк Т.О. Методичні вказівки «Довідкові дані з клімату України». Рівне: НУВГП, 2014. 158 с.
[3] The regional changes of climate as primary causes of strong withering of pine stands in Volyn Polissya / A. Getmanchuk et al. *Scientific Bulletin of UNFU*. 2017. Vol. 27, No. 1. P. 120–124.
[4] Заячук В.Я. Дендрологія. Львів: Апріорі, 2008. 656 с.
[5] Bark beetles, fuels, fires and implications for forest management in the Intermountain West / M.J. Jenkins et al. *Forest Ecology and Management*. 2008. Vol. 254. P. 16–34.
[6] Anatomical and chemical defenses of conifer bark against bark beetles and other pests / V.R. Franceschi et al. *New Phytologist*. 2005. Vol. 167. P. 353–376.
[7] Nikiforuk A. Beetlemania. *New Scientist*. 2012. No. 1–2(14). 2012. P. 62–65.
[8] Baburina N.A., Ivanov V.S. Occurrence of bark beetles of different types in various of the woods of the leningrad region. *ISJ Theoretical & Applied Science*. 2015. No. 04(24). P. 162–165.
[9] Tree regeneration and future stand development after bark beetle infestation and harvesting in Colorado lodgepole pine stands / B.J. Collins et al. *Forest Ecology and Management*. 2011. Vol. 261. P. 2168–2175.
[10] Болюх О.Г., Приянчук І.В. Огляд розповсюдження шкідників та хвороб у 2018 році та прогноз їх розвитку на 2019 рік у лісових насадженнях Житомирського ОУЛМГ. Вінниця: ДСЛП «Вінницялісозахист», 2018. 67 с.
[11] Стегняк В.Д. Огляд розповсюдження шкідників та хвороб у 2018 році та прогноз їх розвитку на 2019 рік у лісових насадженнях Вінницького ОУЛМГ. Вінниця: ДСЛП «Вінницялісозахист», 2018. 55 с.
[12] Тарасевич О.В., Зборовська О.В., Жуковський О.В. Звіт про науково-дослідну роботу за темою: «Вивчення лісопатологічних процесів у всихаючи соснових насадженнях ДП «Червоноармійський лісгосп АПК» за 2015 р.» (заключний). Харків: ПФ УкрНДІЛГА, 2015. 65 с.
[13] Храмцов Н.Н., Падий Н.Н. Стволовые вредители леса и борьба с ними. Москва: Лесная промышленность, 1965. 143 с.
[14] Наставление по надзору, учету и прогнозу массовых размножений стволових вредителей лесов. Москва: Лесная промышленность, 1975. 116 с.
[15] Пашенова Н.В., Баранчиков Ю.Н. Наиболее опасные виды офиостомовых грибов в хвойных лесах Сибири. *VIII Чтения памяти О.А. Катаева* (г. Санкт-Петербург, 18–20 ноя. 2014 г.). Санкт-Петербург, 2014. URL: https://docplayer.ru/28146024-Naibolee-opasnye-vidy-ofiostomovyh-gribov-v-hvoynyh-lesah-sibiri.html (дата обращения: 13.11.2020).

[16] Санітарні правила в лісах України: Постанова Кабінету Міністрів України від 27.07.1995 р. № 555. URL: https://zakon.rada.gov.ua/laws/show/555-95-%D0%BF#n9 (дата звернення: 14.11.2020).
[17] Тыщенко В.П. Физиология насекомых. Москва: Высшая школа, 1986. 303 с.
[18] Костин И.А. Стволовые вредители хвойных лесов Казахстана. Алма-Ата: «Издательство академии наук Казахской ССР», 1964. 179 с.
[19] Climate change and bark beetles of the Western United States and Canada: Direct and indirect effects / B.J. Bent et al. *BioScience*. 2010. Vol. 60. No. 8. P. 602–613.
[20] Мєшкова В.Л. Методичні рекомендації щодо обстеження осередків стовбурових шкідників лісу. Харків: УкрНДІЛГА, 2010. 27 с.
[21] Лесная энтомология: учебник. 3-е изд., перераб. и доп. / под ред. М.Н. Римского-Корсакова, В.И. Гусева. Москва: «Гослесбумиздат», 1949. 504 с.
[22] Гайченя П.А., Сериков А.Я., Фасулати К.К. Стволовые вредители леса (атлас определитель). Киев: «Урожай», 1970, 91 с.
[23] Мозолевская Е.Г., Катаев О.А., Соколова Э.С. Методы лесопатологического обследования очагов стволових вредителей и болезней леса. Москва: Лесная промышленность, 1984. 152 с.
[24] Ophiostoma spp. associated with pine- and spruce-infesting bark beetles in Finland and Russia / R. Linnakoski et al. *Persoonia*. 2010. Vol. 25. P. 72–93.
[25] Christiansen E., Warning R.H., Berryman A. A. Resistance of conifers to bark beetle attack: Searching for general relationships. *Forest Ecology and Management*. 1987. Vol. 22. P. 89–106.
[26] Wermelinger B. Ecology and management of the spruce bark beetle Ips typographus – review of recent research. *Forest Ecology and Management*. 2004. Vol. 202. P. 67–82.
[27] Ophiostomatoid fungi associated with the spruce bark beetle Ips typographus f. aponicus in Japan / Y. Yamaoka et al. *University of Tsucuba Library*. 1997. No. 101(10). P. 1215–1227.
[28] The European spruce bark beetle Ips typographus in a national park: From pest to keystone species / J. Muller et al. *Biodiversity and Conservation*. 2008. No. 17(12). P. 2979–3001.
[29] Byers J.A. Chemical ecology of bark beetles. *Experientia*. 1989. Vol. 45. P. 271–283.
[30] Byers J.A., Zhang Q.-H., Birgersson G. Strategies of a bark beetle, Pityogenes bidentatus, in an olfactory landscape. *Naturwissenschaften*. 2000. Vol. 87. P. 503–507.
[31] European spruce bark beetle Ips typographus / T. Noma et al. *Michigan State University's Invasive Species Factsheets*. 2010. No. 1. P. 1–2.
[32] Кавун Е.М., Логінова С.О. Динаміка та поширення основних шкідників ялини європейської і сосни звичайної в умовах Вінницької та Житомирської областей. *Сільське господарство та лісівництво*. 2017. Вып. 5. С. 174–182.
[33] Воронцов А.И. Лесная ентомология. Москва: Высшая школа, 1982. 367 с.
[34] Кавун Е.М., Логінова С.О. Географо-екологічні аспекти поширення стовбурових шкідників хвойних порід дерев в межах Житомирської і Вінницької областей та їх динаміка. *Сільське господарство та лісівництво*. 2017. № 6(2). С. 120–128.
[35] Логінова С.О. Прогноз масового розмноження стовбурових шкідників хвойних порід дерев в Україні та його актуальнісь. *Сільське господарство та лісівництво*. 2018. Вып. 11. С. 142–151.
[36] Шевченко С.В., Цилюрик А.В. Лесная фитопатология. Киев: Высшая школа, 1986. 384 с.

## Порушення структури біоценозу лісу під дією стовбурових шкідників та методи контролю їх чисельності

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**Анотація**. Дослідження лісової екосистеми, як невід'ємної складової частини протиерозійної системи, пов'язане з низкою питань. Ліс є найбільш могутнім і дієвим засобом у боротьбі з ерозією ґрунтів, посухами і суховіями, а також екологічним стабілізуючим чинником загалом. Лісогосподарська діяльність людини в боротьбі зі всиханням хвойних насаджеь від спалаху масового розмноження і розповсюдження на значні території стовбурових шкідників під впливом комплексу еколого-кліматичних факторів, є одним із серйозних факторів, що порушують структуру біоценозу лісу. Пошук альтернативних рішень локалізації цієї проблеми вимагає детального вивчення поведінки найпоширеніших короїдів хвойних порід дерев у кліматичних та екологічних умовах, що склались в період з 2011 по 2020 роки. У період активних температур 2019 року, а саме з ІІ декади квітня до ІІІ декади жовтня, проводились роботи по стаціонарному нагляду та лабораторно-польові роботи з метою вирішення проблеми з локалізації осередків комплексу стовбурових шкідників соснових насаджень Полісся та Лісостепу. Використовувались методи викладки ловчих дерев і феромонних пасток. На практиці шкідник не заселяв ловчих дерев і потрапляли у пастки лише поодинокі представники в дуже малій кількості та ентомофаги. Натомість він заселив здорові дерева виділів, де були розташовані уловлювачі. Визначено, що з науково-практичної точки зору досліджувана закономірність виникнення осередків всихання сосни чітко приурочена до автомобільних шляхів і лісовозних доріг, а також ареалу поширення відповідних видів стовбурових шкідників і зон ослаблення соснових деревостанів на окремих територіях з інших причин. Доведено, що задля збереження екологічного потенціалу хвойних насаджень і зменшення негативного впливу комах-ксилофагів необхідно запроектувати профілактичні та біологічні методи боротьби з головними стовбуровими шкідниками хвойних порід дерев

**Ключові слова**: ентомофаги, хвойні насадження, стаціонарний нагляд, феромонний нагляд, Полісся, Лісостеп