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Pheromone monitoring of xylophage insects of *Picea abies* (L.) Karst.

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Abstract. Xylophagous insects can inflict significant damage to forests by causing trees to dry out. Pheromone monitoring allows detecting the appearance of these pests in time and taking measures

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to control them. The purpose of the study was to determine the sanitary state of spruce stands and pheromone monitoring of xylophage insect populations. The degree of damage to the spruce plantation was determined in accordance with the scale of sanitary state indices as a weighted average value of the assessment of the distribution of trees of different categories of condition. Based on the results of accounting on the test areas, the sanitary state index (average category) of the spruce stand was calculated, it was found that the most vulnerable to pathological factors were trees in the smallest (8, 12, and 16 cm, respectively) and the largest (44 cm) diameter class. The use of pheromone monitoring to assess the state of forest stands was aimed at identifying the presence of harmful organisms in a certain territory, determining their species composition, abundance, and development dynamics. In the forest area where the pheromone survey was carried out, insects were found and identified, including the sharp-dentated bark beetle *Ips acuminatus*, European spruce bark beetle *Ips typographus*, spruce wood engraver *Pityogenes chalcographus*, synanthropic species of depressed flour beetle *Palorus depressus*, and the predatory ant beetle *Thanasimus formicarius*. The largest number of individuals in traps was recorded in the European spruce bark beetle during the entire observation period, where from 10 to 15 individuals were caught for each trap, as well as in a synanthropic species *Palorus depressus*. The potential reproduction opportunities of xylophage insect populations were analysed, and the population of *Ips typographus* has the highest settlement density, the number of beetles of the younger generation or the production of stem pests of which averaged 34 holes per 1 dm². Despite the low density of the settlement, *Pityogenes chalcographus* has the ability to attack almost healthy trees and forms continuous mass populations in the surveyed plantings together with the European spruce bark beetle. The results obtained will be useful for monitoring and controlling pests, which will allow timely detection and assessment of the level of threat to forest stands

Keywords: phytophagous insects; accounting; pheromone traps; *Ips typographus*; *Pityogenes chalcographus*

Introduction

Forest ecosystems play a key role in the ecological evolution of the biosphere and maintaining its natural state, especially in the modern technological period, when the balance of oxygen and carbon is disturbed under the influence of anthropogenic factors. The composition of forests is undergoing changes, the age structure of forests is changing, the stability and viability of spruce forests are sharply reduced, and their mass death occurs. The area of forest landscapes continues to decline catastrophically, and researchers emphasize that the natural process of forest ecosystem development ensures the stability of mixed forest

stands and their viability, and high productivity of spruce forests under appropriate plant growth conditions.

According to O. Jakoby et al. (2019), spruce stands, especially monocultures, are in a state of degradation and mass drying out. There are several main reasons for the degradation of spruce crops, including, in particular, a decrease in diversity and increased vulnerability to pathogens and pests, disruption of the vital activity of not only the ground part, but also root systems. A decrease in growth and a massive increase in spruce monoculture prevails in mature forests, although smaller volumes are

also observed in middle-aged ones, and even less often in young stands.

P. Lehmann *et al.* (2020) investigated that the European spruce (*Picea abies* (L.) Karst.) has a significant potential for forest restoration, is easily grown in nurseries, successfully takes root in cutting areas, and grows quickly, and its wood is valuable on the market. However, there are certain negative aspects in its genetic structure, such as low wind resistance, vulnerability to rotting diseases of the root system, attacks of phytophagous insects, etc. This is confirmed by the increase in the number of wind trees and the breaking off of spruce branches due to the influence of climatic abiotic factors on spruce stands, and the drying up of plantings due to the intensive spread of pathogens and a complex of insects-phytophagous, which was considered in the study by T. Hlasny *et al.* (2023). It should also be noted that for a significant time of the last century in monodominant spruce plantations in Ukraine, there was a decrease in growth, dryness, and mass drying of spruce.

As noted by S. Karvemo *et al.* (2023), spruce forests in Europe are experiencing large-scale drying caused by spruce bark beetle (*Ips typographus* L.), natural phenomena, and periods of drought that are becoming more frequent as a result of climate change. S. Berthelot *et al.* (2021) proved that tree diversity creates an environment where favored coniferous species are less accessible to bark beetles. *Ips typographus* is one of the most important species that affect the forest ecosystems of Eurasia, causing massive mortality of the host tree *Picea abies* (Hofmann *et al.*, 2024). Global warming and extreme climate events have caused unprecedented outbreaks of xylophage insects in coniferous forests around the world (Marini *et al.*, 2017), hence, J. Romeiro *et al.* (2023) suggested that an effective forest management strategy should assess the structure and composition of plantings to determine potential damage from bark

beetles. Coniferous tree species weakened by abiotic and biotic factors are susceptible to bark beetle colonization. L. Lehmanski *et al.* (2023) found that a significant proportion of trees with weakened protection create favourable conditions for the accumulation of insect populations, but the mechanisms that encourage the search for nutrient plants by pioneer beetles are still unknown to many species, including *Ips typographus*. Consequently, dendrophilous insects have a significant impact on the productivity and stability of stands, since damage can lead to changes in forest biocenoses and even drying out.

The purpose of the study was to investigate the main factors of drying out of spruce stands with an assessment of the sanitary state and analysis of the species composition of xylophage insects by conducting pheromone monitoring.

Materials and Methods

Object of research – the main factors of drying out of spruce stands under the intense influence of abiotic and biotic factors. The subject of the study – pheromone monitoring of insects – xylophages of spruce stands.

The study was conducted during 2023 in a plantation dominated by *Picea abies* in the forestry part of the green zone forests of the Plesetsk Forestry of the separate subdivision of the National University of Life and Environmental Sciences of Ukraine “Boyarka Forest Research Station”, forest crops of heterogeneous composition, namely 30% of Norway spruce (*Picea abies*) aged 46 years, 20% Norway spruce (*Picea abies*) aged 62 years, 20% Scots pine (*Pinus sylvestris*), 30% European white birch (*Betula pendula*) of natural origin and a slight admixture of European aspen (*Populus tremula*) and common oak (*Quercus robur*), with an uneven forest density of 0.85, growth class 1. To determine the dynamics of pathological processes and the volume of drying, field studies and

information from the database of scientific data of the separate subdivision “Boyarka Forest Research Station” of the National University of Life and Environmental Sciences of Ukraine were used.

Detailed forest pathological surveys in the spruce dieback areas were carried out by laying out temporary trial plots around existing group tree dieback areas, according to generally accepted methods (Goychuk *et al.*, 2012; Methodological guidelines..., 2020; Puzrina *et al.*, 2021) and in accordance with regulatory reference materials (Standard of organizations of Ukraine..., 2007). The state of forest stands was determined by the average sanitary state index of trees (I_s), the health of each tree was determined in accordance with the sanitary rules in the forests of Ukraine (Resolution of the Cabinet of Ministers of Ukraine..., 2016).

The following studies were carried out during the fieldwork on the trial areas:

1. Assessment of sanitary state: sanitary state (I_s) of plantings were calculated using the equation (1):

$$I_s = \frac{\sum k_i \cdot n_i}{N}, \quad (1)$$

where I_s – index of sanitary state of plantings; k_i – tree state category (from I to VI); n_i – number of trees of the corresponding state category; N – total number of trees in the sample.

The degree of damage to plantings with a preference in the composition of Norway spruce was determined in accordance with the scale of values of sanitary state indices as a weighted average value for assessing the distribution of trees of different categories of condition. Based on the results of accounting for test areas, the index (average category) of the sanitary state of the spruce stand was calculated

According to the sanitary state indices, plantings are characterised by the following indicators: 1.0-1.50 – healthy; 1.51-2.50 –

weakened; 2.51-3.50 – severely weakened; 3.51-4.50 – drying; 4.51-6.00 – dry (Methodological guidelines..., 2020; Puzrina *et al.*, 2021).

2. Determination of the entomocomplex of insects-phytophagous: identification and counting of insects-xylophages of Norway spruce were carried out. Insect species, their abundance, and distribution in plantings were determined using pheromone traps. A barrier-type trap with a replaceable glass collector and a dispenser with artificially synthesized pheromone was used for accounting *Ips typographus* (manufacturer – BioChemTech, Ukraine). Phenological observations and detection of bark beetles during pheromone surveillance lasted from the second ten days of April to the first ten days of October (Zavada, 2017; Levchenko *et al.*, 2023). Barrier traps were used to detect bark beetles of subfamily *Scolytinae*, to catch adult bark beetles, a pheromone dispenser was attached to the trunk of live trees at the border between live and dead branches (Fig. 1).

Pheromone traps were hung at a height of 1.3 to 1.5 m above the ground at a distance of at least 15 m from each other and 20 meters from the wall of the forest and living trees. When hanging traps, temperature conditions and emergence periods of the bark beetle imago of *Ips typographus* were considered (Zavada, 2017; Puzrina *et al.*, 2021). Control of the number of bark beetles in traps was carried out every 7-10 days and ended on October 7. During the inspection, the traps were regularly checked and cleaned, as dead insects can scare away other insects from the population with their scent.

The population indices of insects that inhabited trees in the drying areas were determined by the pallet method on model spruce trees (Methodological guidelines..., 2020; Puzrina *et al.*, 2021). The state of the population and its impact on forest stands help to assess the quantitative characteristics of the

insect population, in particular: the number, prevalence, production of young beetles (the

number of emergence holes) and the density of the settlement.



Figure 1. Pheromone trap “Barrier” and a dispenser with artificially synthesized pheromone of *Ips typographus*

Source: photo by the authors

When studying the settlement density *Ips typographus*, model trees were cleaned of knots, and a 10 cm wide part of the bark was removed from the base to the top. To determine the settlement density by the number of mother galleries per 1 dm² and production of young beetles by

the number of emergence holes per 1 dm² (Table 1, Fig. 2) the method of accounting palettes was used at the settlement sites of each insect species of the bark beetle subfamily *Scolytinae*.

The collected material was analysed in the laboratory conditions (Fig. 3).

Table 1. Criteria for assessing the density of xylophage insects and the number of young generations

Species	Numerator – settlement density, (number of mother galleries); denominator – the number of the younger generation (emergence holes), units-dm ⁻²		
	low	average	high
<i>Ips typographus</i>	2.5 or less	2.6-6.0	6.1 or more
	10.0 or less	10.1-15.0	15.1 or more
<i>Pityogenes chalcographus</i>	10.0 or less	10.1-20.0	20.1 or more
	20.0 or less	20.1-30.0	30.1 or more
<i>Ips acuminatus</i>	2.0 or less	2.1-5.0	5.1 or more
	6.0 or less	6.1-10.0	10.1 or more

Source: Methodological guidelines for monitoring, recording and forecasting the spread of forest pests and diseases for the flat part of Ukraine (2020), N. Puzrina *et al.* (2021)



Figure 2. Bark beetle passages and emergence holes

Source: photo by the authors

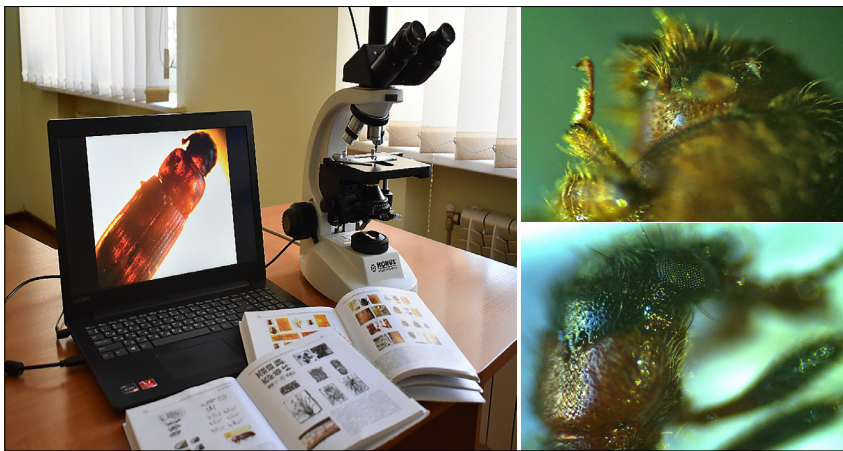


Figure 3. Identification of bark beetles

Source: photo by the authors

The Konus Trinocular Biorex 3 Biological 1,000X microscope was used to identify and photograph captured bark beetles. The authors adhered to the Convention on Biological Diversity (1992) standards and Convention on the Trade in Endangered Species of Wild Fauna and Flora (1973), so experimental studies of plants corresponded to national and international guidelines.

Results and Discussion

The development of drying foci in the study area began with a single death of trees during 2022, but already in 2023 group death prevailed, which tended to expand with the appearance of block and continuous foci over the entire area (Fig. 4). Based on the results of a continuous list of trees of the surveyed plantings on an area of 2.8 hectares, the

sanitary state index of tree species was established. The amplitude of the sanitary state index from 2.43 to 4.05 indicates an almost

uniform nature of weakening and allows identifying a number of factors that cause their weakening (Table 2).



Figure 4. Plantation under study (drying focus)

Source: photo by the authors

Table 2. Sanitary state index

Tree species	Number of trees of the corresponding category, units						Sanitary state index
	I	II	III	IV	V	VI	
<i>Picea abies</i>	9	119	546	398	47	425	IV,05
<i>Pinus sylvestris</i>	29	97	79	36	5	11	II,70
<i>Quercus robur</i>	0	1	7	21	0	0	III,68
<i>Betula pendula</i>	6	29	58	87	0	13	III,46
<i>Populus tremula</i>	2	8	5	0	0	1	II,43
<i>Alnus glutinosa</i>	4	9	48	43	0	3	III,32

Source: compiled by the authors

Assessing the sanitary state of a stand with a composition of 30% Norway spruce (*Picea abies*) aged 46 years, 20% Norway spruce (*Picea abies*) aged 62 years, 20% Scots pine (*Pinus sylvestris*), 30% European white Birch (*Betula pendula*) of natural origin and a slight admixture of European aspen (*Populus tremula*) and common Oak (*Quercus robur*) for the main tree species, it should be noted that the plantings have an average sanitary state index of IV,05 and belong to the drying ones. As can be seen from the analysis of the obtained data from a continuous list of trees of other species,

the *Betula pendula* and *Quercus robur* trees in the plantation are severely weakened.

It was found that trees without damage prevailed in the growth of trees with existing pathological signs of weakening and with indicators of wood decomposition. In accordance with the distribution of trees by diameter class, trees of different diameters died in the drying cells. Comparing the distribution of trees by categories of sanitary state in different diameter classes with the average for planting, it can be noted that the most vulnerable were trees in the smallest (8, 12 and

16 cm, respectively) and the largest (44 cm) diameter class (Fig. 5). Notably, trees with a

diameter of 44 cm as part of the plantation were 62 years old.

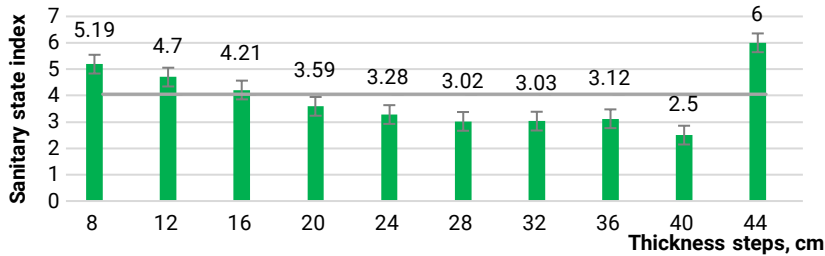


Figure 5. Distribution of *Picea abies* trees of different diameter class

Source: compiled by the authors

In the resulting drying foci, the number of bark beetles was concentrated, followed by the settlement of adjacent spruce trees, the expansion of existing ones and the development of new foci. Spruce trees of different diameter class with a predominance of larger specimens died in the drying foci. In general, during 2022-2023, in plantings with signs of drying out due to the spread of foci of pathological death of trees, the total relative loss in the number of trunks increased, and the condition of very weakened trees worsened to drying out (average index – IV,05). Such dynamics of drying out due to the spread of insect populations-xylophages is inherent in coniferous stands, in particular for pine stands, such dynamics were noted by A.M. Zhezhkun (2021) and N. Puzrina *et al.* (2022). Stem pests participate in the decomposition of wood of individual branches, parts of trunks and whole trees during feeding, but certain species of xylophagous insects under favorable conditions for reproduction and a sharp increase in the population can cause damage to viable trees, which is confirmed by N. Puzrina *et al.* (2022) in pine plantings and the results obtained for plantings with a predominance of common spruce.

Pheromone monitoring of forest stands provides information about the presence of

foci of phytophagous insects in the plantings, helps to determine the species composition, number and dynamics of potential expansion of the focus in plantings with an available food base. It becomes possible to determine the rate of population spread and the variability of morphological features of adult insects during the summer period, especially when the population density is low (the initial phase of focus development) and predict the timing of forest protection measures. Among the various forestry measures to reduce economic losses during outbreaks of bark beetle populations, sanitary tree felling is a method that is often practiced both in Europe and in North America, but in Ukraine, the ban on cutting down freshly planted trees during the “silence period” from April 1 to June 15 reduces the effectiveness of control of xylophage insects (Kramarets & Matsiakh, 2018).

The main tasks of using pheromone traps: detection of new foci; establishment of focus boundaries; establishment of the dynamics of phytophagous insect swarm; creation of the so-called “sexual vacuum” and disorientation of males to reduce the number with the help of pheromone traps, that is, violation of pheromone communication between the sexes (Mujezinovic *et al.*, 2023). According to research

by C. Fettig & A. Munson (2020) and M. Braccalini *et al.* (2024), it is possible to use pheromone traps with bark beetle aggregation inhibitors. Notably, the use of pheromones does not pollute the environment, as they are environmentally safe and act selectively on insects of a particular species. However, not all individuals are attracted to artificial pheromones; part of the population is insensitive to them and gives artificial pheromone-resistant offspring that are also resistant to these pheromones, so if traps are used for several years, a significant part of the population may not respond to the pheromone (Fruhbrodt *et al.*, 2023).

Insects were found and identified in the drying foci, including the sharp-dentated bark beetle *Ips acuminatus* Gyll., European spruce

bark beetle *Ips typographus* L., spruce wood engraver *Pityogenes chalcographus* L., synanthropic species *Palorus depressus* Fabricius, and entomophagous *Thanasimus formicarius*. Among them, the largest number of individuals was the European spruce bark beetle. During the entire period of observations of the traps, the capture of an adult European spruce bark beetle in the amount of 10-15 individuals per trap and synanthropic species *Palorus depressus* was recorded singly. Some species of predatory entomophagous, in particular ant beetle *Thanasimus formicarius* L., fell into the traps, and one of the traps contained the tanner beetle *Prionus coriarius* L., but their number was small and did not exceed one individual per trap during the ten-day catch period (Fig. 6).



Figure 6. Entomocomplex of spruce stands

Source: photo by the authors

To determine the degree of settlement of spruce by xylophage insects, model trees were used, each of them was cleaned of knots, and the length of areas of thin and thick bark was determined. Separately, on dry and drying trees, the species composition

was determined and the density of the settlement was taken into consideration, that is, the average number of species of the subfamily *Scolytinae* families *Curculionidae* per square decimeter of the trunk surface was determined (Table 3).

Table 3. Degrees of tree colonization by xylophage insects

Species	Density of settlements, mother galleries per 1·dm ²		Production of stem pests, emergence holes per 1·dm ²	
<i>Ips typographus</i>	22.8±6.4	high	33.6±2.9	high
<i>Pityogenes chalcographus</i>	6.4±0.2	low	32.4±1.2	average
<i>Ips acuminatus</i>	0.3±0.1	low	1.1±0.2	low

Source: compiled by the authors

The identified populations of xylophagous insects are characterized by different degrees of settlement, and they are also observed on trees of different categories, but only very weakened Norway spruce trees contained single specimens of *Ips acuminatus*. The population of *Ips typographus* has the highest settlement density, the number of beetles of the

younger generation or the production of stem pests of which averaged 34 holes per 1 dm² (Fig. 7). Despite the low density of the settlement, *Pityogenes chalcographus* has the ability to attack almost healthy trees and forms continuous mass populations in the surveyed plantings together with the European spruce bark beetle.



Figure 7. Production of stem pests

Source: photo by the authors

The process of degradation of spruce forests is highlighted in a number of studies by forestry scientists back in the 19th-20th centuries (Austara *et al.*, 1986; Christiansen & Bakke, 1989), when global climate warming, anthropogenic air and soil pollution, etc., were not yet noted. According to research by V. Kramarets & I. Matsiakh (2018) xylophage insects have a significant impact on the deterioration of spruce forests after their weakening under the influence of various factors (dry periods, thinning of stands due to logging, etc.). The largest number of species belongs to the family *Curculionidae*, in particular from the subfamily *Scolytinae*, in particular, the spruce tree is actively inhabited by the European spruce bark beetle *Ips typographus* and its accompanying bark beetle species, which is confirmed

by the current study. The researchers note that the drying processes of spruce and other tree species were previously explained as a consequence of the action of a single factor, but in forest biocenoses there is often a complex action of pathogens, ecological groups of insects-phytophagous, and factors of inanimate nature, the influence of which can be significantly modified by protective mechanisms

S. Hofmann *et al.* (2024) identified species-specific features of *Ips typographus*, which contribute to mass outbreaks, include the ability to successfully populate even healthy trees due to intraspecific pheromone communication, high fecundity, and phenological plasticity. *Ips typographus* is a multivoltine bark beetle that can form up to three generations per year. Most of the beetle's life cycle occurs under the

bark, where it reproduces and develops in the phloem. Consequently, the process of development of foci of mass reproduction of xylophage insects includes different phases, each of which differs in the typical population size, which is confirmed by N. Puzrina *et al.* (2022) in studies on pine plantations and current surveys. Population dynamics of *Ips typographus* in space and time, from the phases of low beetle numbers (endemic stage) to population growth and the outbreak stage, and especially in the dispersal stage, it is characterized by the search for a suitable habitat and nutrient plant. According to N. Puzrina *et al.* (2022), near mass breeding areas, where the population size is too large, migration centers are usually formed, where insects migrate to look for new places to settle. Migration foci exist for several years, until the population completely dissipates and does not return to the initial number.

S. Netherer *et al.* (2024) concluded that during the epidemic phase, mass aggregation using sex pheromones leads to rapid colonization of Norway spruce trees (*Picea abies*), which was also noted during the current study of spruce stands. They noted that the European spruce bark beetle is one of the most dangerous spruce pests. It penetrates under the bark of the tree and feeds on its cambial tissues, which leads to the death of the tree. During a drought, when the tree is already weakened, the bark beetle has a better chance of successful settlement and reproduction. In addition, the bark beetle is often a carrier of pathogenic fungi, such as fungi of the genus *Ophiostoma*, which can cause additional damage to the tree. These fungi spread through the vascular system of the tree, which leads to an even greater weakening of the spruce and accelerates its death.

According to the research by P. Lehmann *et al.* (2020), due to climate change, the distribution of most insect species is determined by temperature-dependent population dynamics

and trophic interactions. In a chronic pest focus, insects that attack trees are usually in a phase of increasing or concentrated abundance, due to the formation of populations with reduced density. L. Meshkova *et al.* (2017) note that they are characterized by a relatively moderate level of insect numbers (although it is increased compared to healthy forests) and a limited number of trees that have withered in the current year. Episodic foci, or foci of mass reproduction, are characterized by a short (3-5 years) period of development, a high level of population size and a significant volume of drying trees. In both cases, reversible and irreversible consequences for forest stands are possible, but in the latter case, when mass reproduction of insects occurs, complete destruction of the forest is usually observed.

Thus, the deterioration of the sanitary state of plantings of Norway spruce is the result of a complex impact of various factors, including abiotic and biotic factors, such as pathogens, insects, climate change, and human activity. Forest degradation includes the loss of resistance of trees to various negative factors, such as diseases and pest attacks, and a decrease in wood growth. To prevent environmental threats in spruce stands, it is effective to control pests and pathogens, as well as control and monitoring of xylophage insect populations and their population dynamics using pheromone traps, in particular.

Conclusions

An assessment of the sanitary state of the plantation with a composition of 30% Norway spruce (*Picea abies*) aged 46 years, 20% Norway spruce (*Picea abies*) aged 62 years, 20% Scots pine (*Pinus sylvestris*), 0% European white birch (*Betula pendula*) of natural origin and a slight admixture of European aspen (*Populus tremula*) and common Oak (*Quercus robur*) and it was found that due to the Norway spruce that

prevails in the composition, the plantings are classified as drying with a sanitary state index of IV,05. For *Pinus sylvestris*, this indicator was II,70; for *Quercus robur* – III,68; for *Betula pendula* – III,46; for *Populus tremula* – II,43; for *Alnus glutinosa* – III,32 respectively. For *Picea abies*, the distribution of trees by categories of sanitary state in different diameter classes was compared with the average indicators for the stand, and a significant deterioration in the sanitary state of trees with the smallest (8, 12 and 16 cm, respectively) and the largest (44 cm) diameter class (age 62 years) was found.

During the surveys, insects were identified in pheromone traps, including *Ips acuminatus* with low settlement density (0.3 ± 0.1 mother galleries per 1-dm^2) and the production of young beetles (1.1 ± 0.2 emergence holes per 1-dm^2), *Pityogenes chalcographus* with low settlement density (6.4 ± 0.2 mother galleries per 1-dm^2) and the average production of young beetles (32.4 ± 1.2 emergence holes per 1-dm^2) and *Ips typographus* with the highest

settlement density values (22.8 ± 6.4 mother galleries per 1-dm^2) and production of young beetles (33.6 ± 2.9 emergence holes per 1-dm^2), respectively.

Pheromone monitoring determines the species composition of xylophage insects, the rate of population spread, the variability of morphological features of adult insects during the summer period, and predict the timing of forest protection measures. Therefore, in order to preserve natural complexes and properly maintain the forest fund in an appropriate sanitary state for the implementation of protective, water-regulating, aesthetic and sanitary-hygienic functions of forests, it is necessary to constantly monitor and take a set of measures to improve the sanitary condition.

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None.

Conflict of Interest

None.

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Анотація. Комахи-ксилофаги можуть завдати значної шкоди лісам, викликаючи всихання дерев. Феромонний моніторинг дозволяє вчасно виявити появу цих шкідників і вжити заходів для їх контролю. Мета дослідження полягала у визначенні санітарного стану ялинового насадження та феромонного моніторингу популяцій комах-ксилофагів. Ступінь пошкодження насадження ялини звичайної визначали відповідно до шкали значень індексів санітарного стану як середньозважене значення оцінки розподілу дерев різних категорій стану. За результатами обліків на пробних площах розраховано індекс (середню категорію) санітарного стану ялинового деревостану загалом, встановлено, що найбільш уразливими до патологічних чинників виявилися дерева в найменших (8, 12 та 16 см відповідно) та найбільшому (44 см) ступенях товщини. Використання феромонного моніторингу для оцінки стану лісових насаджень мало на меті виявлення наявності шкідливих організмів на певній території, визначення їх видового складу, чисельності та динаміки розвитку. У лісовому масиві, де було проведено феромонний облік, виявлено та ідентифіковано комах, включаючи вершинного короїда *Ips acuminatus*, короїда-типографа *Ips typographus*, гравера звичайного *Pityogenes chalcographus*, синантропного виду *Palorus*

depressus та хижого мурахожука *Thanasimus formicarius*. Найбільша кількість особин у пастках фіксувалася у короїда-типографа протягом усього періоду спостережень, де на кожную пастку відловлювалося від 10 до 15 особин, а також у синантропного виду *Palorus depressus*. Проаналізовано потенційні можливості розмноження популяції комах-ксилофагів, найбільшу щільність поселення має популяція *Ips typographus*, чисельність жуків молодого покоління або продукція стовбурових шкідників якого становила в середньому 34 отвори на 1 дм². Незважаючи на низьку щільність поселення, *Pityogenes chalcographus* має здатність атакувати практично здорові дерева і в обстежуваному насадженні формує суцільні масові популяції спільно із короїдом-типографом. Отримані результати будуть корисними для моніторингу і контролю шкідників, що дозволить вчасно виявити та оцінити рівень загрози для лісових насаджень

Ключові слова: комахи-фітофаги; облік; феромонні пастки; *Ips typographus*; *Pityogenes chalcographus*