Parameters of *Pinus sylvestris* health condition and *Ips acuminatus* population in pure and mixed stands of Sumy region

V.L. Meshkova¹, I.O. Bobrov²

Outbreaks of bark beetles have increased in recent years in various regions. Pine engraver beetle (*Ips acuminatus* (Gyllenhal, 1827); Coleoptera: Curculionidae: Scolytinae) is most common in the pine forests of many European countries. Research on its biology and spread carried out in different natural conditions, phases of pest outbreak and considered various parameters to characterize the population of the pest and forest health condition.

The aim of the research was to compare the health condition of Scots pine stands and population parameters of *I. acuminatus* in its two generations in pure and mixed stands in Polissya and Forest-steppe parts of Sumy region. Research was carried out in 2017 in the pure Scots pine stands and mixed stands with Scots pine and other forest species in Polissya (State Enterprise «Seredyno-Budsky Agroforest Economy»; State Enterprise «Seredyno-Budsky Forest Economy») and Forest-steppe parts (State Enterprise «Velykopysarivske Agroforest Economy»; State Enterprise «Okhtyrske Forest Economy») of Sumy region at 26 sample plots. In sample plots, parameters of forest health condition and bark beetle population were assessed in June and in September, after completion of development of spring and summer generation of *I. acuminatus*.

By most of the parameters assessed, significant differences between sample plots in Forest-Steppe and Polissya parts of Sumy region were not found. In pure Scots pine stands the mean area of bark beetles’ foci and bark beetles’ production were larger in Forest-steppe in June, and the density of *Ips acuminatus* nuptial chambers in June and September.

In pure Scots pine stands the area of *I. acuminatus* focus, the number of colonized trees, the proportion of recently died trees, health condition indices, the density of egg galleries and nuptial chambers as well as young beetle’s production increased from June to September. In mixed stands the focus area, the number of colonized trees and health condition index increased insignificantly, and population parameters of *I. acuminatus* decreased from June to September. Pure Scots pine stands changed the health condition from «severely weakened» to «drying up» in three months, and mixed ones remained in the «weakened» category.
In pure pine stands, the density of egg galleries and beetles of the young generation increased for three months from the lower limit of a moderate level to a high level, the density of nuptial chambers – from low to a high level. In mixed stands, all population parameters of *I. acuminatus* correspond to a low population level. The parameters characterizing the investigated foci of *I. acuminatus* in the Sumy region significantly correlated with the participation of pine in the stand composition, and in September the correlation is closer than in June. The data obtained indicate the feasibility of creating predominantly mixed pine stands.

**Key words:** bark beetle; outbreak; health condition index; tree mortality; egg galleries; nuptial chambers; young beetle’s production.

**Introduction.** Outbreaks of bark beetles have increased in recent years in various regions (Wermelinger, Rigling, Schneider, & Dobbertin, 2008; Siitonen, 2014; Andreieva, Guzii, & Vyshnevskyi, 2018; Meshkova, 2019), which is explained by climate change (Andreieva, & Goychuk, 2018; Andreieva, Korma, Zhytova, Martyanchuk, & Vyshnevskyi, 2020) and anthropogenic impacts (Björkman, Bylund, Nilsson, Nordlander, & Schroeder, 2015; Foit, 2015; Shvidenko, Buksha, Krakovska, & Lakya, 2017; Meshkova, Borysenko, & Pryhornytskyi, 2018; Jaime et al., 2019). Pine engraver beetle (*Ips pini* (Gyllenhal, 1827); Coleoptera: Curculionidae: Scolytinae) is most common in the pine forests of many European countries (Colombari et al., 2012, 2013; Andreieva, Vyshnevskyi, & Boliukh, 2019). Its harmfulness increases due to its possibility of vectoring ophiostomatoid fungi to Scots pine trees (Davydenko, Vasaitis, & Menkis, 2017; Davydenko, 2019).

Recently, much research has been published on the biological characteristics of the pine engraver beetle and its distribution in forest stands (Colombari et al., 2012, 2013; Siitonen, 2014; Meshkova, Borysenko, & Pryhornytskyi, 2018; Meshkova, Kochetova, Zinchenko, & Skrylnik, 2017, Andreieva, Guzii, & Vyshnevskyi, 2018; Andreieva, Vyshnevskyi, & Boliukh, 2019).

Pine engraver beetle is found to inhabit trees and forest residues of pine at the beginning of the growing season – in April, but in a few weeks, the females again lay eggs from which the sister brood develops (Colombari et al., 2012). Due to the ability of the pine engraver beetle to hibernate as larvae and imago, under the bark and in the forest litter, to develop in several generations a year, including sister brood, tree colonization occurs throughout whole summer (Meshkova, Kochetova, Zinchenko, & Skrylnik, 2017). Infested trees have been dying for several weeks (Meshkova, 2019). External signs of tree colonization by pine engraver beetle are the change in the color shade of needles and the presence within the projection of crowns of fallen twigs and branches with the galleries of this pest (Colombari et al., 2012). The study of the spatial dynamics of the foci of pine engraver beetle revealed that they are formed from a well-lighted forest wall, clear-cuts or other plots where there has been intensive forest thinning or removal (Andreieva, Guzii, & Vyshnevskyi, 2018; Meshkova, Borysenko, & Pryhornytskyi, 2018).

However, each researcher carried out his studies in certain natural conditions, in different phases of pest outbreak and considered various parameters to characterize the population of the pest and forest health condition. We assumed, that decline of Scots pine caused by pine engraver beetle depends on the natural zone and forest stand structure, particularly its tree composition, and the population parameters of this pest vary in different generations of the same pest at the same year.

**Objects and methods.** Object of research – forest health condition and *Ips acuminatus* population parameters. Subject of research – parameters of Scots pine (*Pinus sylvestris* L.) health condition and *Ips acuminatus* population in pure and mixed stands.

The aim of the research was to compare the health condition of Scots pine stands and population parameters of *Ips acuminatus* in its two generations in pure and mixed stands in Polissya and Forest-steppe parts of Sumy region.

Research was carried out in 2017 in the pure Scots pine stands and mixed stands with Scots pine and other forest species in Polissya (State Enterprise «Seredyno-Budsky Agroforest Economy»; State Enterprise «Seredyno-Budsky Forest Economy») and Forest-steppe parts (State Enterprise «Velykopysarsivske Agroforest Economy»; State Enterprise «Okhtyrskie Forest Economy») of Sumy region.

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The age of stands in sample plots was from 40 to 65 years old (see Tab. 1).

Two groups of parameters were analyzed in sample plots. The first group described the health condition of the forest stand, and the second group characterized the bark beetle population. Taking into account the fact that pure pine stands are represented in all sample plots with fresh relatively poor forest site conditions (*B*), and mixed stands in all sample plots with fresh relatively poor forest site conditions (*A*), all the results of comparing the parameters stand health condition and the bark beetle population in the groups of sample plots *A* and *B* correspond to a comparison of pure and mixed forests.
Table 1

Characteristics of sample plots in the bark beetles’ foci in Sumy region

<table>
<thead>
<tr>
<th>Sample plot (SP)</th>
<th>Forest plot</th>
<th>Subcom-partment</th>
<th>Area, ha</th>
<th>Age, years</th>
<th>Species composition*</th>
<th>Forest site conditions**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92</td>
<td>15</td>
<td>12.5</td>
<td>42</td>
<td>10 Pinsyl</td>
<td>A&lt;sub&gt;2&lt;/sub&gt;</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>2</td>
<td>14.7</td>
<td>54</td>
<td>10 Pinsyl + Betpen</td>
<td>A&lt;sub&gt;1&lt;/sub&gt;</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>1</td>
<td>3.5</td>
<td>44</td>
<td>10 Pinsyl</td>
<td>A&lt;sub&gt;2&lt;/sub&gt;</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
<td>37</td>
<td>9.8</td>
<td>60</td>
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<td>B&lt;sub&gt;2&lt;/sub&gt;</td>
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<tr>
<td>5</td>
<td>84</td>
<td>12</td>
<td>10.7</td>
<td>62</td>
<td>9 Pinsyl 1Betpen</td>
<td>B&lt;sub&gt;2&lt;/sub&gt;</td>
</tr>
<tr>
<td>6</td>
<td>110</td>
<td>12</td>
<td>6.3</td>
<td>54</td>
<td>10 Pinsyl + Betpen</td>
<td>B&lt;sub&gt;1&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

State Enterprise «Seredyno-Budsky Agroforest Economy» (Polissya)

| 7               | 43          | 10              | 11.9    | 43         | 8 Pinsyl 2Betpen     | B<sub>2</sub>           |
| 8               | 5           | 14              | 7.5     | 51         | 7 Pinsyl 3Betpen     | B<sub>2</sub>           |
| 9               | 12          | 4               | 17.9    | 54         | 8 Pinsyl 2Betpen     | B<sub>2</sub>           |
| 10              | 72          | 19              | 10.4    | 56         | 10 Pinsyl            | A<sub>1</sub>           |
| 11              | 85          | 27              | 13.7    | 45         | 10 Pinsyl            | A<sub>1</sub>           |
| 12              | 92          | 13              | 18.4    | 61         | 10 Pinsyl            | A<sub>1</sub>           |
| 13              | 94          | 20              | 3.7     | 65         | 10 Pinsyl            | A<sub>1</sub>           |

State Enterprise «Velykopsarivske Agroforest Economy» (Forest-steppe)

| 14              | 2           | 4               | 10.7    | 56         | 10 Pinsyl            | A<sub>1</sub>           |
| 15              | 7           | 12              | 17.3    | 55         | 10 Pinsyl            | A<sub>1</sub>           |
| 16              | 10          | 15              | 8.4     | 47         | 10 Pinsyl            | A<sub>1</sub>           |
| 17              | 10          | 18              | 6.7     | 62         | 10 Pinsyl            | A<sub>1</sub>           |
| 18              | 12          | 8               | 15.9    | 51         | 7 Pinsyl 3 Betpen    | B<sub>2</sub>           |
| 19              | 12          | 18              | 10.4    | 56         | 8 Pinsyl 2 Betpen    | B<sub>2</sub>           |
| 20              | 24          | 2               | 18.3    | 44         | 9 Pinsyl 1 Betpen    | B<sub>2</sub>           |

State Enterprise «Okhtyrske Forest Economy» (Forest-steppe)

| 21              | 124         | 13              | 20.5    | 53         | 10 Pinsyl            | A<sub>1</sub>           |
| 22              | 50          | 3               | 4.7     | 62         | 10 Pinsyl            | A<sub>1</sub>           |
| 23              | 50          | 42              | 5.8     | 62         | 10 Pinsyl + Betpen   | A<sub>2</sub>           |
| 24              | 43          | 14              | 6.9     | 54         | 8 Pinsyl 1 Betpen 1 Querob      | B<sub>2</sub>           |
| 25              | 58          | 24              | 11.4    | 67         | 7 Pinsyl 2 Querob 1 Betpen   | B<sub>2</sub>           |
| 26              | 62          | 74              | 10.1    | 63         | 7 Pinsyl 2 Betpen 1 Querob   | B<sub>2</sub>           |

Notes: *Pinsyl – Pinus sylvestris; Querob – Quercus robur; Querub – Quercus rubra; Betpen – Betula pendula; ** B<sub>1</sub> – fresh relatively poor forest type condition; C<sub>1</sub> – fresh relatively fertile forest type condition; D<sub>1</sub> – fresh fertile forest type condition (classes by Alekseev-Pogrebnyak).

All parameters were assessed twice – in June and in September, after completion of the development of spring and summer generation of Ips acuminatus.

Average focus area was evaluated in each subcompartment with a sample plot by stand inspection (Mozolevskaya, Kataev, & Sokolova, 1984). The proportion of trees colonized by Ips acuminatus as well as the health condition of trees were evaluated only for Scots pine trees in all sample plots. Category of health condition for each tree was evaluated on a range of visual characteristics according to «Sanitary rules in the forests of Ukraine» (Anonimous, 1995) by the following classes: 1<sup>st</sup> – healthy; 2<sup>nd</sup> – weakened; 3<sup>rd</sup> – severely weakened; 4<sup>th</sup> – drying up; 5<sup>th</sup> – recently died; 6<sup>th</sup> – died over a year ago. Health condition index (HCI) was calculated as mean weighted from trees number of each category of health condition, separately for all living and dead trees (HCI<sub>1-4</sub>) and for living trees only (HCI<sub>1-6</sub>). The number of egg galleries, nuptial chambers, and young beetles was evaluated in model branch sections (with diameter 0.5-2.6 cm and length 10-
15 cm, 7–10 branches per sample plot) and recalculated on 1 dm².

Summary statistics, one-way analysis of variance (ANOVA) and correlation analysis (Atramentova & Utevskaya, 2008) were performed using Microsoft Excel applications.

Results and discussion. The analysis shows a significant difference by the mean area of bark beetles’ foci in pure and mixed stands both in Polissya and Forest-steppe parts of Sumy region (Fig. 1).

In the Polissya part of Sumy region, the mean area of bark beetles’ foci in pure pine stands was significantly larger than in mixed ones. In June it was 8 times larger (F_{fact} = 4.72; F_{0.05} = 4.70; p = 0.05), and in September – 17.7 times larger (F_{fact} = 14.0; F_{0.05} = 4.8; p = 0.003). In the Forest-steppe part of Sumy region the mean area of bark beetles’ foci in pure and mixed stands (F_{fact} = 2.1; F_{0.05} = 4.6; p = 0.5) and F_{fact} = 0.1; F_{0.05} = 5.3; p = 0.7 respectively).

In the Polissya part of Sumy region, the proportion of the trees of the 5th category of health condition was also significantly larger than in mixed ones. In June it was 4 times larger (F_{fact} = 3.5; F_{0.05} = 4.5; p = 0.01) and in September – 4 times larger (F_{fact} = 57.5; F_{0.05} = 4.5; p = 0.001), and in September – 17.3 times larger (F_{fact} = 180.6; F_{0.05} = 4.8; p < 0.001).

In the Polissya part of Sumy region the mean foci area increased in September compared to June in 2.2 times in the pure pine stands (F_{fact} = 7.5; F_{0.05} = 4.5; p = < 0.01) and did not increase in the mixed stands (F_{fact} = 0.04; F_{0.05} = 5.99; p = 0.85). In the Forest-steppe part of Sumy region the mean foci area increased in September compared to June in 1.6 times in the pure pine stands (F_{fact} = 12.5; F_{0.05} = 4.7; p = 0.004) and increased insignificantly in the mixed stands (F_{fact} = 0.01; F_{0.05} = 4.96; p = 0.94).

At the time of June assessment, the trees of the 5th and 6th categories of health condition were available in all sample plots. Proportion of trees which have died over a year ago (the 6th category of health condition) could not change during the season, so the comparison of its share was made only according to the assessment made in June (Fig. 2).

Proportion of the trees of the 6th category of health condition in June was insignificantly larger in pure pine stands than in mixed ones in Polissya (F_{fact} = 0.7; F_{0.05} = 4.8; p = 0.4) and significantly 4 times larger in the Forest-steppe part of Sumy region (F_{fact} = 11; F_{0.05} = 4.8; p = 0.01). The differences in this parameter between Polissya and Forest-steppe parts of Sumy region were insignificant both for pure (F_{fact} = 0.5; F_{0.05} = 4.6; p = 0.2) and mixed stands (F_{fact} = 2.3; F_{0.05} = 5.3; p = 0.2).

Recently died Scots pine trees (the 5th category of health condition) were found in June in all sample plots in the pure Scots pine stands and in 90 % sample plots in mixed stands (Fig. 3). Assessment in September shows an increase the proportion of the trees of the 5th category of health condition compared to June at all sample plots in pure Scots pine stands and in about half of sample plots in mixed stands.

In Polissya part of Sumy region the difference between the proportion of the trees of the 5th category of health condition was significantly (3.3 times) larger in pure Scots pine stands than in mixed stands in June (F_{fact} = 5.5; F_{0.05} = 4.7; p = 0.04) and in September (F_{fact} = 9.5; F_{0.05} = 4.7; p = 0.01). In Forest-steppe part of Sumy region the difference between pure and mixed stands was insignificant in June (F_{fact} = 3.7; F_{0.05} = 4.8; p = 0.1) and significant (7.4 times) in September (F_{fact} = 116.7; F_{0.05} = 4.8; p < 0.001).

In Polissya part of Sumy region the proportion of the trees of the 5th category of health condition was significantly larger in September (5.7 times) compared to June in pure stands (F_{fact} = 27.9; F_{0.05} = 4.5; p < 0.001) and insignificant in mixed stands (F_{fact} = 1.2; F_{0.05} = 5.0; p = 0.3). In Forest-steppe part of Sumy region the proportion of the trees of the 5th category of health condition was also significantly larger (5.7 times) in September compared to June in pure stands (F_{fact} = 107.7; F_{0.05} = 4.7; p < 0.001) and insignificant in mixed stands (F_{fact} = 1.8; F_{0.05} = 5.0; p = 0.2). The proportion of recently dead Scots pine trees differed insignificantly between sample plots in Polissya and Forest-steppe part of Sumy region for pure Scots
pine stands in June ($F_{fact.} = 0.2; F_{0.05} = 4.6; p = 0.6$) and September ($F_{fact.} = 1.3; F_{0.05} = 4.6; p = 0.3$), as well as for mixed stands in June ($F_{fact.} = 0.8; F_{0.05} = 5.0; p = 0.4$) and September ($F_{fact.} = 0.3; F_{0.05} = 5.0; p = 0.6$).

**Fig. 3. Proportion of Scots pine trees of the 5th category of health condition in pure and mixed pine stands in the Polissya and Forest-steppe parts of Sumy region in different dates of assessment**

Health condition index for all living and dead trees ($HCl_{1-6}$) was significantly larger in pure Scots pine stands compared to mixed stands in both natural zones and in both dates of assessment (Fig. 4).

**Fig. 4. Health condition index for all living and dead trees ($HCl_{1-6}$) in pure and mixed pine stands in the Polissya and Forest-steppe parts of Sumy region in different dates of assessment**

Such difference of $HCl_{1-6}$ between pure and mixed stands was significant for Polissya part of Sumy region in June ($F_{fact.} = 9.5; F_{0.05} = 4.8; p = 0.01$) and September ($F_{fact.} = 20.5; F_{0.05} = 4.8; p = 0.001$) as well as for Forest-steppe part of Sumy region in June ($F_{fact.} = 59.9; F_{0.05} = 4.8; p < 0.001$) and September ($F_{fact.} = 223.7; F_{0.05} = 4.8; p < 0.001$).

The $HCl_{1-4}$ increased significantly in September compared to June in pure ($F_{fact.} = 4.3; F_{0.05} = 4.5; p = 0.1$) and mixed stands of Polissya part of Sumy region ($F_{fact.} = 4.4; F_{0.05} = 6.0; p = 0.1$). However, such an increase of $HCl_{1-4}$ was significant in the Forest-steppe part of Sumy region both for pure ($F_{fact.} = 9.8; F_{0.05} = 5.0; p = 0.01$) and mixed stands ($F_{fact.} = 9.8; F_{0.05} = 5.0; p = 0.01$).

The difference of $HCl_{1-4}$ between Polissya and Forest-steppe parts of Sumy region was insignificant for pure Scots pine stands in June ($F_{fact.} = 1.4; F_{0.05} = 4.6; p = 0.3$) and September ($F_{fact.} = 2.1; F_{0.05} = 4.6; p = 0.2$) as well as for mixed stands in June ($F_{fact.} = 0.7; F_{0.05} = 5.3; p = 0.4$) and September ($F_{fact.} = 0.8; F_{0.05} = 5.3; p = 0.4$).

The number of trees colonized by pine engraver beetle was higher in pure stands compared to mixed ones (Fig. 6).

This difference in Polissya part of Sumy region was 7.8 times in June ($F_{fact.} = 12.3; F_{0.05} = 4.8; p = 0.005$) and 5.2 times in September ($F_{fact.} = 12.2; F_{0.05} = 4.8; p = 0.005$). In the Forest-steppe part of Sumy region the difference between a number of colonized trees in pure and mixed stands was 4.8 times in June ($F_{fact.} = 13.3; F_{0.05} = 5.0; p = 0.005$) and 9.4 times in September ($F_{fact.} = 34.2; F_{0.05} = 5.0; p = 0.00025$).

Increase of colonized trees from June to September in Polissya part of Sumy region in pure stands (3.8 times) is significant ($F_{fact.} = 17.4; F_{0.05} = 4.7; p = 0.001$), for pure Scots pine stands in June ($F_{fact.} = 1.6; F_{0.05} = 4.6; p = 0.2$) and September ($F_{fact.} = 2.0; F_{0.05} = 4.6; p = 0.2$), as well as for mixed stands in June ($F_{fact.} = 0.1; F_{0.05} = 5.3; p = 0.7$) and September ($F_{fact.} = 1.6; F_{0.05} = 5.3; p = 0.2$).

Health condition index for living trees ($HCl_{1-4}$) was significantly larger in pure Scots pine stands compared to mixed stands in both natural zones and in both dates of assessment (Fig. 5).
В. Л. Мєшкова, І. О. Бобров. Показники санітарного стану Pinus sylvestris та популяцій Ips acuminatus у чистих і мішаних...
September (F_{fact.} = 13.3; F_{0.05} = 4.6; p = 0.003). In mixed stands, the differences between Polissya and Forest-steppe parts of Sumy region were insignificant both in June (F_{fact.} = 1.9; F_{0.05} = 5.3; p = 0.2) and September (F_{fact.} = 0.4; F_{0.05} = 5.3; p = 0.6).

The density of young beetles (production) of pine engraver beetle was significantly larger in pure pine stands compared to mixed ones (Fig. 9).

Fig. 9. Production of bark beetles in pure and mixed pine stands in the Polissya and Forest-steppe parts of Sumy region in different dates of assessment

The difference of bark beetles’ production in pure and mixed pine stands in the Polissya part of Sumy region was significant in June (F_{fact.} = 6.3; F_{0.05} = 4.6; p = 0.03) and insignificant in September (F_{fact.} = 2.3; F_{0.05} = 4.6; p = 0.2). Such differences in mixed stands were also significant in June (F_{fact.} = 7.8; F_{0.05} = 5.3; p = 0.02) and insignificant in September (F_{fact.} = 0.2; F_{0.05} = 5.3; p = 0.6).

Within the age range of Scots pine stands in sample plots (40–65 years old), no dependence of forest condition and bark beetle population parameters was found on the age of stands (r – 0.01-0.18; p>0.1). A significant dependence of foci area, the number of colonized trees, the proportion of recently died trees, HCl_{1,6}, HCl_{1,4}, the density of egg galleries, nuptial chambers, and production from proportion of Scots pine in the stand composition was shown, which was in September closer than in June (Tab. 2).

### Table 2

<table>
<thead>
<tr>
<th>Parameters</th>
<th>June</th>
<th>September</th>
<th>June</th>
<th>September</th>
<th>June</th>
<th>September</th>
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<tr>
<td>Foci area</td>
<td>0.65</td>
<td>0.8</td>
<td>0.16</td>
<td>0.12</td>
<td>4.19</td>
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<td>Number of colonized trees</td>
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<td>0.74</td>
<td>0.16</td>
<td>0.14</td>
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<td>Proportion of trees of 5 HCl</td>
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<td>0.13</td>
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<td>Density of egg galleries</td>
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<td>0.14</td>
<td>0.12</td>
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<tr>
<td>Density of nuptial chambers</td>
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<td>0.73</td>
<td>0.17</td>
<td>0.14</td>
<td>3.49</td>
<td>5.23</td>
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<tr>
<td>Production</td>
<td>0.69</td>
<td>0.81</td>
<td>0.15</td>
<td>0.12</td>
<td>4.67</td>
<td>6.77</td>
</tr>
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</table>

Note: *N = 26; t_{0.05} = 2.06; t_{0.01} = 2.8 – italic; t_{0.001} = 3.75 – bold.

### Conclusions

By most of the parameters of *Ips acuminatus* outbreak, significant differences between sample plots in Forest-Steppe and Polissya parts of Sumy region were not found. In pure Scots pine stands the mean area of bark beetles’ foci and bark beetles’ production were larger in Forest-steppe in June, and the density of *Ips acuminatus* nuptial chambers in June and September.

In pure Scots pine stands the area of *Ips acuminatus* focus, the number of colonized trees, the proportion of recently died trees, health condition indices, the density of egg galleries and nuptial chambers, as well as young beetle’s production, increased from June to September. In mixed stands, the focus area, the number of colonized trees and health condition index increased insignificantly, and population parameters of *Ips acuminatus* decreased from June to September. Pure Scots pine stands changed the health condition from «severely weakened» to «drying up» in three months, and mixed ones remained in the «weakened» category.
The abundance of *Ips acuminatus* in pure pine stands by the density of egg galleries and by production (the density of beetles of the young generation) increased for three months from the lower limit of a moderate level to a high level, by the density of nuptial chambers – from low to a high level. In mixed stands, all population parameters of *Ips acuminatus* correspond to a low population level.

The parameters characterizing the investigated foci of *Ips acuminatus* in the Sumy region significantly correlated with the participation of pine in the stand composition, and in September the correlation is closer than in June.

The data obtained indicate the feasibility of creating predominantly mixed pine stands.

**References**


Wermeling, B., Rigling, A., Schneider, M. D., & Dobbertin, M. (2008). Assessing the role of bark-
У чистих соснових насадженнях середня площа осередку *I. acuminatus*, кількість заселених дерев, частка свіжого сухостою, індекс санітарного стану сосни, щільність маточних ходів і шлюбних камер корідія, а також його продукція збільшувалась від червня до вересня. У мішаних насадженнях за цей період середня площа осередку *I. acuminatus* та індекс санітарного стану сосни змінилися недостовірно, а параметри популяції *I. acuminatus* зменшилися. За санітарним станом впродовж трьох місяців часті соснові насадження змінили стану від «сильно осlabленних» до «всіхуючих», а мішані залишилися «осlabленями».

У чистих соснових насадженнях щільність маточних ходів і продукція зросли протягом трьох місяців від нижньої межі помірного рівня до високого рівня, а щільність шлюбних камер – від низького до високого рівня. У мішаних насадженнях усі параметри популяції *I. acuminatus* відповідають низькому рівню. Значення показників, які характеризують обстежені осередки *I. acuminatus* у Сумській області, достовірно кореляють із участю сосни у складі насаджень; у вересні зв’язок є тіснішим, ніж у червні.

З погляду біотичної стійкості, одержані дані свідчать про доцільність створення переважно мішань соснових насаджень.

**Ключові слова**: корідій; спалахи; індекс санітарного стану; відпад дерев; маточні ходи; шлюбні камери; продукція молодих жуків.

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Европи. Наведення його біології і розпростра­нення провели в різних природних умовах, фа­зах вспышки і учитували різні показники для ха­рактеристики популяції вредителя і санітарно­го стану насаджень.

**Цель исследований** заключалась в сравнении са­нитарного состояния сосны обыкновенной и пара­метров популяции вершинного короеда двух поко­лений в чистых и смешанных насаждениях полес­ской и лесостепной зон Сумской области. Исследо­вания проведены в 2017 г. на 26 пробных площадях, заложенных в полесской (ГП «Середино-Будский агролесхоз»; ГП «Середино-Будское лесное хозяй­ство») и лесостепной частях (ГП «Великописарев­ский агролесхоз»; ГП «Ахтырское лесное хозяй­ство») Сумской области. На пробных площадях оценивали показатели санитарного состояния на­саждений и популяций вершинного короеда в июне и сентябре – после завершения развития его весен­него и летнего поколений.

По большинству оцененных параметров не об­наружено достоверных различий между пробными площадями в полесской и лесостепной зонах Сум­ской области. В чистых сосновых насаждениях средняя площадь очага короеда и его продукция (плотность молодых жуков) были более высокими в лесостепной части Сумской области в июне, а плотность брачных камер – в июне и сентябре.

В чистых сосновых насаждениях средняя пло­щадь очага *I. acuminatus*, количество заселенных деревьев, доля свежего сухостоя, индекс сани­тарного состояния сосны, плотность маточных хо­дов и брачных камер короеда, а также его продук­ция возрастали с июня по сентябрь. В смешанных насаждениях за этот период средняя площадь оча­га *I. acuminatus* и индексы санитарного состояния сосны изменились недостоверно, а параметры по­пуляции *I. acuminatus* уменьшились. По санитарно­му состоянию за три месяца чистые сосновые на­саждения изменили статус с «сильно ослабленных» на «усыхающие», а смешанные остались «ослабленными».

В чистых сосновых насаждениях плотность маточных ходов и продукция возросли за три меся­ца от нижней границы умеренного уровня до высокого уровня, а плотность брачных камер – от низкого до высокого уровня. У смешанных насажде­ниях все параметры популяции *I. acuminatus* со­ответствуют низкому уровню. Значения показа­телей, характеризующих обследованные очаги *I. acuminatus* в Сумской области, достоверно кор­релируют с долей сосны в составе насаждений, а в сентябре свыше более тесна, чем в июне.

С точки зрения биотической устойчивости, полученные данные свидетельствуют о целесоо­бразности создания преимущественно смешанных сосновых насаждений.

**Ключевые слова:** короед; вспышка; индекс са­нитарного состояния; отпад деревьев; маточные ходы; брачные камеры; продукция молодых жуков.