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EVALUATION OF HARM OF STEM INSECTS IN PINE FORESTS

The score of some traits for stem insects' injuriousness evaluation was clarified using the data from Forest-Steppe and Steppe zones of Ukraine. Physiological harmfulness of *Monochamus galloprovincialis* can be scored as 4-15 points, of *Ips sexdentatus* and *I. acuminatus* as 4-5 points. Depending on preferences to colonize the different parts of stem, technical injuriousness of *M. galloprovincialis* is 12-13.8 points, of *I. sexdentatus*- 3.9-4.5 points, and of *I. acuminatus* -2.8-3.6 points. By general injuriousness, adjusted for insect spread, *I. acuminatus* can be low or moderately harmful in Kharkiv region and non-harmful or low harmful in Luhansk region. *I. sexdentatus* can be moderately harmful in Kharkiv region and non-harmful or low harmful in Luhansk region.

Keywords: stem insect; health condition; maturation feeding; physiological injuriousness; technical injuriousness; general injuriousness.

Introduction

The guild "stem pests" includes the insects, which develop, at least the part of their life cycle, inside xylem or phloem tissues of trees. Traditionally, it is the insects of families Scolytidae, Buprestidae and Cerambycidae that are most often considered as stem pests (Lieutier, et al., 2004). Stem pests of seedlings and saplings are considered as "the pests of unclosed plantations" or "the pests of young stands", and special approach has been developed to evaluate their injuriousness (Meshkova, 2016).

Some stem pests make their galleries and undergo maturation feeding in living trees, which leads to their weakening or death. These pests manifest the so-called physiological injuriousness (Mozolevskaya, 1974). Sometimes their galleries are rather deep in the wood, which causes the deterioration of its quality, so these pests manifest the so-called technical injuriousness (Mozolevskaya, 1974). Other species colonize only severely weakened, dead, wind-broken or felled trees and never colonize healthy or slightly weakened trees. These insects are not dangerous for living trees and are even useful to forest, because they take part in destruction of dead wood, but they cause considerable losses of harvested wood and thus manifest technical injuriousness.

An approach to evaluation of stem pests injuriousness was developed by E. Mozolevskaya (1974). According to this approach, the appraisal by points of general injuriousness for certain insect species must take into account physiological injuriousness and technical injuriousness. The scoring of different peculiarities of tree colonization and life cycle of stem pests was evaluated taking into consideration also timber value of damaged tree species, particularly in different parts of stem.

Such methodical approach has been applied by its author for evaluation mainly pine (*Pinus sylvestris* L.) pests' injuriousness in European part of Russia (Mozolevskaya, 1974), later by Belorussian researchers in spruce stands (*Picea abies* (L.) H. Karst) (Kukhta, Blintsov & Sazonov, 2014), by Ukrainian researchers in oak (*Quercus robur* L.) (Meshkova & Kukina, 2011) and pine stands (Skrylnyk, 2013; 2015).

Our investigations show that the injuriousness of the same stem pests varies in different regions and forest site conditions, and we suggested that the peculiarities and population size should be taken into account when determining the score. Therefore *the aim of this research* is to analyze the score for some traits of stem pests using the data of field research in the Forest-Steppe and Steppe zones of Ukraine.

Material and methods

The field data were obtained in 2004-2016 in pine forests of the Left-bank Forest Steppe Zone (the *Okhtyrske* Forestry Enterprise, the *Vovchanske* Forestry Enterprise, the *Chuhuyevo-Babchanske* Forestry Enterprise, the *Zmiivske* Forestry Enterprise, and the Kharkiv Forest Research Station of Ukrainian Research Institute of Forestry and Forest Melioration named after G. M. Vysotsky) and of the Steppe zone (the *Iziumske* Forestry Enterprise, the *Sievierodonetske* Forest & Hunting Enterprise, the *Kreminske* Forest & Hunting Enterprise, and the *Stanychno-Luhanske* Experimental Forest & Hunting Enterprise).

The category of tree health condition was determined according to "Sanitary rules in the forests of Ukraine" (1995). Each tree was referred to one of six categories of health condition (I – healthy; II – weakened; III – severely weakened; IV – drying; V – recently died; VI – died over year ago).

Population parameters of stem insects, including characteristics of galleries, were assessed according to "Guidelines…" (Meshkova, 2011).

The score of physiological injuriousness of certain insect species was calculated as a sum of points for three

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indicators: ability to colonize living trees, ability to damage the trees during maturation feeding and ability to vector the pathogens.

The score of technical injuriousness of certain insect species was calculated as a product of points for three indicators: tree species, location of galleries in the stem (parts of stem with rough, thin or transitional bark) and destruction ability, whereas destruction ability was calculated as a sum of points for assessment of the width of galleries, depth of timber destruction and colonized surface.

General injuriousness of certain insect species was evaluated as a product of points for physiological injuriousness, technical injuriousness and the number of generations per year (Mozolevskaya, 1974). The points for every indicator will be discussed later on.

Results and discussion

The galleries of the most of stem pests can be found in the trees of categories IV-VI of health condition, however many insects could colonize the tree, when it belonged to categories II-III of health condition. It was suggested (Mozolevskaya, 1974) to evaluate the ability to colonize living trees by the score of 10 for insects that colonize the trees of categories I-II of health condition, the score of 1 for insects that colonize the trees of categories III-IV of health condition and recently felled trees, and the score of 0.1 for insects that colonize only dead trees (categories V-VI of health condition), as well as dead wood.

However to find the signs of stem colonization by insects is almost impossible, if their entrance holes are located at a height of more than 2m on the stem, while other signs of the tree colonization are invisible. At high pest population one can see the frass on the forest litter, but such trees already belong to category III of health condition.

At the same time, the trees, which belonged before felling to categories I, II or III of health condition and then were used as trap trees, are often colonized by many stem insects, which could have never colonized them before felling. Therefore, if we inspect the trees some days or weeks after felling, we may incorrectly conclude that some insect species are able to colonize healthy trees.

Thus, *Monochamus galloprovincialis* (Olivier, 1795) ssp. *pistor* (Germar, 1818), *Tomicus minor* (Hartig, 1834) and *Tomicus piniperda* (Linnaeus, 1758) colonize the trees, which belonged to categories I and II of health condition before felling or windthrow. Pest colonization of trees, which belonged before felling to category II of health condition is often higher than colonization of trees which belonged before felling to category I of health condition (Zinchenko & Skrylnyk, 2013). It may be accounted for by rather good phloem quality for larvae development and lower content of protective substances in the trees of category II of health condition compared with trees of the category I.

The ability to damage the trees during maturation feeding is scored as 2 points (considerable damage), 1 point (low damage) and 0 points (without damage) (Mozolevskaya, 1974). It is considered, that *Tomicus sp*., which damages shoots, and *Monochamus sp*., which damages bark of living trees, are scored as 2 points. *Ips sexdentatus* (Boerner, 1767) is scored as 2 points, if it makes the galleries for maturation feeding under bark of healthy or weakened trees. However, if it makes the galleries in the sites of its development, the tree is already severely weakened or drying, and such maturation feeding does not increase the pest harmfulness. In such case, the ability to damage the trees during maturation feeding must be scored as 1 point.

As we could see, the intensity of tree damage during maturation feeding of stem pests in the Steppe zone is less than in Forest-Steppe and Forest zone. It may be connected with quick mortality and phloem drying of weakened pines in the southern regions, especially after fire or damage by foliage browsing insects (Meshkova & Kolenkina, 2016). Therefore, both the population size and injuriousness of stem pests may be rather low in such conditions.

The ability to vector the pathogens is suggested to score as 3 points, if the insect is a vector of vascular diseases, necrosis or cancer. It is suggested to score as 2 points the vectors of wood destructing fungi and to score as 1 point the vectors of fungi, which cause wood discoloration (Mozolevskaya, 1974). In practice, the most of stem pests have no special organs for fungi vectoring, but can vector them and other pathogens during colonizing the tree and during maturation feeding (Davydenko, Vasaitis & Menkis, 2017; Davydenko, et al., 2014; Lieutier, et al., 2004). Therefore, it is difficult to assess the score of this indicator. This aspect must be studied separately, taking into account also the role of stem insects in vectoring bacteria and nematodes.

Thus, for *M. galloprovincialis* the ability to colonize living trees can be scored as 1 or 10 points, the ability to damage the trees during maturation feeding as 2 points and the ability to vector pathogens as 1 or 3 points (in the last case we take into account its possibility to vector pine wood nematode, *Bursaphelenchus xylophilus* (Steiner & Buhrer, 1934) Nickle, 1970, which has not yet penetrated in Ukraine). Therefore, physiological injuriousness of this pest can be scored as 15 or 4 points.

For *I. sexdentatus* and *Ips acuminatus* (Gyllenhal, 1827), the ability to colonize living trees can be scored as 1 point, the ability to damage the trees during maturation feeding as 1 or 2 points, and the ability to vector pathogens as 2 points. Therefore, physiological injuriousness of these pests can be scored as 5 or 4 points.

In the assessment of technical injuriousness of certain stem pest, it is suggested to use the factors which characterize the value of timber of certain tree species, namely, 1 - for aspen, 1.3 - for birch, 1.7 - for spruce, 2 - for pine and 4.5 - for oak (Mozolevskaya, 1974). This factor depends on market price of timber, and when we compare the injuriousness of different pests for one tree species, this factor is not so important. But if the cost of timber for different conifer species is similar, it is difficult to compare the injuriousness of one pest in different tree species (for example, *Ips typographus* Linnaeus, 1758 in pine and spruce stands).

Location of galleries in the stem (in parts of stem with rough, thin or transitional bark) is the second component in the evaluation of technical injuriousness of certain insect species. It was revealed, that preferences of insects to colonize the parts of stem with rough, thin or transitional bark vary in different regions and are different in living and felled trees.

For example, in Kharkov region, 72 % of galleries of *M. galloprovincialis* were located in the parts of stem with rough bark, and in Luhansk region only 35 % of galleries were located in the parts of stem with rough bark, about 50 % of galleries – in the parts of stem with transitional bark, and 15 % of galleries – in the parts of stem with thin bark. Almost 70 % of *I. acuminatus* galleries were located in the parts of stem with thin bark in Kharkov region, and in Luhansk region they were located almost with equal freq-

uency in the parts of stem with thin and transitional bark (52 and 48 %, respectively).

Like this, over 80 % of *I. sexdentatus* galleries were located in the parts of stem with rough bark in Kharkov region, and in Luhansk region they were located almost with equal frequency in the parts of stem with rough and transitional bark (56 and 44 % respectively).

Colonization of stem parts with transition bark by *I. acuminatus* was significantly higher for the trees, which were colonized after felling, than for the trees, which were colonized before felling (Meshkova, Kochetova & Zinchenko, 2015). Almost all galleries of *T. piniperda* were located in living trees in the part of stem with rough bark, and in the felled trap trees the galleries of this pest were located in the parts of stem with rough (59 %), transitional (25 %) and thin (16 %) bark.

Over 80 % of *T. minor* galleries were located in the part of stem with thin bark in living trees, and in the felled trap trees the galleries of this pest were located in the parts of stem with thin (56 %), transitional (30 %) and rough (14 %) bark. Destruction ability of stem insect is calculated as a sum of gallery width, depth of timber destruction and colonized surface (Mozolevskaya, 1974).

A detailed analysis of these parameters for pine stem pests was carried out by Yu. Skrylnyk in the Forest-Steppe zone. He has shown that the most of bark beetles can damage only outer layer of timber (Skrylnyk, 2015), which leads to decrease in the timber grade from I to II and can be scored as 1.2 points (Mozolevskaya, 1974).

Only *Xyleborus* sp., *Xyleborinus* sp. and *Trypodendron* sp. from bark beetles and longhorn beetle *M. galloprovincialis* browse the galleries in sapwood and heartwood and this can be scored as 4.3 points. Of course, the grade of timber can decrease additionally due to wood-destructing fungi even after superficial damage, but the scoring determination has not yet carried out for this phenomenon.

Therefore, timber destruction ability for *M. galloprovincialis* is calculated as a sum of points for width of galleries, depth of timber destruction and colonized surface, which is (4.3 + 0.1 + 0.2) = 4.6 (Table 1). The score for pine is 2 points. Thus technical injuriousness of this pest is 4.6×2×1.5=13.8 points, if we consider that the most of galleries are located in the part of stem with rough bark. But if the parts of stem with rough and transitional bark are colonized almost equal, or parts with transitional bark are the most colonized, then the factor is 1.3, and technical injuriousness of this pest is 4.6×2×1.3=12 points.

Table 1. Calculation of general injuriousness of some stem pests of pine (min/ max, in points)

Insect species	Physiological injuriouness	Technical injuriousness	Number of generations	General injuriousness
M. galloprovincialis	4 / 15	12 / 13.8	1 / 1.0	48 / 207
I. acuminatus	4 / 5	2,8 / 3.6	1 / 2.5	11.2 / 28
I. sexdentatus	4 / 5	3.9 / 4.5	1 / 2.5	15.6 / 39

The depth of timber destruction by *I. sexdentatus* and the width of its galleries is low (1.2 points and 0.1 points respectively), but colonized surface is rather large (0.2 points). Destruction ability of this pest is (1.2+0.1+0.2) = 1.5 points. Technical injuriousness of this pest is 1.5×2×1.5=4.5 points if the most of galleries are located in the part of stem with rough bark. However, if the most of galleries are located in the part of stem with transitional bark, then technical injuriousness of this pest is 1.5×2×1.3=3.9 points (see Table 1).

The depth of timber destruction, the width of galleries and colonized surface by *I. acuminatus* is 1.2, 0.1, and 0.1 points, respectively. Destruction ability of this pest is (1.2+0.1+0.1) = 1.4 points. Technical injuriousness of this pest is 1.4×2×1= 2.8 points, if the most of galleries are located in the part of stem with thin bark. However, if the most of galleries are located in the part of stem with transitional bark, then technical injuriousness of this pest is 1.4×2×1.3=3.6 points.

General injuriousness of stem pests is calculated as a product of physiological injuriousness, technical injuriousness and number of generations per year (Mozolevskaya, 1974). Most of stem pests of pine in the territory of Ukraine have 1 generation per year. Only *I. acuminatus*, *I. sexdentatus* and *Orthotomicus proximus* (Eichhoff, 1867) are proved to have more than one generation (Skrylnyk, 2015). The number of these generations depends on air temperature of the season, they can overlap, and it is difficult to distinguish the specimens of the first, second or sister broods. We can assume for calculation the existence of 2 main generations and one sister generation.

Therefore, to calculate general injuriousness for these species, we multiply the score for physiological, technical injuriousness and factor 2.5 but in some years it would be 1 or 1.5. It was suggested (Mozolevskaya, 1974) to classify as particularly harmful stem pests the species with general injuriousness over 80 points, moderately harmful – the species with general injuriousness 20-79 points, low harmful – with general injuriousness 10-19 points and non-harmful – with general injuriousness less than 10 points. According to this, *M. galloprovincialis* can be moderately harmful or particularly harmful, and the both *Ips* species can be low harmful or moderately harmful.

Our research shows that estimated general injuriousness of certain insect species characterizes their potential injuriousness, while the actual injuriousness depends on spread of these pests. Therefore, to consider the spread of certain stem pests, it is necessary to multiply their general injuriousness by a factor, which describes the level of insect spread. According to expert estimates (Meshkova, 2011), colonization of 21-60 % of trees by stem pests corresponds to the moderate level of spread (factor 1). Colonization of less than 20 % of trees corresponds to the low level of spread (factor 0.5), and colonization over 60 % of trees corresponds to the high level of spread (factor 1.5) (Table 2).

Table 2. General injuriousness of some pine stem pests adjusted for spread

Insect species	Spread				Adjusted general injuriousness*	
	Kharkiv region		Luhansk region		Kharkiv region	Luhansk region
	%	factor	%	factor		
M. galloprovincialis	73	1.5	24.1	1	72 / 310.5	48 / 207
I. acuminatus	50	1.5	10.7	0.5	16.8 / 42	5.6 / 14
I. sexdentatus	52	1.5	15	0.5	23.4 / 58.5	7.8 / 19.5

Note: min / max, in points

According to adjusted general injuriousness, *M. galloprovincialis* can be moderately harmful or particularly harmful in the both regions. *I. acuminatus* can be low or moderately harmful in Kharkiv region and non-harmful or low harmful in Luhansk region. *I. sexdentatus* is moderately harmful in Kharkiv region and non-harmful or low harmful in Luhansk region (see Table 2).

Conclusions

1. Injuriousness of stem pests varies in different regions, in living and felled trees.
2. Physiological injuriousness of *Monochamus galloprovincialis* can be scored as 4-15 points, of *Ips sexdentatus* and *Ips acuminatus* as 4-5 points.
3. Depending on preferences to colonize the different parts of stem, technical injuriousness of *Monochamus galloprovincialis* is 12-13.8 points, of *Ips sexdentatus* –3.9-4.5 points, and of *Ips acuminatus* 2.8-3.6 points.
4. By general injuriousness, *Monochamus galloprovincialis* can be moderately harmful or particularly harmful, and the both *Ips* species can be low harmful or moderately harmful. By general injuriousness, adjusted for insect spread, *Ips acuminatus* can be low or moderately harmful in Kharkiv region and non-harmful or low harmful in Luhansk region. *Ips sexdentatus* can be moderately harmful in Kharkiv region and non-harmful or low harmful in Luhansk region.
5. Scoring of stem insects' ability to vector fungi, bacteria and nematodes, as well as additional decrease in timber quality due to wood-destructing fungi is necessary to be carried out.

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ОЦІНЮВАННЯ ШКІДЛИВОСТІ СТОВБУРОВИХ КОМАХ У СОСНОВИХ ЛІСАХ

Уточнено бальну оцінку окремих параметрів для розрахунку шкідливості стовбурових комах з використанням даних із лісостепової та степової зон України. Фізіологічну шкідливість *Monochamus galloprovincialis* оцінено у 4-15 балів, *Ips sexdentatus* та *I. acuminatus* – у 4-5 балів. Залежно від переважного заселення окремих частин стовбура технічна шкідливість *M. galloprovincialis* становить 12-13,8 бала, *I. sexdentatus* 3,9-4,5 бала, а *I. acuminatus* 2,8-3,6 бала. За загальною шкідливістю з поправкою на поширеність *I. acuminatus* може бути мало або помірно шкідливим у Харківській області та нешкідливим або мало шкідливим у Луганській області. *I. sexdentatus* може бути помірно шкідливим у Харківській області та нешкідливим або малошкідливим у Луганській області.

Ключові слова: стовбурові комахи; санітарний стан; додаткове живлення; фізіологічна шкідливість; технічна шкідливість; загальна шкідливість.

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ОЦЕНКА ВРЕДОНОСНОСТИ СТВОЛОВЫХ НАСЕКОМЫХ В СОСНОВЫХ ЛЕСАХ

Уточнена балльная оценка отдельных параметров для расчета вредоносности стволовых насекомых с использованием данных из лесостепной и степной зон Украины. Физиологическая вредоносность *Monochamus galloprovincialis* оценена в 4-15 баллов, *Ips sexdentatus* и *I. acuminatus* – в 4-5 баллов. В зависимости от преимущественного заселения отдельных частей ствола техническая вредоносность *M. galloprovincialis* составляет 12-13,8 балла, *I. sexdentatus* 3,9-4,5 балла, а *I. acuminatus* 2,8-3,6 балла. По общей вредоносности с поправкой на распространенность насекомых *I. acuminatus* может быть мало или умеренно вредоносным в Харьковской области и безвредным или мало вредоносным в Луганской области. *I. sexdentatus* может быть умеренно вредоносным в Харьковской области и безвредным или мало вредоносным в Луганской области.

Ключевые слова: стволовые насекомые; санитарное состояние; дополнительное питание; физиологическая вредоносность; техническая вредоносность; общая вредоносность.