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Conference Paper

The Estimation of the Initial Stage of Succession of Green-pine Trees Windfall in the Eastern Moscow Suburbs

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Abstract

The paper is devoted to the study of entomocomplex of stem pests, the number and biology of its dominant species and the ecological structure of the soil mesofauna of the two differing in composition and growing conditions, areas of wind pine forests-green insects. The main causes of windfalls, which are unfavorable soil and soil conditions and the defeat of trees by the root sponge, are established. The degree of participation of different types of feed substrate in the dynamics of the number of stem pests in the lesion is estimated. In addition to the windfall of trees, stem pests are the adjacent one, decreasing the resistance of pine in the walls of the forest, overmature trees or trees weakened by anthropogenic, standing trees, the trunks of which are damaged by windfall to a lesser extent than the remaining standing part of inboard of broken trunks. We identified eight species of entomophagous parasitic on the grubs of Longhorn beetles and jewel beetles. It is noted that the population of ground beetles, in windswept areas studied, is characterized by a decrease in species diversity, a decrease in the number of moisture-loving species typical of pine forests of the Eastern Moscow region, a change in the spectrum of life forms in the direction of reducing litter species and increasing the proportion of litter-soil.

Keywords: entomofauna, windfall, disturbed biocenosis, biomonitoring.

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1. Introduction

The midland of the European part of Russia including the Moscow region is often exposed the abnormal weather phenomena. Recently according to the website meteoservice.ru squally winds in the region were noted in August 7, 2016, in May 29, 2017, in April 10 and 21, 2018. The hurricane of 2017 was the most powerful and destructive, which led to the large-scale forest windfalls and windbreaks with subsequent post-wind changes in the biotic components of ecosystems in the form of successions with many variants of development in time [1]. In this regard, the authors examined one of the pine forest windfalls, identified the root causes of the mass fall of trees, studied the species composition of trunk pests and carabid fauna and some features of their development.

The research was done during the summer period of 2018 in the broken pine forest near the village of Glebovo (GPS coordinates: N 55°3940, E 38°5526) of Likino-Dulevo city district, Moscow region, along Federal highway A-108 of the Moscow big ring in Orekhovo-Zuyevo-Kurovskoye section.

The research objective is to trace the changes in the entomofauna of the broken pine trees after the windfall of 2017.

2. Methods and Equipment

For the survey, two sections two sections areas differing in the composition and growing conditions were selected:

plot 1: complex pine forest, I bonitet class, age is about 80 years old, density is 0.8, composition is 8P2S+B, average diameter is 39.8 cm, area is 0.6 ha;

plot 2: complex pine forest, II bonitet class, age is about 80 years old, density is 0.7, composition is 8P2B, average diameter is 36.9 cm, area is 0.4 ha.

In the course of the detailed forest pathology survey of the plantation it was found that the main factors contributing to the mass windbreak of the pine forest were unfavorable soil conditions in wet plot 1 and damage of trees by root sponge in dry plot 2 (*Heterobasidion annosum* Fr.).

The greatest forest fall noted in plot 2, where the total outbreak was 35 trees. It revealed 21 windfall trees in plot 1.

The analysis of the model trees and the study of the species composition of stem pests was done in July-August 2018 using standard methods [2]. During the study period 6 model trees were analyzed. The collection of data on the carabid fauna was carried out using Barber traps [3]. 4% formalin was used as a fixative. The population density was calculated by the number of specimens per 10 traps / day.

3. Results

In the broken pine, plantation local centers of mass reproduction of stem pests appeared in both areas during the year. The species composition and the formation of the insect xylophage complex are influenced by the nature of tree fall and its localization within the limits of the fall. An important role in the formation of a suitable substrate for colonization by stem pests is played by old wind trees, smaller trees dumped when they fall, nearby

trees with damaged bark, mutts (root parts of broken trunks), as well as location and orientation wind trunks in the cardinal points in the borders of the outbreak [4, 5].

In the selected plots a complex of stem pests typical of pine plantations in central Russia was identified [6], including *Tomicus piniperda* L. and *T. minor* Hart., *Ips sexdentatus* Börn., *Trypodendron lineatum* Oliv., *Acanthocinus aedilis* L., *Monochamus galloprovincialis* Oliv., *Arhopalus rusticus* L., *Spondylis buprestoides* L., *Chalcophora mariana* L., *Phaenops cyanea* F., *Pissodes pini* L. *T. minor, T. lineatum, M. galloprovincialis, Ph. cyanea* should be allocated among the dominant insects of the complex.

In addition to wind trees in the surveyed areas, we identified xylophage complex, primarily *T. minor, M. galloprovincialis* and *Ph. cyanea*, which develops in nearby, heavily weakened pine trees that lose stability during physiological aging, trees weakened by anthropogenic impact, as well as in standing trees whose trunks are damaged by fallen trees and the root parts of broken trunks [7-10].

One of the most physiologically active species in the complex is *Ph. cyanea*. Females of this species lay eggs in places of damage of thick and transitional bark of trunks. Younger larvae gnaw through the winding transverse passages in the cambial layer, then the larvae passages take a longitudinal direction and cut deeper into the trunk tissue. Transverse passages of the larvae, as a rule, lead to the death of the viable tissues of the weakened tree and its death. The process of tissue death is often accompanied by their defeat with the blue fungus *Ceratostomella piliferum* (Fr.) C. Moreau. The external signs of damage by xylophages of standing pine trees losing resistance are manifested in the form of sparsity of tree crowns and yellowing of needles.

In the larval passages of *M. galloprovincialis* and *Ph. cyanea* we found the larvae of parasitic hymenoptera (order Hymenoptera). Imagoes of eight species of entomophages belonging to three families were derived from them:

1. Family Aulacidae. *Aulacus striatus* Iuz.

2. Family Ichneumonidae.

2.1. Subfamily Pimplinae. *Lissonata lineolaris* Gmel., *Ephialtes spatulatus* Tonnes., *Xorides alpestris* Haberm., *X. depressus* Holmgren.

2.2. Subfamily Ophioninae. *Rhimphoctona grandis* Fonsc.

3. Family Braconidae.

3.1. Subfamily Braconinae. *Bracon sp*., *Atanycolus genalis* Thoms.

We failed to determine the role of egg parasites and predators in the destruction of xylophagous eggs. Under natural conditions, oviposition into shelters of the bark

surface reduces the level of their damage by entomophages. A small proportion of eggs probably die due to any violations during the oviposition.

The death of the larvae can be taken into account quite fully. The larvae mortality in the dynamics of the number of xylophages is mainly due to the regulatory action of parasitic insects. Like most stem pests entomophagous prefer the most lighted areas of trunks and parasitize primarily the larvae localized in the places of the irregularities of the thick and transitional bark.

The mortality of pupae and imago in the pupal chambers is small and it is associated with the defeat of the wind-trees by pathogenic microorganisms and unfavorable abiotic factors.

We have not studied the role of entomophages in the mortality of departed beetles. Probably, the role of climatic factors, predatory insects and vertebrates is more evident here.

Considering the unity of the ecological niche and the coincidence of the development periods of a number of xylophages, we can assume that there are no highly specialized entomophages in the studied biocenosis [10].

Simultaneously with the study of xylophilic insects in the broken biocenosis, the study of the terrestrial carabid fauna was done.

The change in environmental conditions that occurred after the windfall (the increase of light, soil temperature) influenced the composition of the soil mesofauna.

Ground beetles are the few families of Coleoptera widespread in biotopes, which experience various types of anthropogenic influence [11-19]. This paper presents the analysis of the species composition and ecological structure of ground beetle complexes in windfalls and in the areas not affected by this type of impact. For ground beetles, the processes of primary succession investigated in places where the mineral soil turn the surface due to the tree falls. It is likely that adaptation to natural windfall disturbances can contribute to the adaptation of soil invertebrates to the development of fellings.

During the study we caught more than six hundred specimens of ground beetles belonging to 22 species of 12 genera. *Pterostichus melanarius* Jlliger and *Carabus nemoralis* O. Muller dominated in both plots. A clear decline in numbers in both areas of the windfall was observed in such species: *C. granulatus* L., *P. oblongopunctatus* F., *Notiophilus biguttatus* F., *Calathus micropterus* Duftschmidt. A separate group consists of species which number is stimulated by wind-breaking disturbances. It includes *Harpalus tardus* Panzer, *H. rufipes* De Geer, *P. niger* Schaller, *Poecilus versicolor* Sturm,

C. erratus Sahlberg. It is characteristic that *P. niger* dominated in the windfall area, which is usually few in the forests of the eastern Moscow suburbs and is sufficient only in urban parks [20]. It is known that this species is sensitive to soil moisture. It is obvious that windfall led to the violation of the hydrological regime of the biocenosis and, as a result, to the change in the species composition of its carabid fauna. Species typical of the pine forests of the Moscow region such as *P. minor* Gyllenhal, *P. strenuus* Panzer, *C. melanocephalus* L. disappear in the windfall area. *C. nemoralis*, *C. arvensis* Herbst, and *C. hortensis* L., *Trechus secalis* Paykull, *Leistus terminatus* Panzer almost did not respond to the changes caused by windfall.

4. Discussion

Based on the counts of the number of some xylophagous species, the settlement of wind trees, pine trunks damaged by wind trees and weakened pines in the forest by them is (in thousand pieces / ha): for all species of bark beetles, among which *T. minor* dominates - 51.8; for *M. galloprovincialis* - 0.6; for *Ph. cyanea* - 1.8.

Based on the analysis of biotopic preferendum data we revealed that the forest species (53.6% of the species composition) play the leading role in the biotopic spectrum of the carabid complex of the cenoses studied. By biotopic preference the population of ground beetles of pine forests belongs to 6 ecological groups: forest, forest-marsh, meadow-field, field, coastal, meadow-marsh. Forest species predominate in all the variants of the forest, averaging about 80% of the numerical abundance. Forest-swamp and marsh species are most abundant in pine forests that are not the subject to wind changes (15.8% of numerical abundance), which is explained by a high level of soil moisture, depending both on the position in the relief and the amount of precipitation retained by trees and forest litter. In both plots of windfalls meadow-field and field species are added to the forest species (6.9% and 5.5%, respectively), which is associated with the increase of light.

The analysis of changes in the spectra of life forms of ground beetles showed that ground beetles in the studied areas belong to 2 classes and 6 groups of life forms. In areas of undamaged pine forests zoophages predominate in species and numerical abundance (78.9% of species and 93% of numerical abundance). Litter-soil stratobionts dominated in the windfall areas by species and numerical abundance. In the control, the undamaged area of the forest the number of stratobionts of the surface-litter and walking epigeobionts was higher. The colonization of the litter layer by ground beetles is by the moisture regime of the biotope. The number of litter and surface litter forms

increases in wetter habitats and significantly decreases in xerophytic. The basis of the abundance in the litter layer of the control forest area is supported by moisture-loving species *Synuchus vivalis* Jlliger and *Loricera pilicornis* F. and to a lesser degree by forest species: *N. palustris* Duftschmidt, *L. terminatus*, *C. melanocephalus*. In windfall plots the number of litter and number especially surface-litter forms is significantly reduced. Myxophytophages are few in all areas and are represent by two groups (24.2% of the species and 7.7% of the total abundance). They include harpoaloid geochortobionts and stratochortobionts.

5. Conclusion

The main causes of windfalls in the pine forests of the eastern Moscow suburbs are root rot and adverse soil conditions. The time of the windfall (early summer) is decisive in determining the species composition of stem pests. The most common types of xylophages in the examined biocenosis are *T. minor*, *M. galloprovincialis* and *Ph. cyanea*. We counted their numbers within the defeat centers and identified eight species of entomophages parasitizing on the larvae.

In addition, the degree of impact of various factors, as well as the subsequent restoration of the soil system, depends on the windfall volume, the type of vegetation and the soil. Local windfalls in forest biocenoses have a negligible effect on the change in soil mesofauna. The population of ground beetles of the studied area of windfalls is characterized by a decrease in species diversity, a decrease in the number of moisture-loving species typical of pine forests of the eastern Moscow region. The spectrum of life forms has changed in the direction of decreasing litter species and increasing the proportion of litter-soil species.

Data on the quantitative and qualitative composition of soil invertebrates can for bioindication and biomonitoring of soil processes after windfalls of varying intensity.

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Conflict of Interest

The authors have no conflict of interest to declare.

References

[1] Ulanova, N.G., Cherednichenko, O.V. (2012). Mechanisms of vegetation successions of continuous windfalls of southern taiga spruce forests. *News of Samara scientific center of the Russian Academy of Sciences*, vol. 14. No. 1 (5), pp. 1399--1402.

[2] Zykov, I. E., Khotuleva, O. V. (2017). *Invertebrates to the forest biocenosis: Methodical manual for students of biological specialties of universities, teachers and lecturers of biology and ecology of SOSCH and SPO and heads of school forestry*. Orekhovo-Zuyevo: Editorial and publishing Department of SUHT.

[3] Alexeev, S.C., Aleksanov, V.V. (2017). Pitfall trap construction affects the efficacy of ground beetle counts. *Entomological Review*, vol. 97. No. 3, pp. 310-319.

[4] Yakovenko, A. I. (2011). Dynamics of populations of pine beetle in the forests of Moscow region suffered from devastating weather phenomena. *Bulletin of the Moscow state University of forest - Forest Herald*, No. 7 (83), pp. 113-122.

[5] Yakovenko, A. I. (2011). Stem pests on wind-blown pine forests of the Moscow region. *Bulletin of the Moscow state University of forest - Forest Herald*, No. 4 (80), pp. 46-53.

[6] Izhevsky, S. S., Nikitsky, N. B., Volkov, O. G., Dolgin, M. M. (2005). *Illustrated Handbook of xylophagous beetles-pests of forests and timber of the Russian Federation*. Tula: Print and K.

[7] Yakovenko, A. I. (2013). To the question on supplementary feeding and wintering pine beetle. *Bulletin of the Moscow state University of forest - Forest Herald*, No. 6 (98), pp. 94-102.

[8] Yakovenko, A. I. (2013). Features of summer pine beetle in the Moscow region. *Bulletin of the Moscow state University of forest - Forest Herald*, No. 6 (98), pp. 89-94.

[9] Yakovenko, A. I. (2014). Phenological features of pine bast beetles (*Tomicus piniperda* L. and *T. minor* Hart.) in the conditions of the Moscow region. *Bulletin of the Moscow state University of forest - Forest Herald*, vol. 18, No. 6, pp. 154-163.

[10] Zykov, I.E. (2015). Materials on the ecology of blue pine jewel beetles - *Phaenops cyanea* F. (Coleoptera, Buprestidae) - Actual problems of modern ecology and environmental education, in *Materials of the All-Russian scientific-practical conference with international participation*. Orekhovo-Zuyevo: MGOGI, pp. 39-43.

[11] Trushitsyna, O.S., Matalin, A.V. (2016). Specific features of the life cycle of Pterostichus melanarius (Coleoptera, Carabidae) in mosaic floodplain meadows. Entomological Review, vol. 96, No. 2, pp. 144-159.

[12] Trushitsyna, O.S., Matalin, A.V., Makarov, K.V. (2016). Long-term dynamics and spatial distribution of stable and labile components in ground beetle communities (Coleoptera: Carabidae) in a mosaic of flood-plain meadows. Periodicum Biologorum, vol. 118, No. 3, pp. 255-272.

[13] Saska, P., Vlach, M., Schmidtová, J., Matalin, A.V. (2014). Thermal constants of egg development in Carabid beetles - variation resulting from using different estimation methods and among geographically distant European populations. European Journal of Entomology, vol. 111, No. 5, pp. 621-630.

[14] Matalin, A.V. (2015). Specific manifestations of polyvariant life cycles in ground beetles (Coleoptera, Carabidae) along a latitudinal gradient. Biology Bulletin, vol. 42, No. 6, pp. 526-530.

[15] Van Schalkwyk, J., Pryke, J.S., Samways, M.J. (2019). Contribution of common vs. rare species to diversity patterns in conservation corridors. Ecological Indicators, vol. 104, pp. 279-288.

[16] Gailis, J., Turka, I., Ausmane, M. (2017). Soil tillage and crop rotation differently affect biodiversity and species assemblage of ground beetles inhabiting winter wheat fields. Agronomy Research, vol. 15, No. 1, pp. 94-111.

[17] Kamenova, S., Polin, S.E., Plantegenest, M., Leroux, C. (2018). Community-wide stable isotope analysis reveals two distinct trophic groups in a service-providing carabid community. *Bulletin of Entomological Research*, vol. 108, No.1, pp. 130-139.

[18] Pozsgai, G., Littlewood, N.A., Pakeman, R.J., Baird, J., Young, M.R. (2018). Phenological changes of the most commonly sampled ground beetle (Coleoptera: Carabidae) species in the UK environmental change network. *International Journal of Biometeorology*, vol. 62, No. 6, pp. 1063-1074

[19] Mader, V., Diehl, E., Wolters, V., Birkhofer, K. (2018). Agri-environmental schemes affect the trophic niche size and diet of common Carabid species in agricultural landscapes. *Ecological Entomology*, pp. 823-835

[20] Khotuleva, O.V. (1996). Structure and some patterns of distribution of complexes of ground beetles in the city, in *Works of young scientists of the Vladikavkaz Scientific Center of the Russian Academy of Sciences*. Vladikavkaz.