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Short communication

Group selection harvesting supports diversity of forest specialist epigaeic arthropods (Coleoptera: Carabidae; Arachnida: Araneae; Isopoda: Oniscidae)

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List of any nonstandard abbreviations
p: significance level
d.f.: degree of freedom

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Abstract

Background and purpose *Timber-oriented forest management alters the environmental conditions, threatening the survival of many native and rare arthropod species. Recognition of the scale and effects of the forest loss has resulted in a considerable degree of interest in the reforestation. Nowadays, the uneven-aged management is recommended during the reforestation procedure, because this is less intensive and could be less harmful than even-aged practices. Our aim was to test the effects of clear-cutting (as even-aged method) and group selection harvesting (as uneven-aged method) on forest specialist epigaeic arthropods.*

Material and methods *Epigaeic arthropod assemblages (ground beetles, spiders and woodlice) in gaps harvested by group selection and clear-cuts were compared to those assemblages in windthrow gaps and mature forest stands. Ground beetles, spiders and woodlice were collected by litter sifting.*

Results *The total number of epigaeic arthropod species was significantly higher in the gaps harvested by group selection than in the clear-cuts and the mature forests. The species richness of forest specialist species was significantly lower in the clear-cuts than in the other habitats.*

Conclusion *Our findings demonstrated that the conventional clear-cutting caused a decrease in the number of forest specialist species. Therefore, group selection method should be favoured during forest management to maintain forest arthropods's diversity.*

INTRODUCTION

The widespread timber-oriented forest managements cause increased fragmentation and considerable environmental changes in almost all European native forests. These alterations in the original habitats threaten the survival of many native organisms *(1, 2)*. In Europe 36% of the land surface are forested, however only 1.7% of these forests are considered natural *(1)*. The unmanaged forests support the formation of microhabitats and food resources (such as decaying materials, old and large trees, cavities) required by forest specialist species *(2, 3)*. While generally, the managed forests have homogeneous tree composition, homogeneous vertical stratification and age structure *(4, 5)*.

During the even-aged management a large part of a forest is harvested and then reforested, which creates monocultural stands with the same age and structure *(1)*. It also has significant effect on the composition of the original arthropod fauna *(6, 7)*. Conventional clear-cutting

of mature forest with site preparation (grubbing, tilling, and deep-loosening) is one of the most inappropriate method among the even-aged silvicultural practices, because it increases the evaporation rate and the soil and air temperature due to removed roots with rhizomes and the ploughed soil *(1, 8)*.

Uneven-aged management methods could be a useful in the maintenance of forest biodiversity *(1)*. During this management trees are removed individually (single tree method) or in small groups (group selection method) from the forest; thus, forest structure and age become diverse ensuring continuous forest cover in the forested area. Multi-aged reforestations may provide more favourable condition for sensitive species compared to even-aged stands, contributing to the maintenance and regeneration of the original arthropod fauna *(1, 6, 9)*. However, only a few papers studied the effects of uneven-aged forest management on arthropods, although there is a growing need for comprehensive researches *(1, 6)*.

Ground beetles (Coleoptera: *Carabidae*), spiders (Arachnida: *Araneae*) and woodlice (Isopoda: *Oniscidae*) are commonly used indicator organisms during the forest management studies. These taxa taxonomically well known and they could be easily collected by pitfall trapping or litter sifting *(8, 10)*.

The aim of our study was to explore the diversity of epigaeic forest specialist arthropods (including ground beetles, spiders, and woodlice); we assumed that group selection harvesting do not cause considerably changes in the environmental conditions and mimics the natural process (windthrow), while clear-cutting alters drastically the original environmental conditions. Therefore, we hypothesized that both windthrow gap, and gap harvested by group selection did not cause significant changes in the diversity of forest specialist species compared to the mature forests. However, the clear-cutting creates large open soil surface and eliminates the microhabitats and resources required by specialist species *(11)*. Thus, we expected that the species richness of forest specialist species will be significantly lower in the clear-cuts compared to the gaps harvested by group selection and the windthrow gaps as well as the mature forest stands.

MATERIAL AND METHODS

Study area and sampling design

The sampling area was located in the Nagyerdő Forest Reserve Area near to Debrecen city (Eastern Hungary). Steppe oak forest (*Convallario-Quercetum roboris*) is a typical native forest association of the region *(12)*. Epigaeic arthropods (including ground beetles, spiders, and woodlice) were collected in four habitat types. (i) The windthrow gaps (size of 0.005 ha) are emerged after strong wind, creating natural gap within mature forest. (ii) In the gaps harvested by group selection a small group of trees was harvested and removed from the mature forest (size of 0.05 ha). (iii) In the clear-cut sites all trees were harvested and timbers were removed resulting harvested area with size of 1 ha. As (iv) control sites 135-year-old unmanaged forest stands (size of 5 ha) with closed canopy cover were selected. There were six sampling sites in each habitat type.

The epigaeic arthropods were collected by litter sifting method. During sampling a metal frame (25 x 25 cm) was used to remove the litter, soil and woody debris from the upper 5 cm of soil and litter, and those were sifted on a screen wire-mesh bottom (30 cm in diameter with 1 cm in diameter size meshes), which was sewn to a cloth sleeve *(3)*. There were two random litter samples in each sampling site. Altogether, there were 48 litter samples (4 habitat types x 6 sites x 2 litter samples). The distance between sampling sites were 100-500 meters. Samples were collected every fourth week from early spring to late autumn in 2014. The studied species were extracted manually from each sample and the specimens were preserved in 70% ethanol *(36)*. Ground beetle, spider and woodlice species were identified to species level using standard keys *(13, 14, 15, 16)*. Collected forest specialist species were classified according to their habitat affinity *(13, 15, 16, 17)*.

Data analyses

For the statistical analyses we pooled the samples for the whole sampling period. Generalized Linear Models (GLMs) were used to test differences in the total number of species, and the number of forest specialist species of epigaeic arthropods among the studied habitats (windthrow gap, gap harvested by group selection, clear-cut and mature forest). When the overall GLMs revealed a significant difference between the means, a Tukey test was used for multiple comparisons among means *(18)*.

RESULTS

During the sampling period we collected 1093 individuals of epigaeic arthropods belonging to 118 species (spiders: 379 individuals, 69 species; woodlice: 389 individuals, 5 species, and ground beetles: 325 individuals, 44 species). Our results showed that the total number of epigaeic arthropod species was significantly higher in the gaps harvested by group selection than in the clear-cuts and in the mature forests (Wald statistic = 15.66, d.f.=1, 3, $p<0.01$; Figure 1A). There were no significant difference between the windthrow gaps, the clear-cuts and the mature oak forests. 119 individuals belonging to 21 species were identified as forest specialist species, of which 10 species were spider, 2 species were woodlice and 9 were ground beetle forest specialist species (Appendix 1). The number of forest specialist species was significantly lower in the clear-cuts than in the other habitat types. Moreover, there were no significant difference in this parameter between the windthrow gaps, the gaps harvested by group selection and the mature forests (Wald statistic = 33.13; d.f.=1, 3; $p<0.0001$; Figure 1B).

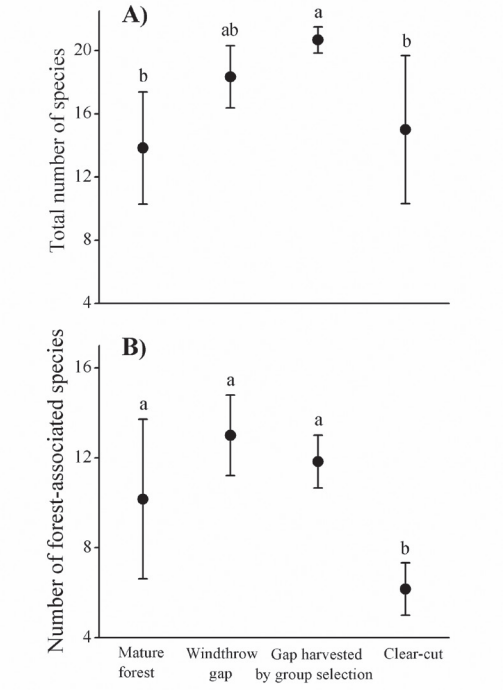

Fig. 1. *Total number of species (A) and the number of forest specialist species (B) (including ground beetle, spider, and woodlice) (mean±SE) in the studied habitat types. Different letters indicate significant differences by Tukey test (p<0.01).*

DISCUSSION

Similarly to our findings Siira-Pietikäinen & Haimi *(9)* also demonstrated that group selection harvesting can support the diversity of epigaeic arthropods. The increased species richness in gaps harvested by group selection is explained by survival of forest specialist species after the harvest. It seems that habitat structure and microclimatic conditions in the gaps harvested by group selection could be favourable for the forest specialist species, contributing to the elevated species richness in these gaps *(1)*.

Our study also showed that the number of forest specialist species was the lowest in the clear-cut sampling sites, supporting our hypothesis that clear-cutting did not provide suitable conditions for the forest specialist species *(1)*. During site preparation trunks, roots, herbs and other organic components was removed; thus the intensity of solar radiation increased remarkably on the open soil surface *(19)*. Higher solar radiation caused higher soil temperature, lower soil moisture and relative humidity. Furthermore, tilling decreases the amount of leaf litter, dead wood and other organic materials, which could provide shelter and food resource for many arthropods *(3)*. The changed environmental conditions are unfavourable for the forest specialist species; they require special microclimatic conditions and food resources *(1, 3)*. Habitat characteristics and the environmental conditions did not change remarkably in the windthrow gaps and in the gaps harvested by group selection compared to the mature forest; thus, they provide suitable circumstances for the forest specialist species *(1)*.

Appendix 1. *The number of individuals of forest specialist ground beetle, spider, and woodlice species in the studied habitat types.*

Forest specialist species	Total number of individuals	Mature forest	Windthrow gap	Gap harvested by group selection	Clear-cut
Coleoptera: *Carabidae*					
Amara convexior	13	2	1	10	0
Amara ovata	5	1	1	3	0
Amara saphyrea	31	2	7	22	0
Asaphidion flavipes	1	0	0	0	1
Bembidion lampros	15	0	2	9	4
Carabus convexus	1	1	0	0	0
Notiophilus palustris	7	2	4	0	1
Notiophilus rufipes	19	3	9	5	2
Ophonus nitidulus	1	0	0	1	0
Arachnida: *Araneae*					
Anguliphantes angulipalpis	1	1	0	0	0
Cozyptila blackwalli	8	2	2	4	0
Dictyna uncinata	1	0	0	0	1
Diplocephalus picinus	2	2	0	0	0
Micrargus herbigradus	1	0	0	1	0
Microneta viaria	2	2	0	0	0
Pardosa alacris	3	0	0	3	0
Tapinocyba insecta	2	0	1	1	0
Tenuiphantes tenebricola	1	0	0	0	1
Trichoncus affinis	1	0	1	0	0
Isopoda: *Oniscidae*					
Protracheoniscus politus	1	0	1	0	0
Trachelipus ratzeburgii	3	1	1	1	0

CONCLUSION

Our findings demonstrated that the group selection harvesting increased the diversity of epigaeic arthropods. Moreover, it seems that this method does not affect harmfully the surrounding habitats and the natural processes compared to the clear-cutting method *(6)*. During the

group selection harvesting small group of trees are cut and removed establishing a multi-aged stand, by contrast, the clear-cutting creates large open area. Small sized gaps may provide an appropriate habitat for forest specialist species *(1)*. Our study showed that forest specialist species responded sensitively to conventional clear-cutting. For this reason, similarly to other studies, we recommend to use the group selection harvesting method during the forest management rather than conventional clear-cutting method *(6, 9)*.

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