

IMPACT OF CLEARCUTTING ON GROUND BEETLES (*COLEOPTERA*: *CARABIDAE*) IN A NORWAY SPRUCE FOREST

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Abstract: *The research was conducted in Veľká Fatra Mountains, Slovakia. Pitfall traps were installed in the forest and in the glade. Overall, 20 species of beetles (Coleoptera, Carabidae) were recorded. In the forest, 1532 individuals belonging to 13 species were recorded. Trechus pulpani had the highest abundance in the forest and represents almost half of all individuals. Paradoxically, on the glade, the numbers of species slightly increased, but their abundance was significantly lower. We recorded only 143 individuals belonging to 16 species. Of the forest species, only Carabus violaceus and Pterostichus unctulatus retained a dominant position, but their abundance has decreased by more than 70%.*

Key words: *Carabidae, clear cut, seasonal dynamics.*

1. Introduction

Clear-cutting represents the method of wood logging in which most of the wood is removed and taken away. Removing the wood causes the decline of microclimate conditions, significant damages of the herbaceous cover, and also destructs the surface of soil in which the beetles live and hide [3]. The forest stands are characterized by a relatively high and stable humidity of the soil, a very important factor, playing a crucial role in the distribution of arthropods [21].

At the stand level, the studied retention felling methods, compared to the clear-cutting, contribute positively to the maintenance of forest Carabid assemblages. The retained trees shelter the

ground layer from sunlight and, to some extent, from microclimatic alterations and changes in the bottom- and field-layer vegetation. However, the sheltering efficiency depends on the number of trees retained, as indicated by the relationship between generalist Carabid and tree density [11]. Many of the environmental factors are multifaceted and interlinked in defining the overall structural complexity of insect habitats [13], [18], [15].

Arthropod activity is influenced by several factors, including temperature. Differences in arthropod activity resulting from variation in density of plant cover, and probably caused by differences in microclimate, have been demonstrated frequently [22].

The younger stands show a higher

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species richness and value diversity indices than the 150-year-old stand. With respect to species composition, large species such as *Carabus scheidleri* and *Carabus coriaceus* were dominant only in the oldest forests [24].

The short-term response of ground-dwelling arthropods to disturbance has been extensively studied. Species adapted to colder climate, that inhabit higher-elevation altitudes, such as flightless forest specialist *Cychnus caraboides*, are less competent to colonize lower areas. Furthermore, they may not survive severe instability of their habitats [19].

Fragmentation and habitat loss are the most important causes of species decline worldwide. Major consequences of fragmentation and associated habitat loss are changes in the size and structure of the habitat. Some experiments have indicated that forest fragmentation causes species to decline and brings about local extinction [14], [4], [16]. Forest fragmentation leads to isolation and reduction in size of mature-forest fragments and to an increase in the proportion of edge habitat at the expense of interior habitat [12], [17]. Dispersal ability is an important factor that can be used in analyses of isolation effects on Carabid assemblages, not only at small scales, but at larger scales as well, showing the uniqueness of large, continuous forest areas.

Brachypterous species, with wings shorter than the elytra, are known as “per pedes colonizers” and have lower dispersal ability, while macropterous species that are able to fly, are better at dispersal [5]. Smaller Carabid species develop faster with shorter generation times and mostly hibernate as adults, and small Carabid

species are more often winged (macropterous) than the large-sized species [2].

The objective of this study was to compare the effects of clear-cutting on carabid assemblages in a post-disturbance Norway spruce ecosystem.

2. Material and Methods

The study was performed in 2013, in spruce forest stands. The age of the trees varied from 90 to 120 years.

2.1. Study Area

The study plots were situated on the Smrekovica near Ružomberok in North Slovakia (Figure 1). Veľká Fatra is a mountain range in the Western Carpathians in Slovakia. Nearly 90% of the area is covered by forests – beech and beech-fir forests, in some places replaced by spruce plantations and relics of pines. The original natural upper borderline of forests was lowered during the Wallachian colonization. Most of the area was protected by the Veľká Fatra national park.

Fatra in the lower areas has a cold climate, and parts of the ridge have cool mountain climate. At long-term average, the coldest month is January. In the area of Krížna, Ostredok and Smrekovica, the temperature decreases to -7°C , the rest of area from -5 to -6°C . At the top of mountains, the yearlong temperature is below the freezing point. The annual average rainfall precipitation is 1200-1400 mm.

The most important factor that influences the climate is the geographical position and the relief.

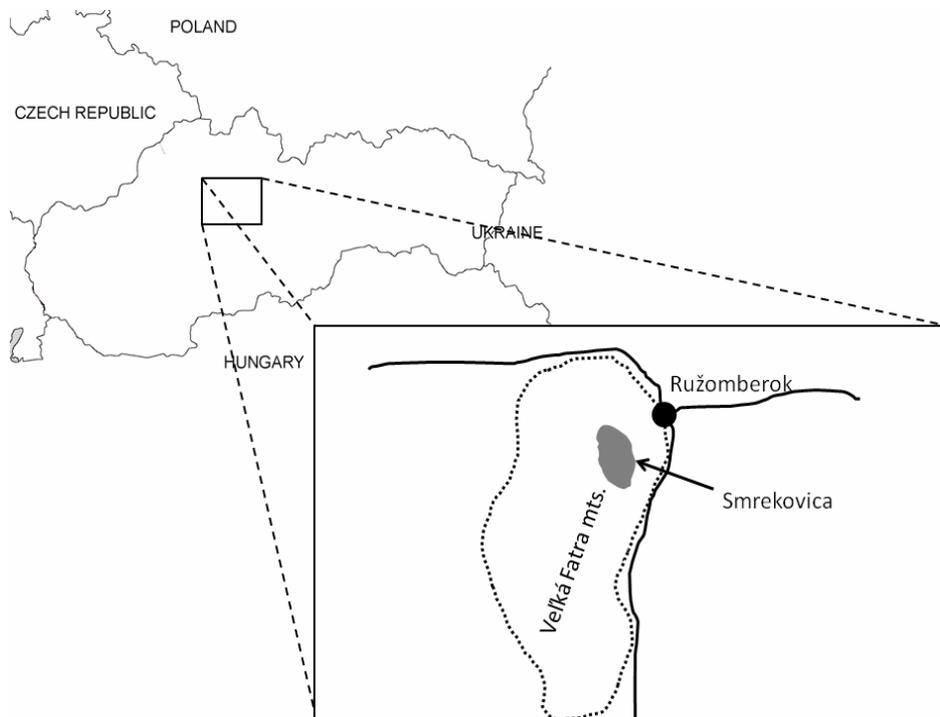


Fig. 1. Location of the study area in Slovakia

2.2. Description of Plot Stands

The study forests were spruce (*Picea abies*)-dominated. The herb layer was dominated by *Vaccinium vitis-idaea* and *Vaccinium myrtillus*. Hylocomium mosses covered most of the ground surface. The clearings resulted from the cutting of 90-120 years old spruce stand in 2010. The study plots were situated at an altitude of 1400 – 1500 m, on a Northeast slope with angle 15°. The soil is a cambisol on granodiorite bedrock.

2.3. Data Collection

The Carabid beetles were pitfall-trapped. Traps were installed in the forest and in the clear-cut which was founded. Carabid beetles were collected from May to November. Six traps (0.5 l plastic jar with a plastic funnel, 10 cm in diameter, containing 100 ml 70% ethylene glycol,

and covered by a 20 cm x 20 cm roof a few cm above soil surface, to protect the samples against rain and litter) were situated in a line at 10-meter distance in both plots. Traps were emptied on the same day approximately every four weeks (a total of seven visits per year).

The species were identified using keys by [8], [10], [6]. They were classified according to the degree of hind wing development into: macropterous, brachypterous or apterous; and polymorphic [23]. According to habitat preferences, they were classified into forest specialists, generalists and open-habitat species [9].

3. Results and Discussions

Overall, 20 species of beetles (*Coleoptera, Carabidae*) were recorded. In the forest, 1532 individuals belonging to the 13 species were recorded. On the

glade, only 140 individuals belonging to the 16 species were recorded (Table 1). The Shannon-Wiener index showed higher values in the forest than in the clear-cut.

3.1. Assemblage Composition

The highest abundance (nearly half of all individuals) in the forest had *Trechus pulpani*. Further dominant species were

Pterostichus unctulatus, *Trichotichnus laevicollis* and *Carabus violaceus*. 54% of the species (76% of the individuals), including most of the dominant ones in the forest, were forest specialists, while 46% of species (25% of the individuals) were generalists. The brachycerous species predominated in the forests, only *Trichotichnus laevicollis* was macropterous.

List of the Carabid species on investigated sites

Table1

Species	EV	Forest			Clear cut			Hab	W
		A	D	CD	A	D	CD		
<i>Amara plebeja</i> (Gyllenhal, 1810)	E	-	-	-	1	0,7	SR	O	M
<i>Anisodactylus signatus</i> (Panzer, 1797)	E	-	-	-	1	0,7	SR	O	M
<i>Carabus auronitens</i> (Fabricius, 1792)	A	4	0,26	SR	3	2,1	SD	G	B
<i>Carabus glabratus</i> (Paykull, 1790)	A	14	0,91	SR	-	-	-	F	B
<i>Carabus linnei</i> (Dejean, 1826)	A	74	4,83	SD	8	5,7	D	F	B
<i>Carabus violaceus</i> (Linnaeus, 1758)	A	40	2,61	SD	18	12,9	ED	G	B
<i>Cychrus caraboides</i> (Linnaeus, 1758)	A	16	1,04	R	7	5,0	SD	F	B
<i>Dromius fenestratus</i> (Fabricius, 1794)	A	2	0,13	SR	-	-	-	F	M
<i>Harpalus affinis</i> (Schrank, 1784)	E	-	-	-	1	0,7	SR	O	M
<i>Harpalus froelichii</i> (Sturm, 1818)	A	-	-	-	1	0,7	SR	O	M
<i>Notiophilus biguttatus</i> (Fabricius 1779)	A	5	0,33	SR	2	1,4	R	G	P
<i>Pterostichus ovoideus</i> (Sturm, 1824)	A	-	-	-	3	2,1	SD	O	M
<i>Pterostichus pilosus</i> (Host, 1789)	A	10	0,65	SR	5	3,6	SD	G	B
<i>Pterostichus pumilio</i> (Dejean, 1828)	A	43	2,81	SD	6	4,3	SD	G	B
<i>Pterostichus rufitarsis</i> (Dejean, 1828)	R	76	4,96	SD	4	2,9	SD	F	B
<i>Pterostichus strenuus</i> (Panzer, 1797)	E	-	-	-	4	2,9	SD	O	M
<i>Pterostichus unctulatus</i> (Duft. 1812)	A	292	19,1	ED	59	42,1	ED	G	B
<i>Trechus pulpani</i> (Reska, 1965)	R	782	51	ED	-	-	-	F	B
<i>Trechus striatulus</i> (Putzeys, 1847)	A	-	-	-	17	12,1	ED	O	B
<i>Trichotichnus laevicollis</i> (Duft. 1812)	A	174	11,4	ED	-	-	-	F	M
Number of species			13			16			
Number of specimens			1532			140			
Shannon's diversity H'			0,22			0,15			

EV=Ecological valence: R-relic, A-adaptable, E-eurytop, A=abundance, D=dominance, CD=class of dominance: SR-subrecedent, R-recedent, SD-subdominant, D-dominant, ED-eudominant species, Hab=Habitat preferences: F-forest specialists, G-generalists, O-open habitat species. W =Wing categories: B-brachypterous, M-macropterous, P-polypterous.

On the glade, the numbers of species slightly increased, but their abundance was significantly lower. From the forest species only the species of *Carabus violaceus* and *Pterostichus unctulatus* retained a dominant position, but their abundance decreased by more than 70%. The most abundant forest species *Trechus pulpani* absented in the clearing. In the clearing 19% of the species were forest specialists (14% of the individuals), 31% were generalists (66% of the individuals) and 50% of the species were open specialists (20% of the individuals). The two most dominant species in the clearing are among the generalists, except *Pterostichus unctulatus*. According to wing morphology, a significantly higher proportion of brachypterous species (76%) were recorded in the forest than in the clearing (37%), and a significantly higher proportion of macropterous species was recorded in the clearing (44%) than in the forest (15%).

3.2. Seasonal Dynamics

The seasonal dynamics of activity in the Carabid assemblage is characterized by qualitative and quantitative changes in the composition of feeding species. Carabid beetles in spruce forests of the temperate zone start their activity just after snowmelt.

Carabid species with spring activity hibernate in decaying wood, which provides the sum of temperatures necessary for early activity. The carabids of summer-autumn activity hibernate in the soil in a wide spectrum of habitats, differing in temperature. The dependence of development on temperature, leads to the heterogeneity in the physiological composition of the individuals within the population.

The maximal activity, observed in the middle of the growing period, decreased in spring and in autumn [20]. Carabid beetles

in spruce forests of the temperate zone start their activity shortly after snow melting. In 2013, it started in late April. The species with spring activity in forest were *Trichotichnus laevicollis* and *Pterostichus rufitarsis*. The Carabid activity increased from July to August and culminated in August with 442 specimens (Figure 2) belonging to 13 species (Figure 3). The species with summer activity were *Pterostichus unctulatus* and *Trechus pulpani*. In the end of August the number of Carabid species started to decline.

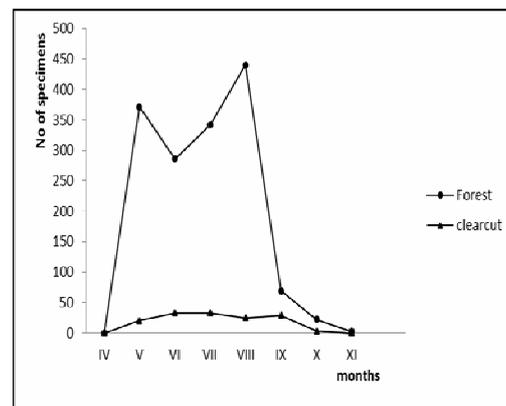


Fig. 2. Seasonal dynamics of abundance in forest and clear cut

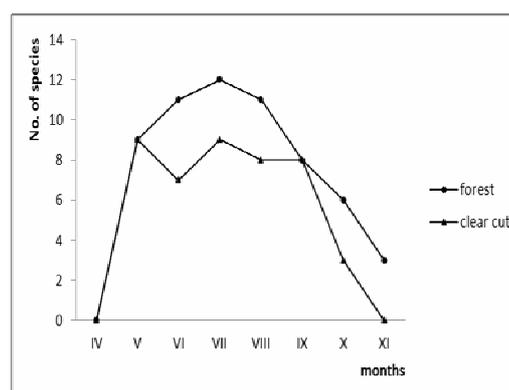


Fig. 3. Seasonal dynamics of species richness in forest and clear cut

The species with spring activity in clearing were *Trechus striatulus* and

Pterostichus unctulatus. An increase in Carabid activity was observed from May to June. The maximum abundance was in the end of June with 51 specimens (Figure 2), belonging to 12 species (Figure 3). In September, the number of Carabid species started to decrease.

3.3 Diversity and Abundance

Forest biodiversity can probably be best maintained if forest management respects natural processes, blends natural structures and maintains natural composition within the stands [7]. Compared to the effects of clear-cutting, logging gaps within intact forests increase the amount of edge habitat more and may, therefore, have cumulative consequences on biota in the long term. For example, open-habitat Carabids had invaded small openings, but also the narrow uncut sections of the same stands [11].

The changes of microclimate resulting from cutting of some forest segments caused unfavourable life conditions for the majority of the species of the original forest fauna. This caused their migration from deforested area and the fall of their abundance. If the deforested area has a direct contact with the cultural steppe, the abundance of the characteristic forest species declines and the species characteristic of the cultural steppe colonize the clearings. If the deforested area is enclosed by a forest, the deforestation causes the decline in abundance of the majority of the species, and their emigration. The species spectrum as such remains uninfluenced [26].

The sensitivity of Carabid assemblages in different forest types, to logging, could be estimated by comparison with the composition before cutting. After logging, the extent of change in forest communities, and especially their recovery, could be assessed by the monitoring of changes in representation

of the species selected as indicators. Carabid beetles are also excellent subject for studies of the effects of fragmentation on species with different dispersal abilities and habitat requirements [15].

The diversity and abundance were higher in the semi-natural habitat than in the managed forest, not only in arthropods, but also in vertebrates. For example, the structure of the forest habitats, is considered to be one of the most important factors influencing the breeding bird community composition. Structurally more homogenous forests are usually characterized by lower number and densities of bird species. The recorded diversity and abundance of birds was significantly higher in the semi-natural habitats than in the managed forest [1].

4. Conclusions

Our results are only partly consistent with those reported in the literature. As expected, forest specialists were rare in our logged plots. Out of the forest species, only *Carabus violaceus* and *Pterostichus unctulatus* retain a dominant position, but their abundance has decreased by more than 70%. The effects of deforestations result in the fall of abundance of the brachypterous species characteristic for the forest.

The fragmentation and creation of large areas of relatively homogeneous young forest stages through logging may have detrimental long-term effects even on the more abundant forest generalists. We must understand better the subtle variations in habitat in order to maintain invertebrate diversity, while harvesting the boreal forest [15].

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