DYNAMICS OF THE FOREST FLOOR BIOMASS IN THE BEECH ECOSYSTEM Calamintho grandiflorae-Fagetum IN MAVROVO NATIONAL PARK

Ljupčo MELOVSKI, *Slavčo HRISTOVSKI, Marjana ŠUŠLEVSKA & Ljupčo GRUPČE

Institute of Biology, Faculty of Natural Sciences and Mathematics, P.O.Box 162, 1000, Skopje, Republic of Macedonia

*Corresponding author: slavco_h@iunona.pmf.ukim.edu.mk

ABSTRACT


The biomass and annual dynamics of forest floor fractions was estimated in the frame of the complex ecosystem investigation in the beech ecosystem Calamintho grandiflorae-Fagetum in Mavrovo National Park. The results show that average forest floor biomass was 20.58 t·ha⁻¹ with maximum in November (23.80 t·ha⁻¹). The highest biomass was recorded in the fraction amorphous matter followed by fragmented leaves (4.47 t·ha⁻¹), branches (3.37 t·ha⁻¹), unaltered leaves (1.23 t·ha⁻¹) and beech acorns (0.67 t·ha⁻¹).

Key words: beech ecosystem, forest floor, biomass.

In forests with many years long life cycle, forest floor is a major source of nutrients systematically enriching the soil (Brożek & Wanic 2002). Released nutrients from the forest floor are supplemented by the continuous input of fresh litter. The biomass of the forest floor in beech ecosystems was investigated in different regions in Europe (Nihlgård & Lindgren 1977; Kavvadias et al. 2001; Santa Regina & Tarazona 2001), but its dynamics was object of study only in few of them (Towpaz 1976). Most of the articles concern the chemical properties of the forest floor and release of nutrients (Joergensen & Meyer 1990; Pardo et al. 1997; Brożek & Wanic 2002).

Introduction

Forest floor in the forest ecosystems is represented by the accumulated litter fall on the soil surface. It is consisted of plant material that is ranging from soft leaf tissue to woody substances, than bacteria, fungal hyphae, various animal materials and excreta (Edwards et al. 1970).

The vertical structure of the forest floor is defined by the undergoing stages of decomposition processes, thus several strata can be recognized. There are three major layers that are defined: unaltered plant and animal remains, a middle one of fragmented and partly decomposed products derived from the top layer and a bottom one of amorphous, finely divided matter (Heatwole 1961).
Presented work was conducted in the frames of the project „Complex ecosystem investigation in stationary conditions in the beech ecosystem Calamintho grandiflorae-Fagetum in Mavrovo National Park“.

Stationary is situated (20°48' E, 41°42' N) in well-developed middle aged beech forest on Shunteski Rid locality, village Leunovo district, near Mavrovo Lake at the elevation of 1400 m. The community is developing on dystric cambisol soil type. Climate is mountain-continental with Mediterranean influence (Filipovski et al. 1996).

Meteorological data according to Lazarevski (1993), based on the measurements of meteorological station Mavrovo (1240 m), show that the average annual temperature is 7.1 °C. The mean annual fluctuation of temperature is 18.7 °C.

The mean annual precipitation is 1103 mm. It consists mainly of snow during the colder periods of year. From October to March there is over 100 mm precipitation per month, April and May are characterized by 80-100 mm and July and August have less than 50 mm monthly precipitation. Permanent snow cover lasts 30-110 days while the snow period is 166 days in average.

Beech (Fagus sylvatica) absolutely dominates in the investigation locality with a density of 1200 trees · ha⁻¹. Mean DBH of trees is about 16 cm. Shrub layer is represented mainly by beech and shrubs of fir (Abies borisii-regis). Herb layer in the investigation site has low biomass (less than 6 kg·ha⁻¹ in average per month).

The annual litter fall in the tree layer is 4,97 t·ha⁻¹ (Šušlevska et al. 2001).

Forest floor was measured in the investigated beech forest during the period of May 1998 to May 2003. In total, 18 samplings were performed in the buffer zone of the stationary. The method used was line transect with sampling frames of 0.25 or 0.0625 m². Frames were placed on the surface of the forest floor and all organic material above the mineral soil was collected. The forest floor fractions were separated in different paper bags:

1. Unaltered leaves (L-layer) - intact fresh leaves or slightly discolored leaves with no or weak breaking up. Some of the other plant organs (bud scales, mail flowers etc.) were included in this fraction
2. Fragmented leaves (F-layer) - medium to strongly fragmented and discolored leaves
3. Amorphous matter - humified, finely divided organic matter which origin is not or hardly recognizable. Beech acorns as well as branches with very soft consistency were included in this fraction.
4. Branches - hard wooded branches which were found mostly on the surface of the forest floor, but some of them were mixed in the fractions of fragmented leaves or even in the amorphous matter.
5. Beech acorns - same explanation as for the fraction of branches can be applied for the fraction of beech acorns.

Three average samples from the fractions collected on the field were oven dried on on 105 °C and weighed in order to determine the moisture percent. The biomass was presented as dry mass (t·ha⁻¹).

Fig. 1. Dynamics of the amorphous matter and total biomass of the forest floor in the beech ecosystem Calamintho grandiflorae-Fagetum in Mavrovo National Park

Сл. 1. Динамика на биомасата на аморфната маса (amorphous matter) и вкупната биомаса (тотал) на шумската прострика во буковиот екосистем Calamintho grandiflorae-Fagetum во НП „Маврово“
The data on litter fall were obtained from Šušlevska et al. (2001) for the period 1998 and supplemented with unpublished data for the period 2001-2003.

**Results and discussion**

The biomass of the forest floor and separate fractions in different months was obtained by calculating average values of the measurements conducted in respective months different years. These values were used to present the biomass dynamics (Fig. 1). The total biomass of the forest floor ranged from 17.98 t·ha⁻¹ in June to maximum value in November (23.80 t·ha⁻¹) with average value of 20.58 t·ha⁻¹ (Fig. 3). Dynamics of the total biomass follows the fluctuations of the amorphous matter that is dominant fraction (Fig. 3). Maximal value of the total biomass was registered in November, due to the intensive leaf-fall in this month - 2.5 t·ha⁻¹ (Šušlevska et al. 2001). This value is very close to the difference of total forest floor biomass in November and October - 2.61 t·ha⁻¹. Compared to literature data it can be concluded that the total biomass of the forest floor in the investigated beech ecosystem in Mavrovo is higher than the one for northern beech forests (Nihlgård & Lindgren 2000).

![Fig. 2. Biomass dynamics of separate fractions: unaltered leaves, fragmented leaves, branches and acorns in the beech ecosystem Calamintho grandiflorae-Fagetum in Mavrovo National Park](image)

![Fig. 3. Average annual biomass (with minimum/maximum values) of forest floor fractions in the beech ecosystem Calamintho grandiflorae-Fagetum in Mavrovo National Park](image)
1977 - 3.4, 5.2 and 8.2 t·ha⁻¹ in Sweden; Joergensen & Meyer 1990 - 8 t·ha⁻¹ in Lower Saxony, Germany; Towpasz - 8.0-11.8 t·ha⁻¹) and lower than the one for southern forests (Tančeva 1988 - 25.21 t·ha⁻¹ for Galičica Mt. in southwest Macedonia; Kavvadias et al. 2001 - 75.6 and 58.8 t·ha⁻¹ for Greece).

Unaltered leaves biomass (Fig. 2) had maximum values in November (after the intensive leaf-fall) and than continuously has been decreasing till August. The beginning of the leaf-fall in September corresponds to the increase of unaltered leaves biomass.

Fragmented leaves biomass dynamics increases with the decrease of unaltered leaves biomass in the period November-May (Fig. 2). The biomass decrease in the period May-July corresponds to the more favorable conditions for decomposition processes and low litter fall input (Šušlevska et al. 2001).

Concerning the amorphous matter it is evident (Fig. 1) that had maximum biomass in November (12.88 t·ha⁻¹) and decreases till June. The most rapid decrease was recorded between May and June (2.13 t·ha⁻¹) as in the case for fragmented leaves.

Beech acorns biomass was greatest in the late spring and early summer period as well as mid autumn due to the more intensive fall of acorns (Šušlevska et al. 2001).

Amorphous matter was dominant fraction (51.5 % in average) in the forest floor according to its biomass (Fig. 3). Second layer of the forest floor - fragmented leaves participated with 21.7 % and the top layer of unaltered leaves with 6.0 %. Branches and beech acorns contributed with 16.4 and 3.25 % respectively.

The Jenny's index (k) and annual loss of the fallen litter (Tab. 1) shows that the leaves decompose more rapidly than the branches and beech acorns. According to the results of litter bag experiment conducted in the same stationary, the annual loss of leaves is 23.8 % (Hristovski et al. 2001) that is very similar to the result obtained from the forest floor measurements - 24.1 % or 23.1 (Tab.1). Similar results (24.5 %), obtained by forest floor data, were published by Santa Regina & Tarazona (2001) for leaf decomposition in beech forests in Sierra de la Demanda (Spain). Towpasz (1976) reported decomposition of 32.7 % of the forest floor and 23.8 % when litter bag experiment was used.

The k index for beech leaves from litter bag experiments ranges from 0.22 to 0.56 (Pardo et al. 1997; Nihlgård & Lindgren 1977). The value of k=0.38 for leaves shows that decomposition process in the beech ecosystem in Mavrovo is moderate according to its intensity. However, it is more intensive than the one for beech ecosystems in Mediterranean area in Spain - 0.22 and 0.29 (Pardo et al. 1997; Santa Regina & Tarazona 2001). There is wide range of data for other beech ecosystems in Central and Northern Europe: 0.52, 0.56, 0.32 for Sweden (Nihlgård & Lindgren 1977), 0.28 for north Germany (0.28 - Irmler 2000), 0.23-0.52 for France (Lemée & Bichaut 1974 in Pardo et al. 1997).

The k index of branches (0,26) is lower that the k index for beech acorns (0,27) which is not in accordance with the results of Hristovski et al. (2001) that the branches decompose faster than the beech acorns. It can be explained by the fact that 1) some partly degraded beech acorns were included in the fraction amorphous matter and 2) in the litter bag experiment only smaller branches with diameter 0,5-1,5 cm were observed (Hristovski et al. 2001).

Tab. 1. Litter decomposition indices in the beech ecosystem Calamintho grandiflorae-Fagetum in Mavrovo National Park

<table>
<thead>
<tr>
<th></th>
<th>A (t·ha⁻¹)</th>
<th>F (t·ha⁻¹)</th>
<th>k</th>
<th>kₜ</th>
<th>P (kg·ha⁻¹)</th>
<th>P %</th>
<th>kd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total litter</td>
<td>5.38</td>
<td>20.58</td>
<td>0.21</td>
<td>0.25</td>
<td>1114.0</td>
<td>5.14</td>
<td>0.79</td>
</tr>
<tr>
<td>Leaves (unaltered+fragmented)</td>
<td>3.48 (5.55)*</td>
<td>5.70</td>
<td>0.38</td>
<td>0.61</td>
<td>1317.2</td>
<td>23.1</td>
<td>0.62</td>
</tr>
<tr>
<td>- annual average</td>
<td>(0.39)*</td>
<td>(0.63)*</td>
<td>(1339.0)*</td>
<td>(24.1)*</td>
<td>(0.61)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Branches</td>
<td>1.21</td>
<td>3.37</td>
<td>0.26</td>
<td>0.36</td>
<td>318.0</td>
<td>9.44</td>
<td>0.74</td>
</tr>
<tr>
<td>Beech acorns</td>
<td>0.25</td>
<td>0.67</td>
<td>0.27</td>
<td>0.36</td>
<td>65.4</td>
<td>9.84</td>
<td>0.73</td>
</tr>
</tbody>
</table>

* measurements in October before main leaf fall (vrednosti za oktomvri pred glavniot listopad)

A - annual litter-fall (2001); F - biomass of the forest floor; k - Jenny’s index: k = A/(A+F); kₜ - Olson’s index: kₜ = A/F; P - annual loss from fallen litter: P = kF; kₜ - coefficient of accumulation of fallen litter: kₜ = (A-P)/A

A - годишн индекс на опад; F - биомаса на шумската простира; k - индекс на Јенин; kₜ = A/(A+F); kₜ - индекс на Олсон; kₜ = A/F; P - годишна загуба од опадот; P = kF; kₜ - коефициент на накупување на акумулираното опад: kₜ = (A-P)/A
Conclusions

In the frame of the complex ecosystem investigation in the beech ecosystem Calamintho grandiflorae-Fagetum in Mavrovo National Park the biomass and annual dynamics of forest floor fractions was estimated. The average forest floor biomass was 20.58 t·ha⁻¹. This value is higher than the biomass in the northern beech ecosystems in Europe and smaller than the southern ones. Amorphous matter was dominant fraction (51.5 %) followed by the fragmented leaves (21.7 %), branches (16.4 %), unaltered leaves (6.0 %) and beech acorns (3.25 %).

The maximum forest floor biomass was recorded in November which corresponds to the maximum litter fall. The dynamics of the unaltered leaves biomass decreased from November till September. Accumulation of the fragmented leaves biomass was observed with the decrease of unaltered leaves. Fragmented leaves biomass decrease in period May-July because of favorable conditions for decomposition and small litter input.

According to the decomposition indices, the highest decomposition rate was recorded for leaves (k=0.38). Branches and beech acorns had slower decomposition rates (0.26 and 0.27).

The value of k for leaves shows that decomposition process in the beech ecosystem in Mavrovo is moderate according to its intensity compared to other beech ecosystems in Mediterranean part of Europe and Central and Northern Europe.

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ДИНАМИКА НА БИОМАСАТА НА ШУМСКАТА ПРОСТИРКА ВО БУКОВИ-ОТ ЕКОСИТЕМ Calamintho grandiflorae-Fagetum VO НАЦИОНАЛНИОТ ПАРК „МАВРОВО“

Љупчо МЕЛОВСКИ, 'Славчо ХРИСТОВСКИ, Марјана ШУШЛЕВСКА и Љупчо ГРУПЧЕ

Институт за биологија, ПМФ, Љубљушка 162, 1000, Скопје
*Аутор за кореспонденција: slavco_h@iunona.pmf.ukim.edu.mk

Резиме

Шумската простирка е изградена од мрти органични материја од растително потекло, а со помал удел учествуваат и остатоци од животински, габи и микроорганизми. Таа претставува резервоар на минерални материја кои постепено се ослободуваат со процесот на разградување кој зазема централно место во кружевото на материјите во шумски екосистеми.

Во рамките на комплексните екосистемски истражувања во буковиот екосистем Calamintho grandiflorae-Fagetum во Националниот парк „Маврово“ беше определена биомасата на фракциите на шумската простирка (цели листови, раздробени листови, аморфна маса, граници и буклени) и нејзината годишна динамика.


Аморфната маса беше доминантна фракција со 51.5 %, а потоа следувала раздробените листови (21.7 %), граници (16.4 %), целу листови (6.0 %) и букалки (3.25 %).

Максималната биомаса на шумската простирка беше утврдена во Ноември што се совпада со максималниот опад (Šulevska et al. 2001). Динамиката на поодделните фракции на шумската простирка зависи од количеството опад и интензитетот на процесот на разградување. Највисоки вредности за биомасата на целата шумска простирка, аморфната маса и раздробените листови беа забележани во јуни и јули заради интензивното разградување, додека целите листови покажуваат континуирано опаѓање на биомасата од листопадот (Ноември).

Според константните на разградување, највисока вредност е регистрирана кај листовите \((k=0.38)\), а границите и букалките покажаа помали вредности \((0.26 \text{ and } 0.27)\). Според к вредноста за листовите може да се заклучи дека процесот на деградација се одвива со среден интензитет во однос на буковите екосистеми во медитеранскиот дел на Европа (Pardo et al. 1997; Santa Regina & Tarazona 2001). За централните и северните делови на Европа се наведуваат вредностите кои варираат во широки рамки \((0.52, 0.56, 0.32 \text{ за Шведска} - \text{Nihlgård} \& \text{Lindgren} 1977, 0.28 \text{ за Германија} 0.28 - \text{Irmler} 2000), 0.23-0.52 \text{ за Франција} - \text{Lemée} \& \text{Bichaut} 1974 \text{ in Pardo et al 1997)}).