

CONTRIBUTION TO THE ASSESSMENT OF MOUNTAIN GRASSLANDS PRODUCTIVITY FROM RÂMNICU SĂRAT RIVER BASIN

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Abstract. *The aim of this study is to assess the grasslands of the Râmnicu Sărat river basin, lying in Buzău and Vrancea counties, to the Curvature Carpathians, in terms of forage species, as well as to determine their productivity, pastoral value (PV), green fodder mass (GM) production and the optimal load of herbivores per hectare (Large Cattle Units). The permanent grasslands of Râmnicu Sărat river basin are spread up to 1340 m altitude above sea level, on flat lands and aspects, up to 30 degrees slopes, where, on average 85 species of plant species are found within a single plant community. The vegetation coverage is in average of 94%, of which 66% participation with fodder species and 28% with harmful species to grass carpet and animal production. The best pastoral value (PV) of 74.8 and a production of 16.62 t/ha of green fodder mass (GM) was evaluated within the ass. *Cirsio cani-Festucetum pratensis* and the lowest of 5.6 PV, with 0.56 t/ha GM within ass. *Festuco capillatae-Nardetum*. The average production of the assessed grasslands was of 7.22 t/ha GM, which allows a load of 0.73 LCU/ha, for an average period of 165 days of grazing, the lowest number being of 125 days in the mountain area and 195 days in the hilly area, for transhumant domestic animals.*

Keywords: grasslands, phytodiversity, green mass production, pastoral value, grazing capacity

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1. Introduction

Determining the meadows productivity (in terms of green mass production and forage quality) is one of the main economic indicators on the basis of which decisions are taken regarding those measures in order to improve the vegetational cover, the farmers being able this way to establish the optimal grazing capacity with domestic animals [17].

Researches on the evaluation of grassland productivity based on floristic survey are incipient in Romania, still being easier to apply with quite good results.

In practice, it is quite difficult to determine the grasslands productivity, the classical methodology requiring fenced areas of various grassland types in more difficult to access areas, such are the mountain grasslands.

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For these reasons, a new methodology to assess the productivity of grasslands based on floristic survey was developed [2, 3, 15, 16).

To date, several assessments have been made on the productivity of grasslands in different mountain areas in Romania [4-14].

This paper continues the evaluation the productivity of mountain grasslands, in this case the Basin of Râmnicu Sărat river, Vrancea Mountains, that continue to serve to a better management of meadows, with appropriate improvement measures and suitable grazing capacity, projected in pastoral arrangements.

2. Materials and Methods

The studied area belongs to the Vrancea Mountains, namely the upper and middle basin of the Râmnicu Sărat river. Vrancea Mountains are a subunit of the Curvature Carpathians, on a North-South direction with a length of 79 Km, and on a West-East direction on a length of 20-35 Km. Vrancea Mountains are of middle heights (the highest peaks are Goru, of 1,785 m a.s.l. (above sea level) and Lăcăuți, of 1,777 m a.s.l.), made on the deposits of the external flysch (as they are conglomerates, marls, sandstones, clays, etc.), of Cretaceous and Palogenic ages [21, 23].

In the upper belt of vegetation of Vrancea Mountains (over 1,600 m alt. a.s.l.) the meadows belong to vegetation class *Juncetea trifidi* Hadač in Klika et Hadač 1944 (on very small patches, not mapped and unevaluated within this paper), and to vegetation class *Calluno-Ulicetea* Br.-Bl. et R. Tx. ex Klika et Hadač 1944. The climate is cold, the average yearly of temperatures being of ± 2 °C, and the average yearly of precipitation of > 1,000 mm.

In the middle belt of vegetation (1,200-1,600 m alt. a.s.l.) the meadows belong to vegetation class *Molinio-Arrenatheretea* Tx. 1937. The average yearly of temperatures is 2 – 4 °C, and the the average yearly of precipitation of 800 - 1,000 mm. The soils are mostly brown acids.

In the lower belt of vegetation (under 1,200 m alt. a.s.l.) the vast majority of meadows belong to vegetation class *Molinio-Arrenatheretea* R. Tx. 1937; only, on sunny and exposed slopes the meadows belong to vegetation class *Festuco-Brometea* Br.-Bl. et Tx. 1943 ex Klika et Hadač 1944. The average yearly of temperatures is 4 – 6 °C, and the the average yearly of precipitation of 700 - 900 mm. The soils are mostly brown acids and brown humics.

Along paths, roadsides, potholes and so on, the meadows belong to vegetation class *Polygono arenastri-Poetea annuae* Rivas-Martinez 1975 corr. Rivas-Martinez et al. 1991 [22].

The studied area includes large surfaces of meadows/grasslands (used both as hayfields or pastures), very valuable in terms of fodder. They form a large feeding base for grazing animals (sheep, goats, cows, horses), as well as for wild herbivores in the area. The meadows are distributed from the lower part to the top of the mountains. It was found that the upper limit of the tree line was artificially lowered by a height of 300-400 m altitude, as a result of its massive deforestation in order to expand the secondary hayfields and pastures [22].

The area of Râmnicu Sărat river basin was chosen by the authors considering that the Romanian legislation in the field obliges the administrative-territorial units from the whole country to evaluate their potential grasslands to support an optimal number of animals that graze, avoiding thus to destroy them.

The Romanian legislation obliges the administrative-territorial units from the whole country to evaluate their potential grasslands in order to support an optimal number of domestic animals that graze on them.

The actual working methodology was presented in detail in the pages of this scientific journal, for the evaluation of the productivity of the meadows in the Perșani Mountains, the reason why we do not return to it [3].

The plant nomenclature was adopted in conformity with the on-line european flora (continuously updated) (<https://www.emplantbase.org/home.html>) and the most recent identification field book for vascular plants in Romania [20].

The coenotaxonomic system used in this paper is according to the most accepted operas that deal the subject of Romanian vegetation cover [1, 18, 19].

3. Results and Discussions

In order to evaluate the productivity of the grasslands, the floristic surveys from the report no. 2 of doctoral thesis entitled “Researching the flora and vegetation in the upper and middle basin of the Râmnicu Sărat river” were used, drafted in 1980 by biologist Nicolae Ștefan under the guidance of Professor dr. Constantin Burduja, from the University “Alexandru Ioan Cuza” of Iași, Faculty of Biology-Geography.

As a general note, the permanent meadows belong to the upper basin of Râmnicu Sărat river, in the Vrancea Mountains, while the middle basin of the same river is situated in the hilly area of Buzău county.

The grassland of the studied area were framed according to some of the coenotaxonomic classifications in use for the Romanian vegetation [1, 18, 19].

The coenotaxonomic classification is as the next:

Cl. **CALLUNO-ULICETEA** Br.-Bl. et R. Tx. ex Klika et Hadać 1944 (Syntax. syn.: Cl. **NARDO-CALLUNETEA** Preising 1949)

Ord. **NARDETALIA** Oberd. 1949

Al. **Potentillo-Nardion** Simon 1958

1. Ass. *Violo declinatae-Nardetum* Simon 1966 (Syntax. syn.: Ass. *Nardetum strictae montanum* Resm. et Csűrös 1963)
2. Ass. *Scorzonero roseae-Festucetum nigrescentis* (Pușcaru et al. 1956) Coldea 1987 (Syntax. syn.: 4. Ass. *Festucetum rubrae montanum* Csűrös et Resm. 1960)

Al. **Violion caninae** Schwickerath 1944

3. Ass. *Festuco capillatae-Nardetum* Klika et Šmarda 1944 (Syntax. syn.: Ass. *Nardus stricta* + *Bruckenthalia spiculifolia* I. Șerbănescu 1961)

Cl. **MOLINIO-ARRENATHERETEA** R. Tx. 1937

Ord. **ARRHENATHERETALIA** R. Tx. 1931

Al. **Cynosurion** R. Tx. 1947

4. Ass. *Festuco rubrae-Agrostetum capillaris* Horv. 1951 (Syntax. syn.: 6. Ass. *Agrostetum tenuis* auct. roman.; Ass. *Agrostetum tenuis montanum* Szafer, Pawł. et Kulkz. 1923)
 - 4a. subass. *typicum* (5. Syntax. syn.: Ass. *Festuceto-Agrostetum tenuis montanum* Csűrös et Resmeriță 1960)
 - 4b. subass. *nardetosum strictae* Oroian 1998 (3. Syntax. syn.: Ass. *Festuceto-Nardetum strictae montanum* Csűrös et Resmeriță 1960)
5. Ass. *Trifolio repentis-Lolietum perennis* Krippelova 1967 (Syntax. syn.: 10. Ass. *Lolieto-Trifolietum repentis* Resm. et al. 1967)
6. Ass. *Agrosteto-Festucetum sulcatae* Csűrös et Kaptalan 1964

Ord. **MOLINIETALIA** W. Koch 1926

Al. **Deschampsion caespitosae** Horvatić 1930

7. Ass. *Cirsio cani-Festucetum pratensis* Májovský et Ružičová 1975 (Syntax. syn.: Ass. *Festucetum pratensis* Soó 1938)
8. Ass. *Poëtum pratensis* Răvăruț, Căzăceanu et Turenschi 1956

Ord. POTENTILLO-POLYGONETALIA R. Tx. 1947

Al. **Potentillion anserinae R. Tx. 1947**

9. Ass. *Rumici crispi-Agrostetum stoloniferae* Moor 1958 (Syntax. syn.: Ass. *Agrostetum stoloniferae* Soó 1957)

Cl. **FESTUCO-BROMETEA** Br.-Bl. et Tx. 1943 ex Klika et Hadač 1944

Ord. *FESTUCETALIA VALESIIACAE* Br.-Bl. et R. Tx. ex Br.-Bl. 1949

Al. **Festucion valesiaca** Klika 1931

10. Ass. *Medicagini-Festucetum valesiaca* Wagner 1941 (Syntax. syn.: 12. Ass. *Festucetum valesiaca* Burduja et al. 1956)
11. Ass. *Taraxaco serotini-Botriochloëtum ischaemi* (Burduja et al. 1956) Sârbu, Coldea et Chifu 1999 (Syntax. syn.: 13. Ass. *Botriochloa ischaemum* Burduja et al. 1956, non Ass. *Botriochloëtum ischaemi* (Krist 1937) I. Pop 1977)
12. Ass. *Agropyretum pectiniforme* Prodan 1939 em. Dihoru 1970

Cl. **POLYGONO ARENASTRIO-POETEA ANNUAE** Rivas-Martinez 1975 corr. Rivas-Martinez et al. 1991

Ord. *POLYGONO ARENASTRIO-POETALIA ANNUAE* R. Tx. in Géhu et al. 1972 corr. Rivas-Martinez et al. 1991

- Al. **Matricario matricarioidis-Polygonion arenastri** Rivas-Martinez 1975 corr. Rivas-Martinez et al. 1991 (Syntax. syn.: Al. *Polygonion avicularis* Br.-Bl. 31 em Tx. 1950)
13. Ass. *Sclerochloa durae-Polygonetum avicularis* Soó ex Kornek 1999 corr. Mucina 1993 (Syntax. syn.: 15. Ass. *Polygonetum avicularis* Gams 1927)
14. Ass. *Poëtum annuae* Felföldy 1942 (Syntax. syn.: 16. Ass. *Poëtum annuae* Gams 1927)

The praticole plant communities (i. e. plant associations, associations for short) in the upper and middle basin of the Râmnicu Sărat river from upstream to downstream are found from 1,340 m altitude a.s.l. in the mountainous area, down to 110 m altitude a.s.l. in the area of low hills towards the plain, on flat lands or various slopes, between 5 and 30 degrees, on all aspects (Table 1).

Table 1. General data on site conditions and plant communities of grasslands in the upper and middle basin of the Râmnicu Sărat river

Nr. crt.	Plant community	Altitude (average/extremes) (m a.s.l.)	Aspect	Slope (degrees)	Vegetation coverage (%)	Plant species	
						no	%

Nr. crt.	Plant community	Altitude (average/extremes) (m a.s.l.)	Aspect	Slope (degrees)	Vegetation coverage (%)	Plant species	
						no	%
1	<i>Festuco capillatae-Nardetum</i>	1,165 (1,020-1,315)	flat ground, E, W, S-E, N-E, N-W	0-5	100	40	47
2	<i>Violo declinatae-Nardetum</i>	1,045 (1,030-1,060)	flat ground, E, W, S-W	0-5	98	38	45
3	<i>Festuco rubrae-Agrostetum capillaris nardetosum strictae</i>	1,160 (1,100-1,270)	E, S-E, S-W, N-E	5-20	98	67	79
4	<i>Scorzonero roseae-Festucetum nigrescentis</i>	1,170 (890-1,340)	E, S-E, S-W, W	15-30	100	87	102
5	<i>Festuco rubrae-Agrostetum capillaris typicum</i>	835 (745-900)	N-E, S-E, E, S-W, W, S, N	5-35	95	124	146
6	<i>Festuco rubrae-Agrostetum capillaris</i>	840 (750-920)	S-E, N-E, W, N-E, N-W	5-25	97	124	146
7	<i>Cirsio cani-Festucetum pratensis</i>	500 (375-620)	S-W, N-W, S, E, N	5-20	97	123	145
8	<i>Poëtum pratensis</i>	470 (195-760)	S-E, N-E, N- W, W, E	5-20	98	104	122
9	<i>Rumici crispi-Agrostetum stoloniferae</i>	385 (220-520)	flat ground, E, N-E, N-W, S-W, S	0-15	94	115	135
10	<i>Trifolio repentis-Lolietum perennis</i>	300 (210-380)	flat ground, N-E, E, W	0-5	95	78	92
11	<i>Agrosteto-Festucetum sulcatae</i>	545 (430-635)	E, S-W, N-E, S	5-25	94	80	94
12	<i>Medicagini-Festucetum valesiaca</i>	280 (110-390)	flat ground, S-E, S-W, S, N-W	0-30	91	122	144
13	<i>Taraxaco serotini-Botriochloëtum ischaemi</i>	185 (120-240)	flat ground, N-E, E, W, N	0-25	89	95	111
14	<i>Agropyretum pectiniforme</i>	175 (110-270)	flat ground, S, E, S-E	0-25	91	67	79
15	<i>Sclerochloo durae-Polygonetum avicularis</i>	235 (125-430)	flat ground, S-E, E, W	0-3	81	52	61
16	<i>Poëtum annuae</i>	480 (360-500)	flat ground, S-E, N-E, E, S-W	0-5	83	44	52

Nr. crt.	Plant community	Altitude (average/extremes) (m a.s.l.)	Aspect	Slope (degrees)	Vegetation coverage (%)	Plant species	
						no	%
	TOTAL AVERAGE	600 (110-1,340)	All	0-30	94	85	100

Data source: all the data processed in table no. 1 were taken over, with the consent of the author, from the report no. 2 of the doctoral thesis of Professor Nicolae Ștefan (Ștefan 1980).

The average vegetation cover was 94%, with limits between 81-83% for the plant associations *Sclerochloa durae-Polygonetum avicularis* and *Poëtum annuae* up to 100% in *Festuco capillatae-Nardetum* and *Scorzonero roseae-Festucetum nigrescentis*.

In terms of the number of vascular plant species (=Cormophytes), the grasslands from the study area are particularly rich, with an average of 85 species. The highest plant diversity, with over 120 species, was registered within the plant associations *Festuco rubrae-Agrostetum capillaris typicum*, *Cirsio cani-Festucetum pratensis*, and *Medicagini-Festucetum valesiaca*.

In contrast to the above situation, the lowest plant diversity, with about 40 species, was found to be inside the plant associations *Violo declinatae-Nardetum*, *Festuco capillatae-Nardetum*, and *Poëtum annuae*.

The mountain grasslands having a small number of plant species indicate an advanced stage of degradation due to their invasion by matgrass (*Nardus stricta*), as well as by other non-valuable plant species from fodder point of view.

As a matter of fact, the grasslands productivity is proportionally influenced by the participation in the grassy cover of the plant species with fodder values that reaches in on average 66%, and of the harmful ones of 28% (Table 2).

Table 2. Feeding value and green mass production of praticalous plant communities in Râmnicu Sărat basin river

No. crt.	Plant communities	Species participation		Pastoral value		Green mass production	
		Fodder plants	Harmful plants	(ind.)	%	t/ha	%
1	<i>Festuco capillatae-Nardetum</i>	9	91	5.6	12	0.56	7
2	<i>Violo declinatae-Nardetum</i>	10	88	6.3	13	0.65	8
3	<i>Festuco rubrae-Agrostetum capillaris nardetosum strictae</i>	48	50	35.4	75	5.30	67
4	<i>Scorzonero roseae-Festucetum nigrescentis</i>	88	12	66.6	140	13.20	166
5	<i>Festuco rubrae-Agrostetum capillaris</i>	80	15	59.8	126	10.56	133

No. crt.	Plant communities	Species participation		Pastoral value		Green mass production	
		Fodder plants	Harmful plants	(ind.)	%	t/ha	%
	<i>typicum</i>						
6	<i>Festuco rubrae-Agrostetum capillaris</i>	80	17	60.8	128	10.43	132
7	<i>Cirsio cani-Festucetum pratensis</i>	81	16	74.8	158	16.62	210
8	<i>Poëtum pratensis</i>	89	9	69.3	146	12.39	156
9	<i>Rumici crispi-Agrostetum stoloniferae</i>	83	11	58.4	123	11.39	144
10	<i>Trifolio repentis-Lolietum perennis</i>	80	15	69.0	146	12.85	162
11	<i>Agrosteto-Festucetum sulcatae</i>	82	12	51.9	109	10.53	133
12	<i>Medicagini-Festucetum valesiaca</i>	72	19	42.1	89	5.04	64
13	<i>Taraxaco serotini-Botriochloëtum ischaemi</i>	17	72	10.4	22	1.39	18
14	<i>Agropyretum pectiniforme</i>	77	14	43.3	91	5.08	64
15	<i>Sclerochloo durae-Polygonetum avicularis</i>	74	7	43.9	93	5.90	74
16	<i>Poëtum annuae</i>	78	5	60.5	128	4.93	62
	AVERAGE	66	28	47.4	100	7.93	100

Data source: all the data processed in table no. 2 were taken over, with the consent of the author, from the report no. 2 of the doctoral thesis of Professor Nicolae Ștefan (Ștefan 1980).

The highest proportion in the grassy carpet of 88-89% of fodder plant species is found in the plant associations *Festuco rubrae-Agrostetum capillaris* and *Poëtum pratensis*, and the lowest, of 9-10%, within those plant communities dominated by the matgrass (*Nardus stricta*) and 17% fodder plant species at *Taraxaco serotini-Botriochloëtum ischaemi* in the hilly area.

The pastoral value, directly influenced by the participation and quality of the fodder plant species is 47.4 (moderate) for the study area.

The highest pastoral value, of 74.8, was evaluated for the plant community *Cirsio cani-Festucetum pratensis*, which is used for hay production, and the lowest one, of 13, for the plant *Violo declinatae-Nardetum*, still being used irrationally for grazing.

The average production of green fodder is of 7.93 t/ha, with the best production of 16.62 t/ha (210% compared to the averages) for the plant community *Cirsio cani-Festucetum pratensis*, and the weakest production of green fodder, of 0.56- 0.65 t/ha to those dominated by the matgrass (*Nardus stricta*).

Between these two extreme figures, the difference in fodder green mass production is more than 27 times larger than that of this economic factor on which domestic animal production depends.

Finally, based on the production data, the optimal grazing capacity was established, at the level of phytocoenological alliances assimilated in general with the new habitats, which is 0.73 Large Cattle Units (LCU)/ha, for a season of 165 days of grazing, corresponding to an altitude of 600 m a.s.l. (Table 3).

Table 3. Optimal length of the grazing season, average green mass production and loading with domestic animals at the level of phytocoenological alliances (habitats)

Plant alliances	Average altitude (m a.s.l.)	Grazing season length (in days)	Green mass production (t/ha)	Animal loading (LCU/ha)	Productivity assessment
<i>Potentillo-Nardion</i>	1,110	125	0.61	0.08	degraded
<i>Violion caninae</i>	1,000	135	9.87	1.12	medium
<i>Deschampsion cespitosae</i> *	430	180	11.89	1.02	medium
<i>Cynosurion cristati</i>	420	180	11.69	1.00	medium
<i>Festucion valesiaca</i>	210	195	3.84	0.30	very low
<i>Matricario matricarioidis-Polygonion arenastris</i>	360	185	5.42	0.45	low
AVERAGE	600	165	7.22	0.73	moderate

* without ass. *Cirsio cani-Festucetum pratensis*, harvested as hay

Data source: all the data processed in table no. 3 were taken, with the consent of the author, from the report no. 2 of the doctoral thesis of Professor Nicolae Ștefan (Ștefan 1980).

The highest grazing capacity, of 1.0-1.12 LCU/ha, is achieved, in order, on the grasslands within the next plant alliances: Al. *Cynosurion/Deschampsion cespitosae* for 180 days of grazing, and Al. *Cynosurion* for 135 days of grazing.

It must be said that the meadows included within the plant association *Cirsio cani-Festucetum pratensis* (Al. *Deschampsion caespitosae*), harvested for hay, were not included on these calculations.

Obviously, the lowest load of only 0.08 LCU/ha was evaluated, as expected, for Al. *Potentillo-Nardion*, which is 14 times lower than the neighboring meadows within the Al. *Cynosurion*.

Due to the very large difference in grazing capacity, between the better managed mountain grasslands of Al. *Cynosurion*, and the poorest productive ones of Al. *Potentillo-Nardion* existing in close pedoclimatic conditions, the existing potential of currently degraded grasslands is noticeable.

Conclusions

(1) The Romanian legislation obliges the administrative-territorial units from the whole country to evaluate their potential grasslands in order to support an optimal number of domestic animals that graze on them.

(2) The grassland of the upper basin of Râmnicu Sărat river are in the Vrancea Mountains, while the middle basin of the same river is situated in the hilly area of Buzău county.

(3) The coenotaxonomic system adopted in this paper includes 14 plant associations, and 2 subassociations, from 7 alliances of vegetation, 6 order of vegetation, and 4 classes of vegetation.

(4) The fodder plant communities in the upper and middle basin of the Râmnicu Sărat river are found from 1,340 m altitude a.s.l. in the mountainous area, down to 110 m altitude a.s.l. in the area of low hills towards the plain, on flat lands or various slopes, on all aspects (East, West, North, and South).

(5) The average vegetation coverage is of 94%, varying between 81-83% for some of the plant associations (*Sclerochloa durae-Polygonetum avicularis*, *Poëtum annuae*) and 100% for other plant associations (*Festuco capillatae-Nardetum*, *Scorzonero roseae-Festucetum nigrescentis*).

(6) The grasslands in the upper and middle basin of the Râmnicu Sărat river are particularly rich in vascular plant species, with an average of 85 per each plant community; the highest number, of over 120 plant species, was registered within some of the plant associations (*Festuco rubrae-Agrostetum capillaris typicum*, *Cirsio cani-Festucetum pratensis*, and *Medicagini-Festucetum valesiaca*); the lowest number of plant species, of about 40 species, was registered for some of the plant associations (*Violo declinatae-Nardetum*, *Festuco capillatae-Nardetum*, *Poëtum annuae*).

(7) The mountain grasslands with a small number of plant species indicate usually advanced stages of degradation due to invasion by *Nardus stricta*, as well as by other non-valuable plant species from fodder point of view.

(8) The average production of green fodder was 7.93 t/ha, with an index of 47.4 pastoral value, with large differences between various plant associations and phytocoenological alliances.

(9) The average grazing capacity in 165 days of the season was assessed at 0.73 LCU/ha, respectively from over 1 LCU/ha within the plant alliances *Cynosurion cristati* and *Deschampsion caespitosae*, to 0.08 LCU/ha on degraded grasslands of the Al. *Potentillo-Nardion*.

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