CONTRIBUTIONS TO THE ASSESSMENT OF THE PRODUCTIVITY OF FORAGE GRASS VEGETATION IN THE DANUBE DELTA

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Abstract

The grassy vegetation of the Danube Delta is extremely diverse due to the water regime from surplus to very reduced, soil texture from coarse to very fine, different stages of salinity, zooanthropic influence and other factors. 27 plant vegetal associations belonging to 10 alliances, 6 orders and 5 phytosociological classes were determined. The grassy carpet is dominated by hydrophilic species with no fodder value such as reeds (Phragmites australis), reeds (Typha sp.), sedges (Carex sp) and some species on salt soils (Juncus sp. and others). On average, the pastoral value (PV) of 7.2 and green fodder mass production (DM) of 0.86 t/ha are considered degraded and can only provide 0.08 LU/ha in 160-day grazing season, for times below the established level of 0.30 LU/ha, for granting subsidies. In addition, the hay produced from cane, rushes and sedges in fodder value is only 50% of the value of cereal straw and 5 times weaker than alfalfa hay. With a few exceptions, such as the associations of Puccinellietum limosae on salt soil and Festucetum beckeri on beams that can be classified as permanent grasslands, the rest of the phytocenoses with very low fodder productivity are not part of this mode of agricultural use.

Keywords: Delta Dunării vegetation, pastoral value, production of green fodder mass, animal load, hay quality

INTRODUCTION

The evaluation of the productivity of permanent grasslands (pastoral value, production of green mass and livestock, etc.) is the main component of pastoral arrangements and optimal management further (MARUȘCA et al., 2014).

In a first approximation, the productivity of the permanent grasslands habitats in our country was evaluated, which partially included those in the plains, meadows and Delta Dunării area (MARUȘCA et al., 2020, 2021; MARUȘCA, 2022; MARUȘCA, VINȚAN 2022; MARUȘCA et al., 2022 a, b, c, d, e; OPREA, MARUȘCA, 2022; MARUȘCA, 2023; MARUȘCA et al., 2023 a, b).

In addition to these, the entire Delta Dunării was studied, as an integral part of the Biosphere Reserve, with grassy vegetation, partly used as fodder for the livestock of the inhabitants of the area.

MATERIAL AND METHOD

For this purpose, the synthesis work "Vegetation of the Delta Dunării" published in 1997 under the care of the Mureș County Museum, MARISIA publication, vol. XXV, 126 pages, with authors Popescu A., Sanda V., Oroian Silvia with the collaboration of Chifu Th., Ștefan N and Sârbu I., some of the most important geobotanists in our country.

The floristic surveys were compiled and classified according to the Braun-Blanquet phytosociological method (Anghel et al., 1971; Coldea,1991; Cristea et al., 2004).

The herbaceous vegetation was classified into 5 classes, 6 orders, 10 alliances and 27 phytosociological associations with 276 floristic surveys as follows:

HELOPHILOUS VEGETATION (PALUSTRA)
CL. ***PHRAGMITETEA*** Tx et Prsg.1942
Ord. *PHRAGMITETALIA* Koch 1926 emend Pign 1953
Al. ***Phragmition*** Koch 1926
1. As. *Scirpo - Phragmitetum* Koch 1926
(Syn. *Phragmitetum communis* (All.1922) Pign 1953; *Scirpo-Phragmitetum austro-orientale* Soó 1957, *Phragmitetum natans* (Borza 1960, Nedelcu 1967)
2. As. *Typhetum angustifoliae* (All.1922) Pign.1943
3. As. *Glycerietum maximae* Hueck 1931
(Syn.*Glycerietum aquaticae* Nowinski 1928
4. As. *Schoenoplectetum(Scirpetum) lacustris* Eggler 1933

HALO - PSAMOPHILOUS VEGETATION
CL. ***JUNCETEA MARITIMI*** Br-Bl.1931
Ord. *JUNCETALIA* MARITIMI Br.-Bl.1931
Al. ***Juncion*** **maritimi** Br.-Bl.1931
5. As. *Juncetum maritimi* (Rübel 1930) Pign 1953
6. As. *Juncetum littoralis* Popescu et al.1992
(Syn. *Juncetum acuti* Popescu et Sanda 1976)
Al. ***Armerion maritimae*** Br.-Bl. Et DeL. 1936
7. As. *Plantaginetum coronopi* Tx. 1937

HALOPHILOUS VEGETATION
CL. ***PUCCINELLIO - SALICORNIETEA*** Țopa 1939
Ord. *SALICORNIETALIA* Br.-Bl. (1928) 1933
Al. ***Thero-Salicornion*** Br.-Bl. (1928) 1933

8. As. *Salicornietum europaeae* Wendelbg 1953
9. As. *Suaedetum maritimae* Soó 1927
10. As. *Aeluropo Salicornietum* Krausch 1965
11. As. *Puccinellio - Salicornietum* Popescu et al. 1987
Ord. *PUCCINELLIETALIA* Soó 1940
Al. ***Puccinellion limo sae*** (Klika 1937) Wendelbg 1943
12. As. *Puccinellietum limosae* Rapaics 1927
13. As. *Plantaginetum maritimae* Rapaics 1927
14. As. *Agrostetum ponticae* Popescu et Sanda 1973
15. As. *Aeluropetum littoralis* (Prodan 1939) Șerbănescu 1965
16. As. *Limonio - Aeluropetum littoralis* Sanda et Popescu 1992
17. As. *Aeluropo - Puccinellietum limosae* Popescu et Sanda 1975
Al. ***Cypero - Spergularion*** Slavnic 1948
18. As. *Acorelletum pannonici* Soó 1939
19. As. *Spergularietum mediae* (Șerbănescu 1965) Popescu et al. 1992
20. As. *Polypogonetum monspeliensis* Moraru 1957

COASTAL DUNE VEGETATION
CL. ***AMOPHILETEA*** Br-Bl. et Tx.1943
Ord. *ELYMETALIA ARENARIAE* Br.-Bl. et Tx 1943
Al. ***Elymion gigantei*** Morariu 1957
21. As. *Elymetum (gigantei) sabulosi* Morariu 1957 corr.hoc.loco.
22. As. *Secaletum sylvestre* Popescu et Sanda 1973 non Șerbănescu
Al. ***Agropyro - Minuartion*** Tx.1945 apud Br.-Bl. et Tx.1982
23. As. *Aperetum maritimae* Popescu,Sanda,Doltu 1980
(Syn. *Aperetum spicae-venti* Soó 1953 subass *ponticum* Popescu et Sanda 1972)
CL. ***FESTUCETEA VAGINATAE*** Soó 1969
Ord. *FESTUCETALIA VAGINATAE* Soó 1957
Al. ***Festucion vaginatae*** Soó 1929
24. As. *Festucetum beckeri nomen* novum
(Syn. *Festucetum vaginatae* (Rapaics 1923) Soó 1929 subass. *arenicolum* Popescu et Sanda 1976)
25. As. *Koelerio glaukae-Stipetum borysthenicae* Popescu et Sanda 1987
Al. ***Scabiosion argenteae*** (Boșcaiu 1975) Popescu et Sanda 1987
26. As. *Scabioso argenteae - Artemisietum campestris* Popescu et Sanda 1987
27. As. *Scabioso argenteae-Caricetum colchicae*(Simon1960) Krausch 1965 (Syn. *Caricetum colchicae* Simon 1960)

The evaluation of the pastoral value and the production of green fodder mass was carried out according to the new method based on the floristic survey (Maruşca 2019).

According to this method, numerous phytocoenoses of lowland grasslands were evaluated, most of them published in this journal, so we will not return to this method.

In addition to this evaluation of the productivity that refers to the green mass of the grasslands used occasionally by grazing with the animals, studies were carried out on the vegetation of the permanent grasslands of Sf. Gheorghe - Delta as part of a pastoral management project.

From the very beginning we noticed the very strong invasion of reeds (*Phragmites australis*), rushes (*Typha angustifolia*) and sedges (*Carex sp*.) of permanent grasslandss with excess moisture due to the rise of the water table as a result of the digging of a Cordon Litoral channel parallel to the shore of the sea from Sf. Gheorghe towards Sulina and of the non-harvesting of hay necessary for the wintering of livestock in that area (Maruşca 2017).

The feed analysis was carried out at ICD Pajişti - Braşov using the Near Infrared Spectroscopy (NIRS) technique.

Hay quality was achieved according to the standards of the United States Department of Agriculture regarding the nutritional value of forages (Table 1).

Table 1

Quality classes assigned by American Forage & Grassland Council, Hay Marketing Task Force (adapted*)

APPRECIATION CLASS	% CP	% ADF	% NDF	% DSU	RFV
Excellent	>19	<31	<40	>65	>151
Very good	17-19	31-35	40-46	62-65	125-151
Good	14-16	36-40	47-53	58-61	101-124
Middle	11-13	41-42	54-60	56-57	86-100
Poor	8-10	43-45	61-65	53-55	77-85
Very poor	<8	>45	>65	<53	<76

*Alex Rocateli, Hailin Zhang, Forage Quality Interpretations, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University, http://osufacts.okstate.edu

For comparison on the fodder quality of the reed hay from the Delta Dunării, alfalfa hay and two-row barley straw were additionally analyzed as controls, although in a monographic work there is no reference that the reed would have fodder value (Rudescu et al., 1965).

In this way, a concrete and complete answer is given on the fodder productivity of the grassy vegetation used as green mass through grazing and the optimal

load with animals, as well as for the fodder value of the hay they are fed with during the stalling period.

RESULTS AND DISCUSSIONS

The grassy vegetation in the Delta Dunării is strongly influenced by the excess or lack of moisture, the coarse texture of the substrate in different stages of salinization, the degree of salinity, the zooanthropic impact through grazing, harvesting, fires and other factors.

Phytodiversity in the 27 plant vegetation associations is very different, with an average of 32 cormophytes, being quite low (Table 2).

The phytocoenoses richest in species were *Scirpo-Phragmitetum* (68 sp), *Typhetum angustifoliae* (65) and *Juncetum maritimi* (56).

The fewest species are in the associations *Spergularietum mediae* (11 sp), *Puccinellio - Salicornietum* (12) and *Aeluropo - Puccinellietum limosae* (16 species).

Regarding the participation of forage species, only two associations have more than 85%, namely *Puccinellietum limosae* (90%) from the salt soil and *Festucetum beckeri* (86%) from the sandy soils of the shingles, the only ones that we can consider as permanent grasslands. With 38% participation, *Puccinellio - Salicornietum* is present, the rest of the associations have between 1 - 25% participation of forage species in the grassy carpet.

Within the limits of 1 - 5%, the grassy associations should no longer be included in the category of permanent grasslands and those between 6 - 25% on salt or sand after improving the texture and reaction of the soil with environmental protection reserves in the protected areas would could improve and finally pass to the category of permanent grasslands.

Table 2

Forage structure and pastoral productivity of grassland from the Delta Dunării

Nr crt	The grassland association	No. surveys	No. cormophyte	vegetation structure (%)		Pastoral value (ind)	Production Green mass	
				Fooder	Harmful		t/ha	%
	Al. ***Phragmition***							
1	*Scirpo - Phragmitetum*	15	68	6	94	3,4	0,72	78
2	*Typhetum angustifoliae*	19	65	4	96	1,9	0,46	50
3	*Glycerietum maximae*	11	41	2	98	0,6	0,13	14
4	*Schoenoplectetum lacustris*	6	19	4	96	2,9	0,43	47

Nr crt	The grassland association	No. surveys	No. cormophyte	vegetation structure (%)		Pastoral value (ind)	Production Green mass	
				Fooder	Harmful		t/ha	%
	Al. ***Juncion maritimi***							
5	*Juncetum maritimi*	18	56	5	95	2,5	0,21	23
6	*Juncetum littoralis*	13	24	1	99	0,6	0,10	11
	Al. ***Armerion maritimae***							
7	*Plantaginetum coronopi*	10	24	5	95	3,2	0,22	24
	Al. ***Thero-Salicornion***							
8	*Salicornietum europaeae*	22	38	1	99	0,5	0,03	3
9	*Suaedetum maritimae*	14	23	1	99	0,3	0,02	2
10	*Aeluropo Salicornietum*	8	23	12	88	7,6	0,51	55
11	*Puccinellio - Salicornietum*	10	12	38	62	29,4	2,27	247
	Al. ***Puccinellion limosae***							
12	*Puccinellietum limosae*	11	43	90	10	65,9	5,91	642
13	*Plantaginetum maritimae*	3	24	2	98	1,1	0,08	9
14	*Agrostetum ponticae*	11	53	9	91	6,5	0,56	61
15	*Aeluropetum littoralis*	9	21	2	98	1,6	0,11	12
16	*Limonio - Aeluropetum littoralis*	15	20	24	76	18,8	1,38	150
17	*Aeluropo - Puccinellietum limosae*	7	16	25	75	18,5	1,35	147
	Al. ***Cypero - Spergularion***							
18	*Acorelletum pannonici*	6	37	1	99	0,7	0,08	9
19	*Spergularietum mediae*	6	11	4	96	3,4	0,38	41
20	*Polypogonetum monspeliensis*	8	31	2	98	1,2	0,10	11
	Al. ***Elymion gigantei***							
21	*Elymetum (gigantei) sabulosi*	10	32	1	99	0,4	0,04	4
22	*Secaletum*	9	31	15	85	9,7	0,56	61

Nr crt	The grassland association	No. surveys	No. cormophyte	vegetation structure (%)		Pastoral value (ind)	Production Green mass	
				Fooder	Harmful		t/ha	%
	sylvestre							
	Al. ***Agropyro - Minuartion***							
23	*Aperetum maritimae*	7	34	3	97	1,8	0,18	20
	Al. ***Festucion vaginatae***							
24	*Festucetum beckeri*	5	22	86	14	47,8	8,27	871
25	*Koelerio glaukae-Stipetum borysthenicae*	10	29	4	96	2,3	0,29	32
	Al. ***Scabiosion argenteae***							
26	*Scabioso argenteae-Artemisietum campestris*	10	26	4	96	2,8	0,38	41
27	*Scabioso argenteae-Caricetum colchicae*	10	36	1	99	0,6	0,06	7
	AVERAGE	**11**	**32**	**13**	**87**	**8,7**	**0,92**	**100**

Participation in the grassy carpet of forage plants directly influences the pastoral value and the production of usable green mass through livestock.

The highest pastoral value (PV) in this case is *Puccinellietum limosae* (65.9) and *Festucetum beckeri* (47.8) where we also record the highest productions of green fodder mass (GM) 5.91 for the first and 8 .27 t/ha in the second association, being considered medium and good in terms of productivity.

Only one association, *Puccinellio - Salicornietum*, is mediocre from a productive point of view, having 29.4 PV index, below 5 being degraded, between 5 -15 poor from a qualitative point of view.

The production (GM) except for the first two associations (*Puccinellietum* and *Festucetum*) is between 0.02 - 2.27 t/ha, respectively from almost non-existent to very weak.

On average, for all associations, the participation of 13% in the grass carpet of forage species and 87% of worthless, harmful species with 8.7 PV (very poor) and 0.92 t/ha GM (very low) can be considered as a whole degraded from the point of view of productivity.

Analysis of grazing capacity in approx. 160 days normal season, i.e., the optimal load with animals

was carried out at the level of phytosociological alliance that assimilates with the practical habitats accepted in the European Union (Gafta, Mountford, 2008) (Table 3).

Table 3

Forage green mass production and possible grazing animal loading of herbaceous vegetation at phytosociological alliance level

Phytosociological Alliance	Pastoral value (ind)	Green mass production (t/ha)	Possible loading in 160 days		Appreciation
			LU/ha	%	
1. Phragmition	2,2	0,44	0,04	50	Degraded
2. Juncion maritimi	2,6	0,16	0,02	25	Degraded
3. Armerion maritimae	3,2	0,22	0,02	25	Degraded
4. Thero-Salicornion	9,5	0,71	0,07	88	Degraded
5. Puccinellion limosae	18,7	1,57	0,15	188	Degraded
6. Cypero - Spergularion	1,8	0,19	0,02	25	Degraded
7. Elymion gigantei	5,1	0,60	0,06	75	Degraded
8. Agropyro - Minuartion	1,8	0,18	0,02	25	Degraded
9. Festucion vaginatae	25,1	4,28	0,41	513	Poor
10. Scabiosion argenteae	1,7	0,22	0,02	25	Degraded
AVERAGE	**7,2**	**0,86**	**0,08**	**100**	DEGRADED

In this case, with 7.2 PV and 0.86 t/ha, on the current grassy vegetation in the Delta Dunării, only 0.08 LU/ha can be maintained on average, 4 times fewer grazing animals than the mandatory scale of over 0.30 LU/ha equivalent to 3 ha, required for 1 LU, for EU grassland grants granted by APIA.

Between alliances (habitats) there are very large differences from 0.02 - 0.41 LU/ha depending on PV and GM production previously evaluated.

The only alliance that meets the APIA eligibility condition is *Festucion vaginatae* on beams with consolidated sandy soils, the rest of the alliances are below this level.

Exceeding these optimal animal load levels can seriously damage phytodiversity and grassland biodiversity in general.

With 1 LU per 15 hectares of animal load, 5 alliances *Juncion maritimae*, *Armerion maritimae*, *Cypero - Spergularion*, *Agropyro - Minuartion* and *Scabiosion argentae* are registered, followed by 1 LU for 7.5 ha at *Pragmition*, 5ha for *Thiero - Salicornion* and *Elynion gigantei* finally 2 ha needed for the phytocoenoses of the *Puccinellion limosae* alliance.

With the exception of the *Festucion vaginatae* alliance, which has a productivity assessed as poor, all other alliances (habitats) are considered degraded from a forage point of view, lacking economic efficiency through animal grazing.

The improvement of the grassy carpet of these areas with grassy vegetation degraded from a fodder point of view involves very expensive agropedo-ameliorative land improvement works that contradict the conservation of the current biodiversity imposed by the Delta Dunării Biosphere Reserve.

The only way to improve the grass carpet in this case is to regulate the optimal animal load per hectare, where grazing does not affect biodiversity.

In addition, compared to the evaluation of PV and GM based on the floristic survey of the grassy phytocenoses, an analysis of the quality of the harvested hay for the animal housing season was carried out.

For this purpose, 3 average samples of hay produced on the Cazacu and Crasnicol bales were taken from freshly harvested and stored bales (Table 4).

Table 4

The nutritional value of some hay samples from the Danube Delta

Parameter	A. Grindul Cazacu				B. Grindul Crasnicol			
	1	2	3	**Average**	1	2	3	**Average**
Crude protein	2,8	3,7	4,6	**3,7**	3,5	4,3	3,4	**3,7**
Ash	5,3	7,2	7,8	**6,8**	8,4	7,0	6,6	**7,3**
Crude fibre	56,8	49,1	41,0	**49,0**	55,0	45,6	49,9	**50,2**
NDF*	86,7	83,1	78,6	**82,8**	82,7	82,8	84,5	**83,8**
ADF**	61,4	53,7	46,7	**53,9**	59,1	49,4	53,0	**53,8**
ADL***	8,7	7,1	5,5	**7,1**	7,3	5,6	6,0	**6,3**
DMD****	15,2	26,2	33,4	**24,9**	20,8	35,4	31,7	**29,3**
DOM*****	12,1	22,0	25,9	**20,0**	15,5	31,3	27,2	**24,7**

*NDF = Neutral Detergent Fibre, **ADF = Acid Detergent Fibre, ***ADL = Acid Detergent Lignin, ****DMD = Digestibility dry matter, *****DOM = Digestibility organic matter

Finally, the data on the qualities of the traditionally harvested hay from the two bales were compared with those of an alfalfa hay and two-row barley straw, harvested in the same year 2017 at ICD Pajiști – Brașov (Table 5).

Crude protein content is one of the most widely used indices for forage quality characterization. Delta hay was very low in crude protein (3,7%) compared to two-row barley straw (8,3%) and alfalfa hay (17,1%). The increased value of the ADF content of the hay from the delta places it in a very poor-quality class, according to the specialized literature (Canbolat et al., 2006; Schroeder, 2006), knowing that too much accumulation of the portion of acid detergent fibre (ADF) can affect feed digestibility and implicitly its consumption by animals. The deterioration of hay quality is also due to the high content in lignin (6,7%). In order to obtain a better digestibility of the

feed, it is indicated that this lignin content is as low as possible, because it can affect both the digestibility and the quality of the feed (Schroeder, 2006).

Thus, the current hay in the delta has a nutritional value more than 50% lower than the value of two-row barley straw and 5 times lower than that of alfalfa hay, results based on which this plant material cannot be considered forage for animal feed.

It is no coincidence that animals fed exclusively with this type of hay, very poor in nutrients, do not all survive until the grass turns in the spring!

Table 5

Comparative data on the nutritional value of delta hays, alfalfa and straw

Parameter	Alfalfa hay (%)	Two-row barley straw (%)	Deltă hay (%)	Differences (+, -) deltă hay versus:		Relative value (%) to:	
				Alfalfa	Two-row barley	Alfalfa	Two-row barley
Crude protein	17,1	8,3	3,7	- 13,4	- 4,6	22	45
Ash	9,4	9,9	7,0	- 2,4	- 2,9	74	71
Crude fibre	34,3	43,4	49,6	+ 15,3	+ 6,2	145	114
NDF	48,3	75,2	83,0	+ 34,7	+ 7,8	172	110
ADF	37,4	48,6	53,9	+ 19,2	+ 5,3	155	111
ADL	3,0	6,1	6,7	+ 3,7	+ 0,6	223	110
DDM	63,1	32,6	27,1	- 36,0	- 5,5	43	83
DOM	59,7	29,9	22,3	- 37,4	- 7,6	37	75

Currently, homesteaders buy alfalfa hay bales from outside the delta, where this forage cannot be grown.

As the quality of the current hay made from cane, rushes, sedges and other species of excess moisture is very low, it is preferable to bring in grain straws that have double the protein content of what is made now as coarse fodder in cattle feed.

All these actions must be in harmony with the indications of the Delta Dunării Biosphere Reserve which include these wet grasslands, where animal breeding activity in the "bio" system is accepted but with severe restrictions on the use of pesticides, chemical fertilizers and the introduction of some plant species that they are not present in the spontaneous flora.

Through these radical measures, it will be possible to ensure milk and meat both for the needs of the population and for the booming agritourism and heliomarine leisure guesthouses in this part of the country.

CONCLUSIONS

The grassy vegetation in the Delta Dunării in the 10 alliances has an average pastoral value (PV) of 7.2 (degraded) and a production of 0.86 t/ha green mass (GM), which ensures 0.08 LU/ha 4 times lower than the level required to grant subsidies from the European Union, (0.30 LU/ha) on permanent grasslands.

The most degraded phytosociological alliances (habitats) with a possible load of 0.02-0.04 LU/ha are: *Phragmition, Juncion maritimi, Armerion maritimae, Cypero - Spergularion, Agropyro - Minuartion, Scabiosion argenteae,* which are also the most widespread, can only be classified as permanent grasslands after extensive and expensive land improvement works, which contravene the restrictions imposed by the Management Plan of the Delta Dunării Biosphere Reserve.

Hay produced from reeds (*Phragmites australis, Typha sp., Carex sp.* and other hydrophilic species), has an extremely low fodder quality of barely 50% of the value of cereal straw and 5 times lower than that of alfalfa and cannot be considered coarse fodder.

The only associations of the 27 described that can fit into permanent grasslands are *Puccellietum limosae* on salted soil (65.9 PV and 5.91 t/ha GM) and *Festucetum beckeri* on beams with consolidated sandy soils (47.8 PV and 8, 27 t/ha GM), used by grazing with animals.

The management of grass vegetation for the conservation of biodiversity at the level of phytosociological alliances (habitats) will have to take into account the very reduced capacity of support and load with animals in the grazing season and prohibition of the harvesting of reeds for hay for animals, which is the main nesting habitat of waterfowl.

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