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NATURAL AND UTILITY VALUES OF MEADOW COMMUNITIES OF THE ORDER *ARRHENATHERETALIA* IN WAŁBRZYCH COUNTY IN RELATION TO HABITAT CONDITIONS

Summary

The aim of this study was to estimate natural and utility values of meadow communities of the order Arrhenatheretalia situated in Wałbrzych County in relation to habitat conditions. Moisture and trophic status were selected for analyses from among many habitat conditions. Plants of fresh habitats dominated (57-62% of the total number of species) in all described communities (Arrhenatheretum elatioris, Poa pratensis-Festuca rubra, Agrostis capillaris-Festuca rubra, Trisetum flavescens). Phytocoenoses of the order Arrhenatheretalia showed a high species richness amounting from 83 to 115 species. Depending on community, diversity index varied from 2.99 to 3.40. Comparative analysis of natural valorisation showed that studied communities had small to medium natural values. The share of plant functional groups differed among studied phytocoenoses. Grasses constituted 14.8 to 17.7% of the sward and legumes – from 8.9 to 14.5%. Herbs and weeds were the most numerous groups in meadow communities and contributed in more than 60% to the sward composition. Depending on phytocoenoses, the number of utility value (Lwu) of the sward varied between 5.4 and 6.4 which placed the meadows in the group of mean to good fodder quality (Lwu>6.0). Performed evaluation allowed to distinguish Trisetum flavescens community, which showed the highest natural and utility value.
***Key words**: habitat factors, meadow community, natural value, the Sudetes, utility value*

WALORY PRZYRODNICZE I UŻYTKOWE ZBIOROWISK ŁĄKOWYCH Z RZĘDU *ARRHENATHERETALIA* W POWIECIE WAŁBRZYSKIM NA TLE WARUNKÓW SIEDLISKOWYCH

Streszczenie

Celem pracy było określenie wartości przyrodniczo-użytkowej zbiorowisk łąkowych z rzędu Arrhenatheretalia zlokalizowanych w powiecie wałbrzyskim, na tle warunków siedliskowych. Spośród wszystkich czynników siedliskowych do analizy wybrano uwilgotnienie i trofizm. We wszystkich omawianych zbiorowiskach występujących na badanym terenie (Arrhenatheretum elatioris, Poa pratensis-Festuca rubra, Agrostis capillaris-Festuca rubra, Trisetum flavescens) dominowały rośliny siedlisk świeżych z udziałem od 57 do 62% ogółu gatunków. Fitocenozy badanego terenu z rzędu Arrhenatheretalia charakteryzowały się dużym bogactwem gatunkowym – od 83 do 115 gatunków. Obliczony na podstawie badań wskaźnik różnorodności H' przyjmował wartość, w zależności od zbiorowiska, od 2,99 do 3,40. Analiza porównawcza waloryzacji przyrodniczej wykazała, że badane zbiorowiska charakteryzowały się małymi i średnio małymi walorami przyrodniczymi. Udział poszczególnych grup funkcjonalnych roślin w badanych fitocenozach był zróżnicowany. Trawy stanowiły od 14,8 do 17,7% składu runi, a rośliny bobowate od 8,9 do 14,5%. We wszystkich badanych zbiorowiskach łąkowych najliczniejszą grupę stanowiły zioła i chwasty, a ich udział w runi wynosił ponad 60%. W zależności od badanej fitocenozy liczba wartości użytkowej runi (Lwu) wahała się od 5,4 do 6,4, co charakteryzuje je jako łąki o miernej i dobrej (Lwu>6.0) wartości paszowej. W przeprowadzonej ocenie wartości przyrodniczo-użytkowej wyróżniało się zbiorowisko z Trisetum flavescens, które charakteryzowało się największą wartością przyrodniczą i użytkową runi.
***Słowa kluczowe**: czynniki siedliskowe, zbiorowiska łąkowe, wartość przyrodnicza, Sudety, wartość użytkowa*

1. Introduction

Many habitat conditions like soil, moisture, insolation, elevation above sea level affect the development of plant communities [1]. Moisture.is particularly important among these factors. Moisture determines soil trophic status, pH and affects soil processes thus contributing to differentiation of meadow habitats and species composition of plant communities [2]. Close relationship between habitat conditions and phytocoenotic character is decisive for productive and non-productive functions of plant communities, for management and its intensity [3, 4].

Many meadow communities, including those in the Sudetes, have underwent unfavourable changes in the last several decades [5]. Natural conditions in mountain areas make them particularly susceptible to abandonment of utilisation, which is associated with less favourable management conditions. Studies performed in the Tatra Mountains demonstrated that the abandonment of traditional grassland use was followed by changes in the composition of sward and by the loss of their natural and utility value [6]. Since permanent grasslands cover a significant part of agriculturally utilized area of the Sudetes (more than 50%) [7], it is important to study floristic composition of meadow communities, which would enable assessment of their present status, biological and utility value.

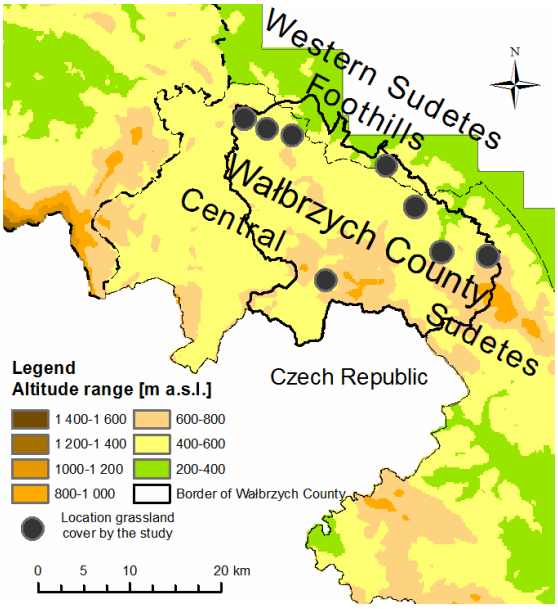
The aim of this study was to assess natural and utility value of meadow communities of the order *Arrhenathere-*

talia in one of the counties located in the Sudety in Wałbrzyski district, counties in relation to habitat conditions – moisture and trophic status. It represents mountain region of the Sudetes with respect to both physiographic conditions and land use structure.

Agricultural lands occupy 17 thousand ha in the county (18% of its total area). 56% of these lands (about 9.4 thousand ha) is covered by permanent grasslands, mostly (81%) by meadows. Brown leached and acidic soils dominate in the county. Grasslands are dominated by 2z soil-agricultural complex (66%), the remaining grasslands are classified in 3z complex [8].

2. Study area and methods

Field studies were made in the years 2009-2011 on extensively used (mown once or mown and grazed) and on not used meadows situated in Walbrzych County (fig. 1). Wałbrzych County is one of the four counties in the Sudetes situated in south-western Poland in Dolnośląskie Province. According to physiographic division of Poland, the county belongs to the two macroregions: Pogórze Zachodniosudeckie and Sudety Środkowe [9].



Source: own studies

Fig. 1. The study area

Studies on meadow vegetation were performed with the Braun-Blanquet method [10]. In total, 242 relevés were made of an area of 25 m^2 each, in uniform patches. Obtained material underwent phytosociological analyses. Classification of communities and their characteristics are given in Paszkiewicz-Jasińska and Nadolna [11]. All distinguished meadow communities belong to the class *Molinio-Arrhenatheretea*, to the orders: *Arrhenatheretealia* (communities *Arrhenatheretum elatioris* and *Poa pratensis-Festuca rubra*, community with *Agrostis capillaris-Festuca rubra* and community with *Trisetum flavescens*) and *Molinietalia* (community with *Alopecurus pratensis*). Most numerous were communities of the order *Arrhenatheretealia* – lowland and mountain grassland communities [12].

Distinguished meadow communities of the order *Arrhenatheretealia* were characterised for their natural and utility value in relation to habitat conditions. Natural values were assessed based on the total number of species, on the presence of rare and endangered species and on diversity index *H'* [13]:

$$H' = -\sum_{i=1}^{S}(p_i)(\log_2 p_i)$$

where:
$\sum$ – the number of all species in the community,
p_i – the number of occurrences of a species in relevés.

Natural valorisation was made according to the method proposed by Oświt [14]. Utility value of meadow communities was determined with the Filipek's method [15]. The method considers fodder value of particular plant species, their growth rate and toxic properties. From these data the number of utility value (Lwu) was calculated and the number of species valuable as fodder (Lwu>6.0) was given. The structure of functional plant groups was estimated with the division into grasses, legumes and herbs and weeds. The share of rushes and sedges, seedlings of trees and shrubs and melliferous plants was recorded. Estimation of habitat conditions (soil moisture W and trophic index Tr) was performed with the phytoindication method based on the analysis of floristic composition of communities with the use of the index numbers after Zarzycki et al. [16]. The numbers were proposed as a result of Polish taxonomical and geobotanical studies and characterise Polish populations of vascular plants on the background of local climatic and edaphic conditions. The scale for soil moisture is six-grade and for trophic status is five-grade in the rising order.

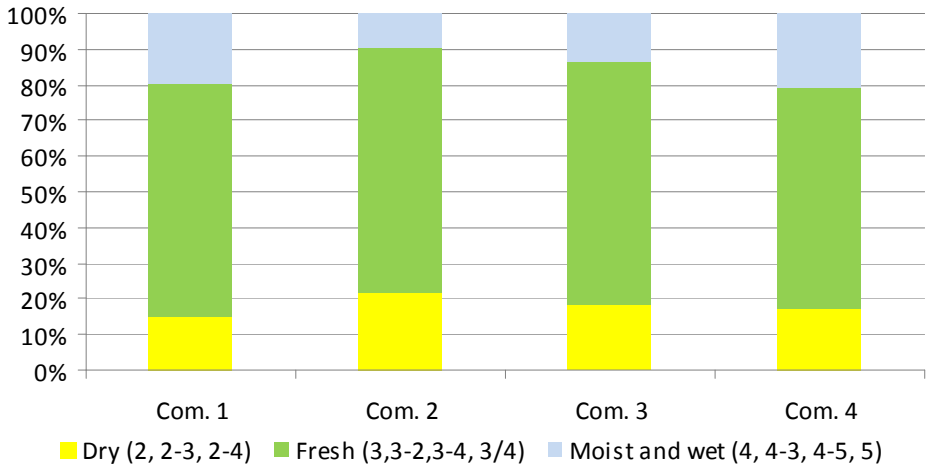
3. Results and discussion

Habitat conditions

From among habitat factors, soil moisture and trophic status were selected for analyses. According to many authors [2, 3, 17] these factors exert a significant impact on species composition, density and species diversity of plant communities. Studies by Żyszkowska [17] indicate that species composition of plant communities of the order *Arrhenatheretalia* properly reflects moisture conditions of their habitat.

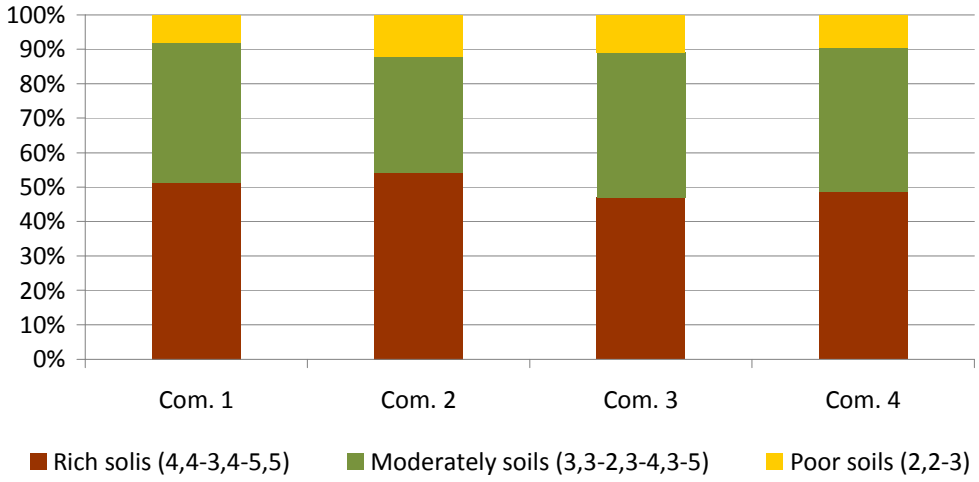
Plants of fresh habitats, whose share varied from 62 to 69% of all species, dominated in all analyses communities in the study area (fig. 2, 3). Most species of these habitats were found in patches of the community *Arrhenatheretum elatioris* (74) and the least – in the community *Poa pratensis-Festuca rubra* (57). A bigger share of species form moist and wet habitats was found in two phytocoenoses; in *Arrhenatheretum elatioris* (19%) and in the community with *Trisetum flavescens* (21%). In the *Poa pratensis-Festuca rubra* community the share was small (9%). A group of species characteristic for dry habitats stood out (22%) in this community. These results confirm data reported in the literature [3, 12, 17].

Analysis of vegetation for the occurrence of species characteristic for soils of a definite trophic status showed the biggest share of species that prefer rich (eutrophic) and very rich soils (from 47 to 54%), less species (34-42%) preferred poor (mesotrophic) soils. The share of species from oligotrophic habitats was slightly higher in the *Poa pratensis-Festuca rubra* community than in other meadow communities. Such findings seem to confirm studies by Żyszkowska [17] and Nadolna [3], who found substantial share of species indicative for rich habitats in grassland phytocoenoses of the order *Arrhenatheretalia*.



Source: own studies

Fig. 2. The share of plants species groups (%) characteristic for a definite moisture in the surveyed meadow communities; soil moisture indices (W): 2 – dry, 3 – fresh, 4 – moist, 5 – wet. Explanation: Com.1 – *Arrhenatheretum elatioris*, Com.2 – community *Poa pratensis-Festuca rubra*, Com.3 – community with *Agrostis capillaris-Festuca rubra*, Com.4 – community with *Trisetum flavescens*



Source: own studies

Fig. 3. The share of plants species groups (%) characteristic for a definite trophic type in the surveyed meadow communities (Tr); soil moisture indices: 2 – poor soils, 3 – moderately poor soils, 4 – rich soil, 5 – very rich soil. Explanation: Com.1 – *Arrhenatheretum elatioris*, Com.2 – community *Poa pratensis-Festuca rubra*, Com.3 – community with *Agrostis capillaris-Festuca rubra*, Com.4 – community with *Trisetum flavescens*

Natural value

Phytocoenoses of the order *Arrhenatheretealia* in the study area were characterised by relatively high species richness – from 83 to 115 species. The highest total number of species (115) was found in the community dominated by *Trisetum flavescens*. This community was found in mown-grazed meadows, where animal stock did not exceed 1 LU ha^{-1} of grasslands situated more than 550 m a.s.l. From studies by Żyszkowska et al. [18] it appears, that mowing followed by grazing is the best way of maintaining high species richness of grassland communities. The lowest number of species (83) was noted in the *Poa pratensis-Festuca rubra* comunity that occupied habitats situated 430 - 520 m a.s.l., which were mown or not used. Obtained results about the total number of species in grassland communities are higher than those given by other authors [19, 20, 21], who carried out their studies in the Sudetes region. Studies by Kostuch [2] in the Carpathians and by Nadolna [3] in the Sudetes showed that phytocoenoses richest in species grow at an altitude between 300 and 750 m a.s.l. on slopes inclined to 10^{o} and on compact soils. All analysed meadow communities conformed to these parameters.

The diversity index *H'*is the the parameter determining natural value (tab. 1). Meadow communities had relatively high value of this index from the highest (*H'*=3.40) in *Arrhenatheretum elatioris* community to slightly lower (*H'* = 3.39) in the community with *Trisetum flavescens*. Minimum value of this index (less than 3) was calculated for the community with *Agrostis capillaris-Festuca rubra*. Various authors carrying out their studies in the Sudetes reported different diversity indices. For *Arrhenatheretum elatioris* community it varied from 1.76 [22], 1.78 [20], 2.06 [21] to 2.48 [3].

Table 1. Natural values of the analysed meadow communities

Syntaxon	Overall number of species	*H'* index	Mean valorisation index	Valorisation class	Natural values
Arrhenatheretum elatioris	113	3.40	2.0	III	small
Community *Poa pratensis-Festuca rubra*	83	3.22	1.9	II	medium-small
Community with *Agrostis capillaris-Festuca rubra*	102	2.94	1.8	II	medium-small
Community with *Trisetum flavescens*	115	3.39	2.0	III	small

Source: own studies

According to Szoszkiewicz and Szoszkiewicz [23] the natural value of plant communities is evidenced by the presence of rare and endangered species. Very valuable species were found in studied plant communities including those legally protected in Poland like *Platanthera bifolia* (L.) Rich) and *Carlina acaulis* L. in the community *Arrhenatheretum elatioris* or *Carlina acaulis* L. in the community with *Agrostis capillaris-Festuca rubra*.

Both are on the list of partially protected plant species [24]. There was one strictly protected species - *Gymnadenia conopsea* (L.) R. Br. subsp. *conopsea* in the community with *Trisetum flavescens*. Similar results were obtained by Grynia and Kryszak [19], Żyszkowska [25] and Kryszak et al. [22] in their studies on grasslands in the Sudetes.

Studied meadow communities had medium small to small natural values. Natural valorisation index varied from 1.8 to 2.0 and valorisation class was II – III. More valuable among analysed meadows appeared *Arrhenatheretum elatioris* community and the community with *Trisetum flavescens*. Protected species considered in the Oświt's method [14] were found in these phytocoenoses. The study showed that not all of recognised species had their indices like e.g. *Carlina acaulis*, which was found in the community with *Agrostis capillaris-Festuca rubra* and in *Arrhenatheretum elatioris* community. In such a situation, calculated valorisation classes might be underscored, which was also found in studies by Podlaska [26]. Kryszak et al. [22] obtained slightly higher values of the mean valorisation index for communities of the order *Arrhenatheretealia* in Kłodzka Valley in the Sudetes. They varied from 2.1 (*Poa pratensis-Festuca rubra*) to 3.3 (*Arrhenatheretum elatioris*).

Utility value

Various functional groups of plants (grasses, legumes, herbs and weeds) contributed in different proportion to the structure of studied phytocoenoses. Grasses were the most important group of plants in meadow communities and decided upon their efficiency and fodder value [2]. The share of grasses varied from 14.8 to 17.7%. Slightly higher per cent of grasses in meadow communities of the Sudetes was found by Grynia and Kryszak [19] and by Paszkiewicz-Jasińska [21]. The biggest share of grasses in this study was noted in the community with *Agrostis capillaris-Festuca rubra* and the smallest in the community with *Trisetum flavescens.*

Legumes, due to high concentrations of protein, vitamins and mineral compounds, are important component of sward in meadow communities. Studied plant communities had the smallest share of legumes in sward ranging from 8.9% in *Arrhenatheretum elatioris* community to 14.5% in the community *Poa pratensis-Festuca rubra.* Similar results for grasslands in the Sudetes were obtained by Paszkiewicz and Nadolna [27] and Paszkiewicz-Jasińska [21], slightly smaller by Grynia and Kryszak [19]. Species of this group included i.a. *Lathyrus pratensis* L., *Lotus corniculatus* L., *Trifolium repens* L., *Trifolium pratense* L. and *Trifolium dubium* Sibth. According to Filipek [15] these species are of good or very good utility value (tab. 2).

Studies performed in the Sudetes by Grynia and Kryszak [19], Paszkiewicz-Jasińska and Nadolna [27] and by Paszkiewicz-Jasińska [21] indicated, that most Sudetes meadows are the so-called multi-species herb meadows. Species of this group are rich in macro- and microelements and carotenoids, have dietetic and therapeutic properties and therefore, improve nutritive value and palatability of fodder obtained from such meadows [28, 29]. Herbs and weeds constituted more than 60% of sward in all analysed meadow communities, typical weeds averaged about 20%. Most species of herbs and weeds group were found in the community with *Trisetum flavescens*. Herbs and weeds included desired species that increase fodder value – the so-called fodder herbs. The percentage of these species constitute about 18%. Most frequent in this group were *Alchemilla monticola* Opiz, *Achillea millefolium* L. s. str., *Taraxacum officinale* F.H. Wigg., *Plantago lanceolata* L. and *Leucanthemum vulgare* Lam. s. str. The group included also undesired species like toxic *Colchicum autumnale* L., *Senecio jacobaea* L., *Tanacetum vulgare* L., *Euphorbia cyparissias* L. or parasitic *Rhinanthus* sp. Studied meadow communities hosted also a few rush species: *Juncus conglomeratus* L., *Luzula campestris* L.(DC.), *Luzula luzuloides* (Lam.) Dandy & Wilmott and one species of sedges: *Scirpus sylvaticus* L. Their share in meadow sward did not exceed 3.5%. There were also few seedlings of trees (*Salix* sp., *Acer* sp., *Sorbus* sp.) and shrubs (*Rosa* sp., *Rubus* sp.), from three to six species per community. Analysed meadow communities were characterised by not very differentiated utility value of their sward. The number of utility value ranged from 5.4 to 6.4. Respective values for the Sudetes given by other authors [22, 27] varied from 5.2 to 8.2. The sward of the community with *Trisetum flavescens* and of *Poa pratensis-Festuca rubra* community should be considered good (Lwu>6.0), that from other communities – mean. Similar results for *Poa pratensis-Festuca rubra* and *Arrhenatheretum elatioris* communities were obtained by Paszkiewicz-Jasińska [21] but Kryszak et al's [22] data were different. In own research 6% undesired species (toxic and parasitic) were noted in each of *Arrhenatheretum elatioris* community and in the community with *Agrostis capillaris-Festuca rubra*, which decreased utility value of the sward of these phytocoenoses. 3.6% undesired species were noted in *Poa pratensis-Festuca rubra* community.

Table 2. Utility values of the identified meadow communities

Syntaxon	FVS	The structure of plant functional groups (%)			Rushes and sedges	Seedlings of trees and shrubs (%)	Share of nutritionally valuable species (%)	Melliferous plants
		grasses	legumes	herbs and weeds				
Arrhenatheretum elatioris	6.0	15.0	8.9	67.5	3.5	5.3	18.6	*Centaurea jacea* L., *Chamaenerion angustifolium* (L.) Scop. *Geranium pratense* L., *Heracleum sphondyliu* L. s. str. *Leucanthemum vulgare* Lam. s. str., *Lotus corniculatus* L., *Lychni flos-cuculi* L., *Ranunculus repens* L., *Sedum maximum* (L.) Hoffm. *Solidago virgaurea* L. s. str., *Symphytum officinale* L., *Taraxacun officinale* F. H. Wigg., *Thymus pulegioides* L., *Trifolium hybridum* L. *Trifolium pratense* L., *Trifolium repens* L., *Vicia cracca* L.
Community *Poa pratensis-Festuca rubra*	6.3	16.9	14.5	63.8	-	4.8	26.5	*Centaurea jacea* L., *Heracleum sphondyliu* L. s. str., *Lathyru pratensis* L., *Leontodon autumnalis* L., *Leucanthemum vulgare* Lam s. str., *Lotus corniculatus* L., *Medicago sativa* L. s. str., *Prunell vulgaris* L., *Ranunculus repens* L., *Sedum acre* L., *Solidago virgaure* L. s. str., *Taraxacum officinale* F. H. Wigg., *Trifolium hybridum* L. *Trifolium pratense* L., *Trifolium repens* L., *Vicia cracca* L.
Community with *Agrostis capillaris-Festuca rubra*	5.4	17.7	11.8	65.7	2.0	5.9	15.7	*Centaurea jacea* L., *Chamaenerion angustifolium* (L.) Scop. *Heracleum sphondyliu* L. s. str., *Lathyrus pratensis* L., *Leucanthemun vulgare* Lam. s. str., *Linaria vulgaris* Mill., *Lotus corniculatus* L. *Lychnis flos-cuculi* L., *Primula veris* L., *Prunella vulgaris* L. *Ranunculus repens* L., *Sedum maximum* (L.) Hoffm., *Taraxacun officinale* F. H. Wigg., *Thymus pulegioides* L., *Trifolium hybridum* L. *Trifolium pratense* L., *Trifolium repens* L., *Vicia cracca* L.
Community with *Trisetum flavescens*	6.4	14.8	10.4	68.7	3.5	2.6	17.4	*Centaurea jacea* L., *Chamaenerion angustifolium* (L.) Scop. *Geranium pratense* L., *Heracleum sphondyliu* L. s. str., *Lathyru pratensis* L., *Lathyrus sylvestris* L., *Leucanthemum vulgare* Lam. s str., *Lotus corniculatus* L., *Lychnis flos-cuculi* L., *Ranunculus repen* L., *Sedum maximum* (L.) Hoffm., *Solidago virgaurea* L. s. str. *Symphytum officinale* L., *Taraxacum officinale* F. H. Wigg., *Thymu pulegioides* L., *Trifolium hybridum* L., *Trifolium pratense* L. *Trifolium repens* L., *Vicia cracca* L.

Source: own studies

Moreover, many species of high fodder value (Lwu> 6.0) were found in this community, their density was, however, low. *Trisetum flavescens* community had the highest Lwu = 6.41. The share of valuable species was smaller there than in *Poa pratensis-Festuca rubra* community but they occurred in higher densities [11]. Utility value of the sward depended more on the coverage by species of high fodder value than on the number of species, which confirms the results obtained by Paszkiewicz and Nadolna [27]. Meadow vegetation contained also melliferous plants, which according to many authors [30] increases the utility value of analysed meadow sward.

4. Conclusions

1. Meadow communities of the order *Arrhenatheretalia* in the Sudetes are characterised by different species richness from 83 to 115 species in total. *Trisetum flavescens* is the community richest in plant species.

2. Floristic diversity expressed with diversity index *H'* was moderate (2.94 to 3.44) and the highest diversity was found in *Arrhenatheretum elatioris* community and the community with *Trisetum flavescens*.

3. Natural valorisation made with the Oświt's method indicates medium small to small natural values of analysed phytocoenoses; it doesn't, however, fully reflect natural value of meadow communities of the order *Arrhenatheretalia*.

4. Protected and endangered species (*Platanthera bifolia* (L.) Rich), *Carlina acaulis* L., *Gymnadenia conopsea* (L.) R. Br. subsp. *conopsea*) were found in the composition of meadow communities, which increases their natural value.

5. Only two communities (*Poa pratensis-Festuca rubra* and the community with *Trisetum flavescens*) developed the sward of good utility value (Lwu>6.0).

6. Performed evaluation distinguished the community with *Trisetum flavescens* of highest utility value of the sward and of remarkable natural values.

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