ГЕОБОТАНИКА

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ПЛОЩАДЬ ЛИСТЬЕВ ЛУГОВЫХ РАСТЕНИЙ ПРИ СЕНОКОСНОМ И ЗАПОВЕДНОМ РЕЖИМАХ НА ПРИМЕРЕ ЦЕНТРАЛЬНО-ЛЕСНОГО ЗАПОВЕДНИКА

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Leaf area of meadow plants under regimes of mowing and protection in the Central Forest Reserve

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Аннотация**.** Площадь листа и удельная листовая поверхность (УЛП) измерены у 16 видов травянистых растений на косимых и выведенных из использования лугах Центрально-Лесного заповедника (Тверская область). У 12 из 16 изученных видов сенокошение не влияло на эти признаки. У *Agrostis tenuis* и *Plantago lanceolata* уменьшилась площадь листа, и увеличилась УЛП на заповедных участках. У *Rumex acetosa* на заповедных участках увеличилась площадь листьев, а УЛП не изменилась. Участие видов в сообществе не было скоррелировано с площадью листьев и УЛП. Таким образом, сенокошение, по-видимому, не влияет на отбор по этим функциональным признакам.

Ключевые слова: площадь листа, удельная листовая поверхность, луга, сенокошение, заповедный режим.

Abstract. Leaf area and specific leaf area (SLA) of 16 herbaceous plant species were studied on the mown and abandoned meadows of the Central Forest Reserve, Tver`region. In 12 of 16 studied species, there was no significant impact of mowing to these traits. *Agrostis tenius* and *Plantago lanceolata* decreased leaf area and increased specific leaf area on the abandoned sites, *Rumex acetosa* increased leaf area on the abandoned sites without changes in SLA. Species number in the community was not related to their leaf area and SLA, thus mowing probably has no impact on selection by studied traits.

Keywords: leaf area, specific leaf area, meadows, mowing, protection regime.

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Introduction

Plant functional traits reflect their «economics spectrum» and are often used for estimation of their ecological strategies (Freschet et al., 2010; Pierce et al., 2017). Leaf traits, such as leaf area and specific leaf area (SLA), are closely related to plant competitive ability, adaptation to habitat and interactions with organisms of other trophic levels. Recently, there're a number of databases containing plant functional traits, such as LEDA (Kleyer et al., 2008) or TRY (Kattge et al., 2011), but data from Russia are fragmentary. Also, leaf traits may considerably vary across the habitats, but their variability is poorly studied (Akhmetzhanova et al., 2012; Lemke et al., 2015). That's why it is recommended to measure plant traits directly on the target sites to reveal local patterns of vegetation functional structure (Corlandwehr et al., 2013). Relative abundance of plants with different leaf size and specific leaf area reflects position of community along the geomorphological catena and shows whether the community is exposed to various kinds of disturbance, such as grazing (Elumeeva et al., 2015; Li, Shipley, 2017). Therefore, there are few data explaining how mowing influences leaf traits. Mowing is an unselective process, where plants are cut independently of their taxonomic identity and suits of traits. This fundamentally differs it from grazing. Generally, mowing should benefit perennial species with ability to grow fast after defoliation. High relative growth rate is commonly linked with high SLA (Hunt, Cornelissen, 1997; Pérez-Harguindeguy et al., 2013).

Mowing is one of the traditional land use types, which maintains herbaceous vegetation in the forest zone. However, during the recent decades a lot of hayfields were abandoned in the middle Russia. Meadows of the Central Forest Reserve are an interesting object for ecological studies, because they represent a long-term experiment with mowing cessation after reservation. When abandoned, their structure changed dramatically. Forbs increased, and grasses decreased their abundance (Borodulina et al., 2016). However, data on plant functional traits for plants of Central Forest Reserve are not available.

The aims of our study were (1) to establish a database of the plant functional traits for the Central Forest Reserve and (2) to assess variability of leaf traits (leaf area and specific leaf area) for herbaceous plants on the mown and abandoned meadows.

Materials and methods

The study was conducted during the period from 2 to 14 August 2016 in the Central Forest State Biosphere Reserve in the Tver` region. The reserve is located at the SW part of Valdai Upland within the main Caspian-Baltic watershed of the Russian plain (N 56°26′–56°39′, E 32°29′–33°01′). For 51 years (1963–2014), the mean annual rainfall was 760 mm (510 to 1050 mm in different years). The mean January temperature was –8,6°C and the mean July temperature was +16,9°C. Long-term climatic data were obtained from meteorological station «Forest reserve» (available as the database of the archive of the Central Forest Reserve). The territory of the Central Forest Reserve belongs to the subzone of coniferous-broad-leaved forests. Forests represent the prevailing vegetation type. Meadows occupy less than 1% of the territory.

The site with abandoned due to reservation meadows was located in the Krasnoye site (core area of the reserve), and the site with mowing was located near the village Fyodorovskoye (buffer zone of the reserve). Both sites are covered with short grass meadows, which belong to association ***Anthoxantho odorati–Agrostietum tenuis*** Sillinger 1933. The meadows in Krasnoye site were abandoned in the middle of 1980s. Managed grasslands are mown once early in August, no nutrient addition is applied. On each site, we established 4 plots of 100 m^2, where relevés were made earlier (Cherednichenko, 2014). Plant abundance was estimated using the Braun-Blanquet scale. For further analysis, this scale was transformed into a ball scale, where «r» corresponded to «1», «+» corresponded to «2», «1» corresponded to «3» and so on. We calculated light availability, moisture, soil reaction and nitrogen pool using Ellenberg's ecological scales for each plot. To reveal differences between sites, we ran non-parametric Kruskall-Wallis ANOVA for estimated indicator values.

To study leaf traits, we selected 16 species of herbaceous plant species (5 grasses and 11 forbs), which occur in all the plots. On each plot, we sampled at least 5 leaves from different individuals, thus replication was at least 20 leaves per treatment. We selected undamaged leaves of average size. Fully water-saturated leaves were scanned at 300 dpi for big and 600 dpi for small or strongly dissected leaves, then dried in the oven and weighed to the nearest of 0,1 mg. Leaf area was measured in ImageJ software. Specific leaf area was calculated as a ratio between leaf area and leaf dry mass.

The statistical analysis was conducted in R statistical environment (R Core Team, 2015). To compare leaf area and specific leaf area at mown and abandoned sites, we ran mixed linear models in the *nlme* package (Pinheiro et al., 2015). As a fixed effect, we used treatment (mown or abandoned). To consider leaf traits variability within a plot, we added plot of relevé as a random effect. To assess significance of the treatment, we ran «null» models without fixed effect and compared two models using a likelihood ratio test. To link species abundance and their leaf traits, we used non-parametric Spearmen rank correlation.

Results and discussion

The studied plots were similar in terms of light availability, soil reaction and nitrogen content. Soil moisture was higher at the mown site ($p = 0,021$), however this difference may not be linked with mowing.

Most of the studied species had no significant differences in leaf area and SLA between mown and abandoned sites (table). Only in two species, *Agrostis tenuis* and *Plantago lanceolata*, both traits changed: leaf area decreased and SLA increased without mowing. In abandoned sites leaf area of *Rumex acetosa* increased almost twice, and SLA increased in *Centaurea phrygia*.

Abundance of *Agrostis tenuis* and *Plantago lanceolata* was higher in the abandoned sites in comparison with the mown sites. Increase of SLA in plants growing without mowing may be

caused by the fact, that rosette plants, such as *Plantago lanceolata*, suffer shading by tall herbs and are forced to form long thin leaves. The same can be seen in semi-rosette *Centaurea phrygia*. Populations of low stature rosette and semi-rosette plants at mown meadows are exposed to drastic increase in light intensity after mowing. Probably it results in the selection of ecotype with lower SLA (thicker leaves), adapted to temporal conditions of high light availability.

Table

Leaf traits of herbaceous plants at the mown and abandoned meadows (mean and standard error)
Significance of differences is based on the results of mixed linear model

Species	Treatment	n	Abundance	Leaf area, cm^2			SLA, cm^2/g		
				Mean±SE	L-ratio	p	Mean±SE	L-ratio	p
Achillea millefolium L.	M	23	2,5	16,3±2,2	0,01	0,907	189±10	2,03	0,154
	A	24	3,0	16,6±1,9			159±8		
Agrostis tenuis Sibth.	M	25	2,8	4,7±0,4	4,96	**0,026***	287±15	5,11	**0,024***
	A	29	3,8	2,5±0,2			354±16		
Anthoxanthum odoratum L.	M	32	2,6	7,7±0,8	1,42	0,234	302±9	0,19	0,662
	A	33	2,5	5,4±0,4			294±15		
Centaurea phrygia L.	M	29	4,2	68,3±5,4	2,37	0,124	304±10	4,49	**0,034***
	A	26	4,2	87,2±8,0			360±16		
Deschampsia cespitosa (L.) P. Beauv.	M	23	2,7	8,1±0,8	<0,01	0,962	121±7	0,25	0,620
	A	26	2,3	7,8±0,6			113±4		
Festuca pratensis Huds.	M	26	3,8	19,3±2,0	0,07	0,788	203±7	0,80	0,370
	A	28	2,7	18,5±2,0			216±8		
Hypericum maculatum Crantz	M	28	3,3	2,6±0,1	1,67	0,196	295±9	0,04	0,838
	A	34	3,8	2,2±0,2			291±12		
Leucanthemum vulgare Lam.	M	20	2,7	6,2±0,6	3,30	0,069	256±11	0,33	0,567
	A	29	3,4	8,1±0,6			273±16		
Phleum pratense L.	M	26	2,7	8,0±0,6	3,49	0,062	254±15	0,58	0,447
	A	38	2,8	5,6±0,6			234±8		
Plantago lanceolata L.	M	24	2,3	27,6±1,6	5,29	**0,021***	192±9	8,09	**0,004****
	A	29	3,2	20,2±1,6			231±7		
Potentilla erecta (L.) Raeusch.	M	23	2,6	5,0±0,4	0,32	0,567	263±13	0,03	0,858
	A	27	3,7	4,7±0,2			261±9		
Ranunculus acris L.	M	29	2,8	24,9±2,5	0,68	0,409	252±8	0,79	0,373
	A	33	2,2	27,7±2,3			263±8		
Rumex acetosa L.	M	18	2,0	7,9±0,7	8,22	**0,004****	486±31	0,04	0,846
	A	33	2,8	20,0±2,4			499±50		
Succisa pratensis Moench	M	22	3,2	68,1±5,9	0,15	0,696	178±6	0,47	0,492
	A	17	1,5	63,2±8,7			186±10		
Trifolium medium L.	M	29	4,0	10,7±0.5	0,12	0,732	220±11	0,04	0,851
	A	34	4,0	10,4±0,4			238±11		
Veronica chamaedrys L.	M	35	3,1	3,5±0,4	0,47	0,492	260±11	0,68	0,410
	A	45	3,8	2,9±0,2			242±11		

M – mown meadows, A – abandoned meadows. n – number of replicates, Abundance – abundance of species according to modified Braun-Blanquet scale (mean, based on 4 plots), L-ratio – likelihood ratio, p – significance level.

We expected that mowing should benefit the fast-growing plants with high SLA, which usually corresponds to high relative growth rate. However, there were no significant correlations between species abundance and their SLA, as well as between abundance and leaf area. Leaf traits were not related to the species response to grassland abandonment in the south of Sweden (Johansson et al., 2011). Probably, mowing mostly restricts seed reproduction of vascular plants, and leaf traits are not important for maintenance of plant abundance. Also, as the set of studied species was limited and did not include species growing on only one site, or growing at low abundance, we could miss some significant interactions. Database of plant traits should be established for further evaluation of mowing impact on functional structure of meadows in the Central Forest Reserve.

Conclusions

In 12 of 16 studied species there were no significant impact of mowing to leaf area and specific leaf area. *Agrostis tenius* and *Plantago lanceolata* decreased leaf area and increased specific leaf

area in abandoned sites. *Rumex acetosa* increased leaf area in abandoned sites with no changes in SLA. Species abundance was not linked with leaf area and SLA, thus mowing probably has no impact on selection by studied traits.

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