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Abstract. Despite the big number of studies dedicated to the nutrition of the wild tundra reindeer, there are hardly any data found in Russian or foreign literature on the nutrition of the forest subspecies of the wild reindeer in the Middle Yenisei taiga. The studies carried out in the zone of overlapping winter habitats of the forest and tundra reindeer are of special interest. Since the research covered the territory of a special protected natural area, it was decided to use the non-invasive method of coprological cuticular analysis. As a result of the compositional analysis of the March reindeer faeces, some fragments of the flowering plants, lichens and mosses were found in the collected samples. As a result, it was found that in March and April the main fodder of the reindeer residing in the territory of the Middle Siberia were the flowering plants of the Cyperaceae, Poaceae, and Equisetum families.

1. Introduction

Quite a lot of works dedicated to the nutrition of the wild tundra reindeer were published in the 1960-80s [1-5]. Some aspects of the nutrition of the wild reindeer in different regions of Russia were described in the 1990s [6-8].

At the present moment, the nutrition of the wild forest reindeer remains an understudied issue in both Russian and foreign science.

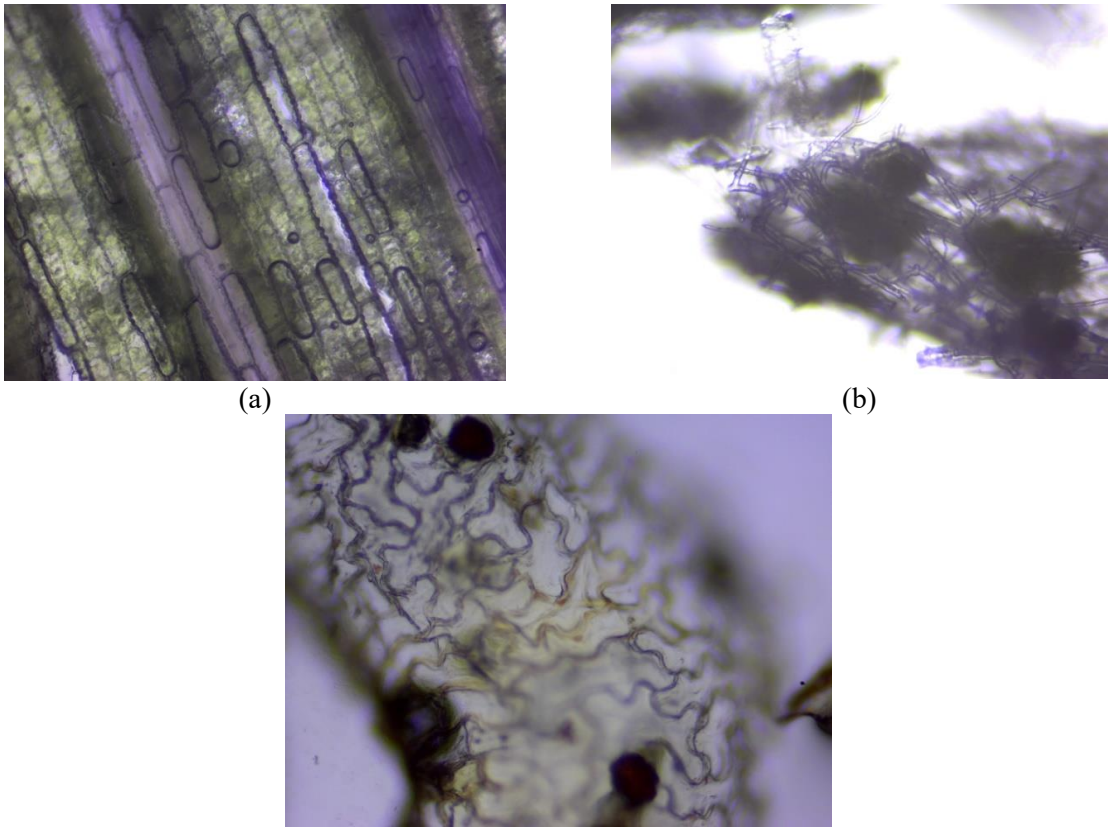
According to the statistical meteorological data, the current climate change features a complicated regional structure with a significantly uneven distribution of the ground temperatures around the Middle Siberian territory. The uneven nature of climate change explains the complicatedness and diversity of the ground vegetation responses. The increasing temperature and precipitation tendency may cause serious changes in the structure and species composition of the vegetation cover. Climate change may make a significant impact on the seasonal vegetation development times [9]. This raises the need for studies of the current diet of the wild reindeer (forest subspecies) (Rangifer tarandus L.) in the territory of the Middle Siberia in general and the territory of the Central Siberian Nature Reserve in particular.

2. Materials and methods

Since the wild reindeer (forest subspecies) diet research is carried out in a special protected natural area, the non-invasive method of coprological cuticular analysis was selected [10, 11]. This method is based on diagnostics of the plant fragments by means of identification of the species-specific epidermal cell ornament found on the cuticle.

For the wild reindeer diet study, 13 samples of reindeer faeces were collected in March and April 2019 and 2020 in the Central Siberian Nature Reserve and the Yeloguysky Sanctuary. For every sample, minimum 10 pellets were collected.

Samples of all plants growing in the research area had been collected and identified in advance. The species were identified by the research fellows of Komarov Botanical Institute of the Russian Academy of Sciences (BIN RAS, St. Petersburg). The collected samples of the epidermis of the plants growing in the sample collection area were preserved in glycerine, which caused swelling of the parenchymal and mesophyll cells. Later, the cells were photographed for comparison with the material recovered from the faeces to identify the species of the swallowed plants (figure 1).



(a) (b)

(c)

Figure 1. Forms of plant epidermal cells: (a) Cyperaceae; (b) Cladonia stellaris; (c) Dryopteris fragrans).

For the microscopic analysis, the faeces samples were preserved in the 5% glycerine solution and mixed. From the samples, five specimens on microscope glasses of 22x50 mm were prepared. On each glass, a square divided by four transects with the interval of 5 mm was outlined. 100 fragments were analysed and registered. The cuticular analysis method is based on several postulates:

- Many species of plants feature a cuticular layer that protects the leaves.
- The print of the plant epidermis ornament on the internal side of the cuticle is species-specific and resistant (for example, it does not change even when exposed to the digestive ferments in the gastrointestinal tract of animals).
- Analogous to wax, the cuticle is resistant to oxidation by strong non-organic acids but can be hydrolysed by alkali.

The coprological cuticular analysis consists of the following actions:

Herborization of the fodder plants. The reference samples of the epidermis ornaments were made of the fodder plants collected in the reindeer feeding areas.

Preparation of the reference samples. The epidermis and cuticle are separated from the mesophyll by means of maceration. Maceration destructs the intercell matrix, which splits to separate cells. Maceration was carried out in concentrated nitric acid in a heated porcelain crucible; 5 mm fragments of different plant organs were placed into the crucible for heating in 3-5 drops of concentrated nitric acid. The tissues were heated for 2-3 minutes until their green colour changed to orange. The remains were placed on a plate with water. The floating epidermis particles were placed on the microscope glass and brought for the microscope examination. The non-damaged particles were selected and placed in a glycerol drop for a while to be used as reference samples later.

The further actions involved preparing the samples and sealing the covering glass edges by lacquering. Then the samples were arranged in the reference bank and labelled.

Preparation of faeces samples. For the study of the reindeer fodder residues, the reference plant epidermis fragments were compared with the fragments of the plant residues recovered from the faeces. The samples were collected and dried to an airy dry condition. Then the fragments were ground and grated to equal-sized particles. Then the ground particles were placed in water, and after precipitation of the heavy parts, the remaining epidermis fragments were placed on the microscope glass with a pipette for a further microscope examination.

The analysis results are presented in tables 1, 2.

Table 1. The results of analysis of feces of reindeer (forest subspecies) collected in March.

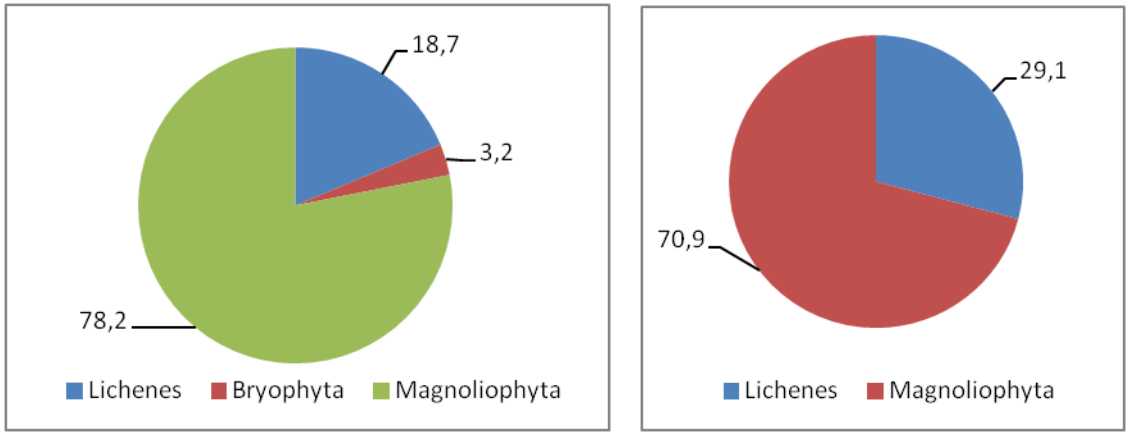
Name of plants	Species participation in the trial, %									Type of participation, %
	Probe									
	1	2	3	4	5	6	7	8	9	
Lichenes	15.3	23.5	30.7	23.3	16.5	13.5	12.1	22.9	18.5	18.7
Bryophyta	-	-	-	-	-	-	-	-	14.4	3.2
Magnoliophyta	84.7	76.5	69.3	76.7	83.5	86.5	87.9	77.1	67.1	78.2
Cyperaceae	38.2	20.0	48.0	16.8	47.9	30.8	39.3	23.0	20.7	30.3
Equisetum	9.7	21.2	0.0	10.5	0	15.8	7.5	0.0	6.8	8.5
Poaceae	36.8	14.1	0.0	8.4	17.8	28.6	41.1	17.6	32.9	25.2
Polygonaceae	-	10.6	-	14.7	0	-	-	17.6	6.8	5.1
Campanulaceae	-	10.6	21.3	13.7	-	-	-	-	-	3.8
Fabaceae	-	-	-	12.6	17.8	11.3	-	18.9	-	5.4

As a result of analysing the March samples of the reindeer faeces, the composition was assessed as 78.2% of flowering plants, 18.7% of lichens and 3.2% of mosses. Among the flowering plants, the dominating ones are the Cyperaceae (30%) and Poaceae (25%). Moreover, the remains of the Equisetum family plants (8.5%), Fabaceae (5.5%), Polygonaceae (5%), and Campanulaceae (4 %) were found (figure 2a). All these plants are recovered by the reindeer from underneath the snow during feeding. Therefore, during this period the reindeer need specific weather conditions for feeding. The weather in the sample collection month is presented in tables 3, 4.

The April samples analysis results showed the presence of plants in the following proportion: flowering plants – 70.9%, lichens – 29.1%. The dominating flowering plants in the faeces composition are the Poaceae (16.5 %), Equisetum (14.6 %), and unidentified epidermal cells (15.5 %). Moreover, in the samples, the remains of plants belonging to the Cyperaceae (7.2 %), Polygonaceae (4.8 %), Campanulaceae (3.3 %), Dryopteridaceae (3.1 %), Rubiaceae (2.7 %), Ericaceae (2.0 %), Rosaceae (1.4 %) were found (figure 2b).

Table 2. The results of analysis of feces of reindeer (forest subspecies) collected in April.

Family of plants	Species participation in the trial, %				Type of participation, %
	Probe				
	1	2	3	4	
Lichenes	**29.0**	**26.3**	**23.7**	**38.8**	**29.1**
Magnoliophyta	**71.0**	**73.7**	**76.3**	**61.2**	**70.9**
Poaceae	12.4	31.1	21.1	-	16.5
Rubiaceae	10.4	-	-	-	2.7
Polygonaceae	10.3	9.3		-	4.8
Equisetum	17.5	24.8	15.0	-	14.6
Motley grass	20.4	-	16.9	23.8	15.5
Ericaceae	-	8.5	-	-	2.0
Campanulaceae	-	-	11.5	-	3.3
Rosaceae	-	-	4.9	-	1.4
Cyperaceae	-	-	6.9	23.5	7.2
Dryopteridaceae	-	-	-	13.9	3.1



(a) (b)

Figure 2. The share of plants in the sample (a. March; b. April), %.

Table 3. Average weather indicators for the month of March in the area of the reserve “Eloguysky”.

Year	Air temperature, °C			Amount of precipitation, mm	Wind direction and speed, m/s	Snow depth, cm
	min.	max.	sr.			
March 2019	-22.8	+8.2	-4.1	26	S – 1.8	77.9
March 2020	-33.1	+5.8	-5.9	57	S – 2.3	98.3
April 2019	-22.8	+6.8	-3.8	26	W – 2.6	63.5
April 2020	-6.9	+18.9	+4.6	16	SE – 1.9	58.4

Table 4. Average weather indicators for the month of March in the area of the reserve «Tsentralnosibirsky».

Year	Air temperature, °C			Amount of precipitation, mm	Wind direction and speed, m/s	Snow depth, cm
	min.	max.	sr.			
March 2019	-19.0	+8.9	-3.6	37	S – 1.3	76.8
March 2020	-25.7	+8.4	-5.3	83	S – 5.3	100.4

April 2019	-21.5	+8.6	-1.6	64	W – 1.9	62.3
April 2020	-7.0	+20.3	+5.9	6.6	SE – 1.6	51.8

3. Conclusion

To conclude, we may confidently announce that the flowering plants belonging to the Cyperaceae and Poaceae families were the basic fodder for the reindeer in the month of March; in April, the Poaceae and Equisetum plants prevailed. In the samples collected in the territory of the Yeloguysky Sanctuary, a higher percentage of lichens was discovered. Generally, lichens are not the prevailing nutrition element in the reindeer diet, constituting 29 % of the general fodder. The mosses are most likely to have been accidentally caught in the feeding process, as they hardly play any role in the diet of the wild forest reindeer.

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