Зоологические исследования

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SIGNS OF VITAL ACTIVITY OF BROWN BEAR IN THE SUBALPINE BELT OF THE WESTERN SAYAN MOUNTAINS[1]

Brown bear (*Ursus arctos* L.) populations in the forest zone form communicative systems of marks left primarily on trees. This species also inhabits areas with low forest cover, including the subalpine belt. We studied the communication systems of brown bear populations in 2007-2009 in the Western Sayan, in the Ergaki natural park. The purpose of the study was to identify signs of the life activity of the brown bear in the subalpine belt, which could be used by these animals for indirect communication. We registered a total of 120 bear trees (BT) among which Siberian pine (*Pinus sibirica*) prevailed (83.3%). The linear frequency of marking was registered low: 2.66 BT per 10 km of the route. We found increased incidence of damaging marks and footprint marks left by adult males. Cluster analysis of data by 15 types of bear marks revealed two major groups: marks left by adult males and "marks" that bears of all age and sex groups are capable to leaving on BT.

Keywords: brown bear, communication systems, signs of vital activity, marking behavior, bear tree, the Western Sayan

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The communication systems (CS) of the brown bear (*Ursus arctos* L.) populations of the Holarctic forest territories have long and effectively been studied. The basic means of communication in these conditions are the marks left by bears on trees and near them. However, within this species' area there is a significant amount of territories with reduced forest cover inhabited by bears the same. We studied the CS of brown bear populations in 2007-2009 in the Western Sayan. We spent the first two years surveying the mountain forests of Bolsheurskoye and Yeniseiskoye forestry districts located in Sayano-Shushenski nature reserve [1]. In 2009 (from July 20 to August 23) we performed field observations in the Ergaki natural park which features the subalpine belt more extensively. The purpose of the study was to identify signs of the brown bear life activity in the subalpine belt, which could be used by these animals for indirect communication.

Materials and methods

All applied methods are non-invasive. The material was collected by route survey method, bear trees (BT) and other elements of CS of brown bear populations were described in accordance with the previously developed protocol [2-5], objects coordinates were defined with GPS navigator. The coordinates were later used to map the registered BT on the digital cartographic base (fig. 1, 2) with help of MapInfo 12.5 GIS.

Quantitative data were statistically processed, in particular, using the methods of cluster and correlation analysis, with application of Statistica 6.0 software. Monitoring of the chosen sites in subalpine belt and adjoining forest areas was conducted along trails (table 1, 2) used by humans and bears (as well as other animals); on subalpine meadows the field crew sometimes went without trails where they moved along natural boundaries. The indices of the rate of bear's marking behavior included the marking frequency (defined by the average occurrence of 15 different types of marks on one BT), the linear marking frequency (LMF), and occurrence of individual marks [6]. The process of field data collection turned quite labor intensive, especially in the mountainous conditions, which presented a certain limitation of our method. Nevertheless, it warrants the completeness of the resulting material, sufficient amounts of data which allow for rather detailed description of populations' CS, and application of mathematical statistical methods.

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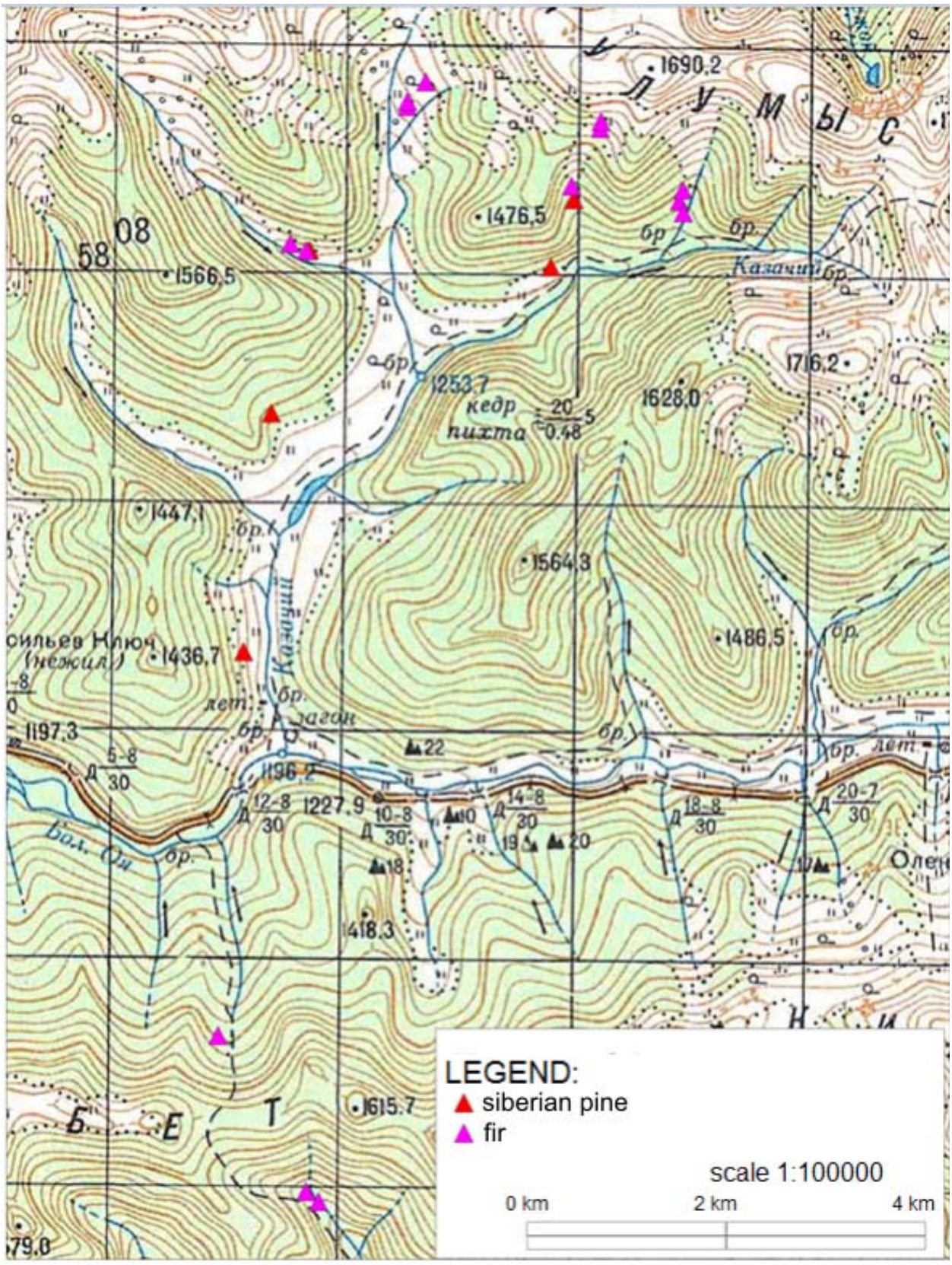

Fig. 1. Location of bear trees in Ergaki natural park, the western part (2009).

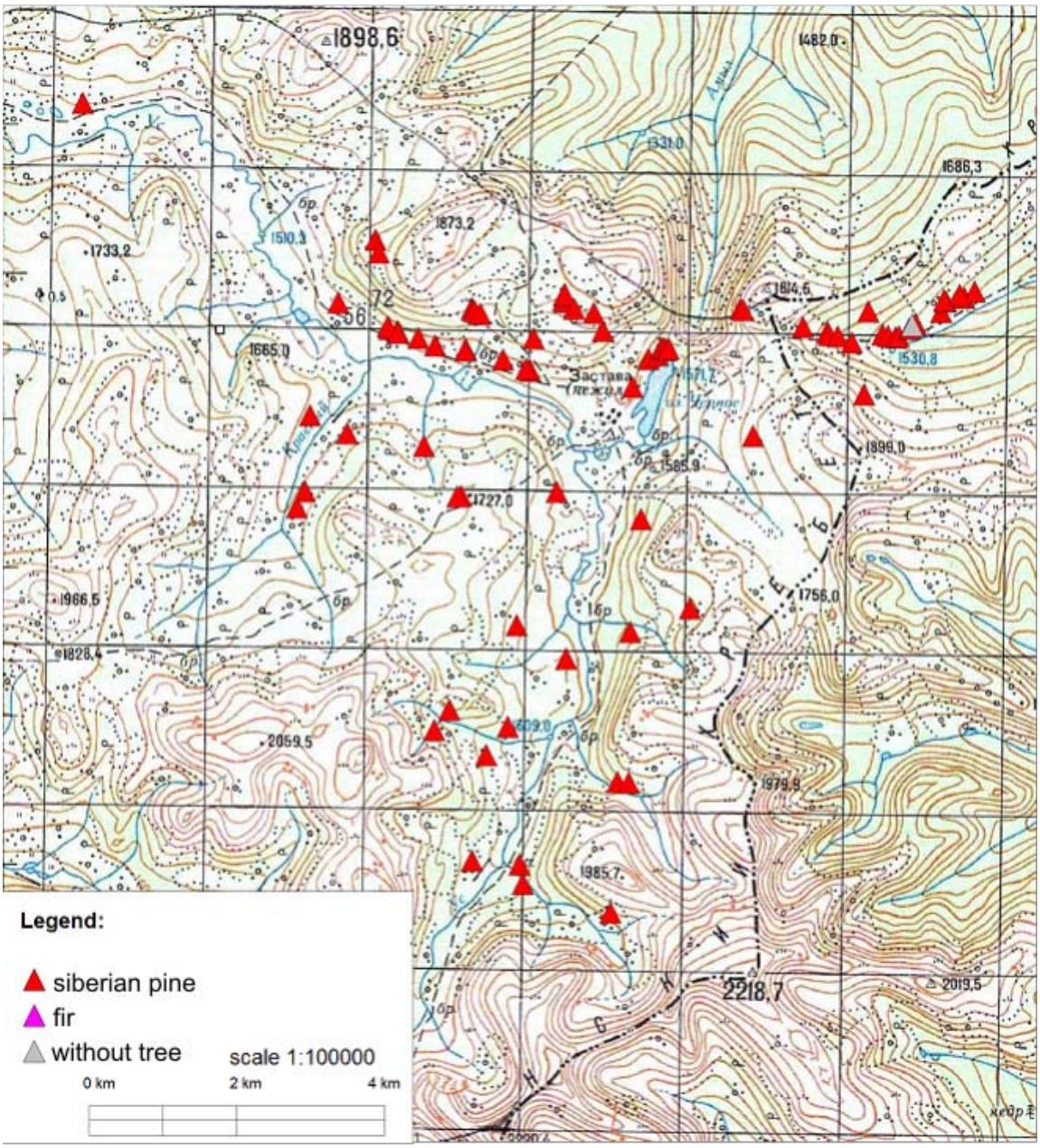

Fig. 2. Location of bear trees in Ergaki natural park, the eastern part (2009). Bear rolling site on the trail and footprint marks without evident connection with bear trees were registered once each.

The forests of the Ergaki park are represented by dark coniferous taiga dominated by siberian pine, with addition of fir and spruce. At higher altitudes the dominance of siberian pine is more prominent, spruces almost absent from the forest stands. Within altitudes range of our survey area meadows can be found at all absolute elevations. At lower elevations meadows run along watercourses (represented mainly by river and stream valleys); higher elevations feature subalpine meadows alternating with dwarf birch thicket and occasional willow stands. In subalpine belt forested areas are made solely by siberian pine oftentimes taking slight suppressed forms. Increased occurrence of damaged trees is highly characteristic of forest edges, which could be accounted for by mechanical (falling rocks, wind, snow) and biotic impact. The later is the most pronounced in the signs of Siberian red dear activity.

Anthropogenic impact on local eco-systems is more noticeable compared to the territories of Sayano-Shushenski nature reserve [7; 8]. It is conditioned by better accessibility (gentler landscape farther away from the Yenisey valley), and the former status of exploited territory. The regional nature reserve of Ergaki was established on April 4, 2005 by the decree of the administration board of Krasnoyarski krai; the status of

the specially protected area has been in effect for a short period of time. The headland of the Bolshaya Oya river (its tributary the Kazachiy stream) was used for pasturing livestock as lately as 2008. The headland of the Usa river (Chernoye lake) was used for yaks pasturing; according to the survey data, free-range livestock breeding has not been practiced on these territories just in the past ten years (approximately). On the other side, the vegetation of meadows and dwarfbirch thickets is quicker (compared to forest) to counter-balance anthropogenic damage; trails and other traces left by domestic animals and man are becoming less and less detectable.

Table 1

Main quantitative characteristics of field work conducted in the Ergaki natural part

Characteristic	Quantitative data
Period of works	20 July – 23 August, 2009
Length of the working route, km	452
Range of absolute elevations, m	1247 - 1812
Registered BT	120
LMF (number of BT per 10 km of the route)	2.66
Number of BT marked by bears in the year of monitoring (n/%)	84/70.0
LMF defined by BT marked in the year of monitoring	1.86

Table 2

Types of BT monitoring routes. Ergaki natural park, 2009

Type of route	Number of BT/length of the route, km
Animal trail	24/100.5
Anthropogenic trail	57/238.4
Animal-anthropogenic trail	8/33.4
Bear trail	12/0.2
Natural boundary	4/16.7
No well-marked trail or boundary	15/62.7
Total:	120/451.9

Results and discussion

120 BT were registered in the Ergaki natural park made up of 100 (83.3%) siberian pine trees, and 20 firs. The dominance of siberian pine trees on absolute elevations where the works were conducted (table 1) is in conformity with the pattern of altitude distribution of the forest-forming species in the Western Sayan [9-11]. Of all BT just one was classified as the defensive tree [12]; prey trees were not detected. BT distribution in the area is shown on maps (fig. 2 and 3). LFM in the subalpine belt is times less compared to the mountain forests of the Western Sayan (table 4). Bear's rolling site on the trail and footprint marks not evidently linked with BT were registered once each (marked as "without tree" on the map).

Species composition of BT in our materials on the Western Sayan region is rather complex. Spruce dominates in the combined sample, followed by siberian pine and fir [1]. The Bolsheurskoye forestry district of the reserve has the most prominent dominance of spruces (52.8%), whereas no spruces were registered among BT in the Ergaki. In the materials gathered in Yeniseyskoye forestry district the dominance of fir is as pronounced (52.7%). In the Ergaki siberian pines are spread among the BT even wider (83.3%). It is evident that the aforesaid examples of the three coniferous species dominance generally reflect the differences in the dominant species of the local forest stands [9; 10; 13; 8]. The same dependency applies to BT representing relatively rare species: larch, birch, and scots pine. We should remind that in the regions where the forest stands are characterized by the dominance of one particular species, e.g. larch [14], scots pine [15], dwarf birch [16], BT are largely represented by these very species.

Data on alternative registered signs of bears presence are given in table 3. These signs included bears' passing traces (normally on grass), biting (eating), scat, ground digging, footprints, lairs, damage to fallen trees, overturned boulders. The average frequency of their occurrence was registered at 17.2 per 10 km of the route, passing traces, ground digging, and biting signs prevailing. These signs of bears presence can potentially be used by them as elements (signals) of the CS.

Table 3

Signs of bears presence (other than BT) registered in the Ergaki natural park

Signs	Number of registered signs	Number of registered signs per 10 km
Passing traces	326	7.2
Biting (eating)	102	2.3
Scat	48	1.1
Ground digging	239	5.3
Footprints	19	0.4
Lairs	11	0.2
Damage to fallen trees	25	0.6
Overturned boulders	8	0.2
Total	778	17.2

Table 4 represents the materials on registration of BT and other signs on our research sites in the Western Sayan mountains. Throughout the three years of our work 726 BT were described. The LFM in two forest districts of the Sayano-Shushenski nature reserve was relatively high, with somewhat increased frequency in the Yeniseyski district (the Talovka basin) – 33.18 BT per 10 km of the route. The LFM in the Ergaki is insignificant (2.66) compared to the nature reserve. In course of three years we encountered just one prey tree [3] and 6 defensive trees. We generally observed low occurrence of the two latter types of trees [3; 4]. Furthermore, there were 23 dry trees among BT (3.17%). Dry trees are used by bears for marking purposes quite rarely compared to live trees. However, they have been mentioned in the works of some authors in connection with different regions within and outside of Russia [17; 18; 2]. The occurrence of the damaging BT marking and footprints in the subalpine belt is relatively high (table 4). To our knowledge, it is in line with the peculiarities of space distribution of adult male bears, who, in mountainous areas, spend much of the summer (including mating period) above the forest boundary [19-22].

Table 4

Parameters characterizing the rate of brown bear marking behavior on the territory of the specially protected nature reserve of the Western Sayan (2007–2009)

Parameters	Bolsheurskoye forest district	Yeniseyskoye forest district	Ergaki
Results for all registered BT			
Number of BT	386	220	120
LFM	28.96	33.18	2.66
Results for BT marked in the year of registering			
Number of BT (n/%)	291 / 75.98	140 / 64.22	84 / 70.0
LFM	20.96	21.12	1.86
Marking rate (by 15 types of marks)	4.62	3.33	3.67
Incidence of damaging marking (n/%)	101 / 34.71	22 / 10.28	44/52.38
Incidence of footprint marking (n/%)	16 / 5.50	15 / 7.35	10/11.90
Incidence of fresh hairs (n/%)	260 / 89.35	134 / 64.73	69/82.14
Incidence of hairs from previous years (n/%)	257 / 88.32	182 / 87.50	52/61.90

Table 4 contains parameters describing bears' dendroactivity in specially protected nature reserve of the Western Sayan. It is evident that average values of activity parameters (e.g. LFM, marking frequency defined by 15 types of marks) do not reveal wide variations in local parameters readings. Very low LFM in Ergaki is presumably explained by subalpine conditions (reduced forest cover). The marking frequency in these conditions corresponds to average values. Analysis of variance was used to compare marking frequency values (4.62, 3.33, 3.67 in chronological order). Difference between these average values turned significant at any of the applied significance levels (α=0.05; α=0.025; α=0.001). The minimum frequency of damaging marking was observed in Yeniseyskoye forestry district (10.28 which is also in line with the low rate of local marking activity), maximum frequency (52.38) – in Ergaki. It appears that relatively low incidence of footprint marks in Bolsheurskoye forestry district is partly conditioned by the abundance of

grass stands in local open forests incorporating (if not dominated by) larch trees. In the conditions of solid sod footprint depressions turn out to be less conspicuous, less detectable, and therefore they could have been missed by the field crew in some cases. The incidence of fresh hairs is also low in the Yeniseyskoe forestry district. The incidence of hairs from previous years is relatively low in Ergaki. Let us confine ourselves to the conclusion that readings for these two types of marks combine randomly.

Data obtained in Ergaki are relatively scarce, however they yielded impressive results. Let us dwell on the discussion of 15 marks data from table 5 describing only those BT which were marked in the year of monitoring (n=83). All damaging marks show positive correlation (the correlation coefficient varies from 0.23 to 0.44) with a minor exception of nibbled branches mark for which negative correlation with clawing cuts was determined (-0.19). Rubbing (against the tree trunk) has strong correlation with hairs from the previous years, and even stronger correlation with mass fresh hairs and stamping (0.25, 0.52, and 0.58). Stamping is tightly linked with surface cuts, nibbled branches, rubbing, and mass fresh hairs.

High negative correlation (-0.50) between singular fresh hairs and mass fresh hairs is worth noticing. Mass fresh hairs reveal strong positive correlation with several marks, among them rubbing, hairs from previous years, and stamping – all of which can be easily explained. While the aforesaid negative correlation with singular fresh hairs needs explanation which is not as obvious. Let us once again presume that the tendency we observed is conditioned by the increased mobility (change of biotopes) of local bears, as well as by the prolonged molting period of the brown bear [23; 20; 24]. We are not aware of the publications in which the correlation between brown bears molting and their marking behavior would be considered. These phenomena are addressed tangentially in our research on the CS of the brown bears dwelling in the Udmurt region [25].

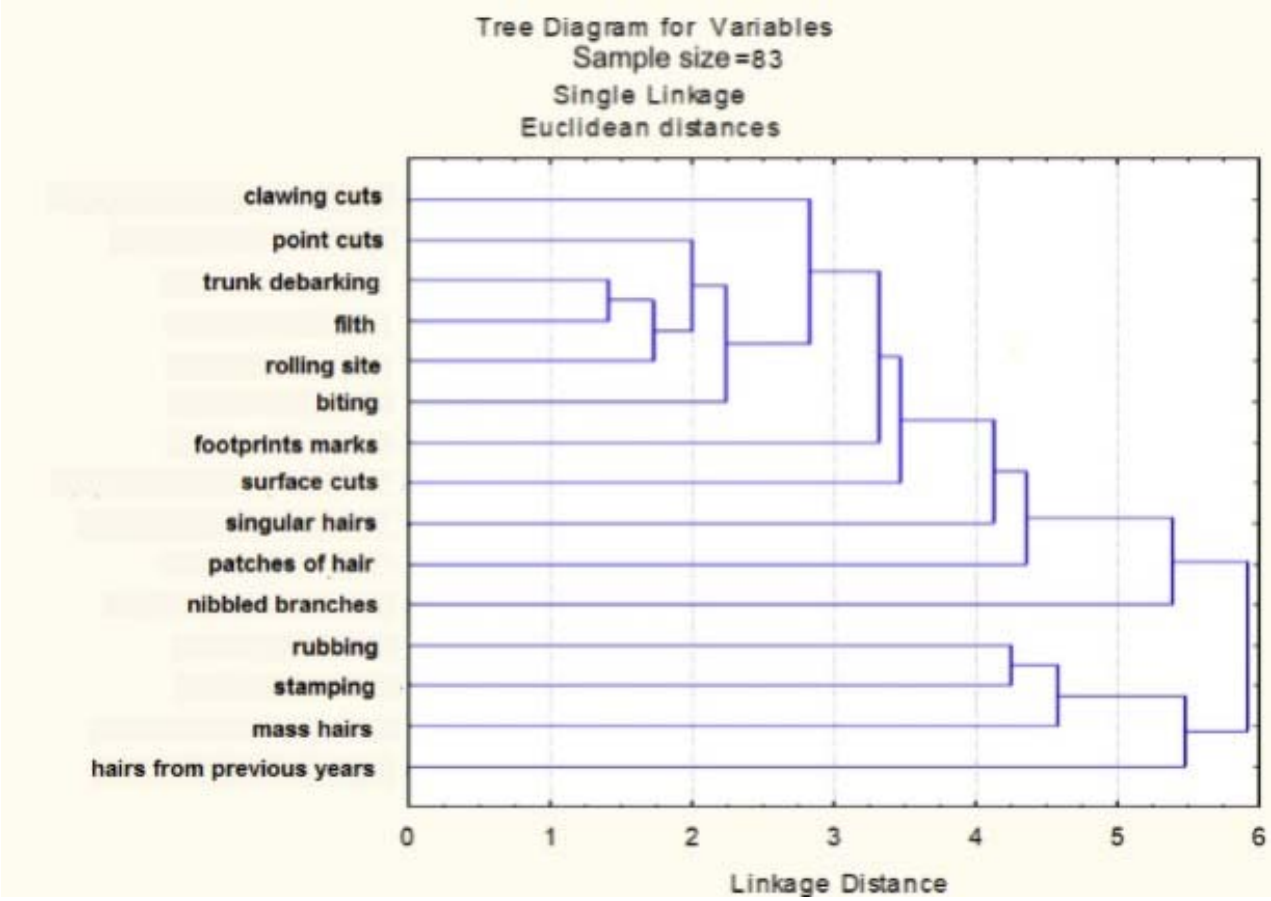

Fig. 3. Results of the cluster analysis by 15 marks based on materials from the Ergaki park (2009)

The results of the cluster analysis by 15 types of “marks” left on BT marked by bears in the year of monitoring (2009) are shown in the dendrogram (fig. 1). The cluster stands out which includes all damaging marks (clawing cuts of surface and point varieties, trunk debarking, nibbled branches, biting), rolling site, footprint marks, patches of hair. Surface cuts, mass hairs and filth belong to the same cluster, although not quite manifestly. Rubbing, stamping, hairs from the previous years, singular hairs fall into a separate cluster.

The marks of this cluster may correspond to dendroactivity of bears from different sex and age groups. Whereas the first cluster features marks characteristic of dendroactivity of adult males during the mating period [26; 17; 5; 22].

Conclusions

1. The linear frequency of marking in the Ergaki natural park is relatively low: 2.66 BT per 10 km of the route.

2. Average incidence of signs signaling bears presence in the Ergaki park amounted to 17.2 per 10 km of the route, with higher frequency of passing traces, ground digging, and biting (eating).

3. Siberian pine dominates among the BT in the Ergaki park (83.3%). The same tree species dominates in the subalpine belt.

4. BT registered in the Ergaki park show the increased incidence of damaging and footprint marks left by adult males.

5. Cluster analysis by 15 types of bear marks identified two coherent groups: marks left by adult males, and marks which bears of any sex or age groups are capable of leaving on BT.

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СЛЕДЫ ЖИЗНЕДЕЯТЕЛЬНОСТИ БУРОГО МЕДВЕДЯ В СУБАЛЬПИКЕ ЗАПАДНОГО САЯНА

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В лесной зоне в популяциях бурого медведя (*Ursus arctos* L.) формируются коммуникативные системы меток, размещаемые, главным образом, на деревьях. Этот вид обитает также и на территориях с невысокой залесённостью, в том числе - в субальпийском поясе. Нами изучались коммуникативные системы популяций бурого медведя в 2007–2009 гг. в Западном Саяне, в природном парке Ергаки. Целью работы являлось выявление в субальпийском поясе следов жизнедеятельности бурого медведя, которые могли бы использоваться этими зверями для опосредованной коммуникации. Зарегистрировано в общей сложности 120 медвежьих деревьев (МД), среди которых преобладали деревья сосны сибирской (*Pinus sibirica*) (83,3%). Линейная частота мечения была невелика: 2,66 МД на 10 км маршрута. Выявлена повышенная встречаемость повреждающих меток и следовых меток, которые оставляют взрослые самцы. Кластерный анализ данных по 15 типам меток медведей обнаружил стяжение признаков в две группы: метки, оставляемые взрослыми самцами и метки, которые способны оставить на МД медведи всех возрастных и половых групп.

Ключевые слова: бурый медведь, коммуникативные системы, следы жизнедеятельности, маркировочное поведение, медвежье дерево, Западный Саян

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