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Spatial distribution and dynamics of the left-bank population group of Siberian ibex (*Capra sibirica*) in the Pre-Yenisei part of the West Sayan

Roman G. Afanasiev* & Vladislav V. Vinogradov

ABSTRACT. The paper encompasses the spatial distribution, size (head count) and sex-age structure of the herd of Siberian ibex in the central part of the West Sayan from 2014 to 2020. There, the studied animals are grouped into 3 isolated loci. The paper presents the results of the ibex sighting on the left-bank group of Siberian ibex populating the grounds of Sayano-Shushensky Biosphere Nature Reserve.

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KEY WORDS: Siberian ibex, West Sayan, range, population size (head count), herd structure.

Roman G. Afanasiev [afanasiev-zapoved@yandex.ru], Katanov Khakass State University, Lenin str. 90, Abakan 655000, Russia; Vladislav V. Vinogradov [vlad-vin@yandex.ru], Krasnoyarsk State Medical University named after Prof. V.F. Voino-Yasenetsky, Partizan Zheleznyak str.1, Krasnoyarsk 660022, Russia.

Территориальное размещение и динамика численности левобережной популяционной группировки сибирского горного козла (*Capra sibirica*) в Приенисейской части Западного Саяна

Р.Г. Афанасьев*, В.В. Виноградов

РЕЗЮМЕ. Рассматриваются территориальное размещение, численность и половозрастная структура стада сибирского горного козла в центральной части Западного Саяна за период с 2014 по 2020 г. Здесь козероги сгруппированы в три изолированных очага обитания. В статье приведены результаты учетных работ левобережной группировки козерогов, которая обитает в пределах Саяно-Шушенского биосферного заповедника.

КЛЮЧЕВЫЕ СЛОВА: сибирский горный козел, Западный Саян, ареал, численность, структура стада.

Introduction

In mid-20th century, Siberian ibex (*Capra sibirica* Pallas, 1776) was commonly found throughout the vast territory of the West Sayan along the rocky banks of the Yenisei and its tributaries, from west off spurs of the Kurtushibinsky Range in the south up to the Bolshoi Tepsel River in the north (Sokolov & Balagura, 1973; Sokolov, 1979, 1988; Zavatskyi, 1989; Smirnov & Tkachenko, 1992). From 1978 to 1995 Sayano-Shushenskoe water reservoir had been impounded, it created a hardly passable water barrier, splitting the population of Siberian ibex, naturally inhabiting the West Sayan and territories adjacent to the Yenisei, into three isolated population groupings: the Usinsk, the Urbun and the left-bank reserve ones (Lineitsev, 2005).

The present paper analyzes the data obtained over many years of Siberian ibex sighting and observations in the central pre-Yenisei part of the West Sayan. The main aim of the research is to describe the Siberian ibex's spatial distribution, population dynamics and sex-age structure of the herd. In this paper, the range borders are precisely identified thus allowing to update the data on the species range borders within the region (Reading *et al.*, 2020).

Material and methods

The material for the present study was collected at the territory of Sayano-Shushensky Biosphere Nature Reserve during 2014–2020. Total area involved in the research exceeded 1000 sq. km.

The identification of Siberian ibex range borders was based upon the data collected during ibex sighting (both direct and feces) along pedestrian survey routes. The

* Corresponding author

routes were laid in habitats preferred by ibexes along rivers and over watershed mountain crests descending to the banks of the water reservoir. Total length of the survey routes measured up to 250 km, the surveys were carried out yearly from 2014 till 2020 in June, October and February to illustrate the details of the species' seasonal behavior within the studied territory. The following valleys and watersheds of the following rivers have been investigated: Bolshie Ury, Malye Ury, Khem-Terek-Tig, Kalbak-Mys, Chalban-Mys, Taldazhil, Mezhel, Uzun-Sug, Shignota, Bolshaya Kerema, Malaya Kerema, Sarly, Madarlyk, Srednyaya Kyzylkhaya and Kara-Kem. When identifying Siberian ibex habitats, data of forest management fieldworks carried out in 2015 (Nazimova D.I., Konovalova M.E. & Korets M.A., 2015) were used. The borders of rangelands populated by the studied species have been clarified on the ground of GIS-layers analysis provided to the nature reserve upon the forest management works. All mapping works (border drawing, area measurement) were done using ArcMap 9.0 software.

In certain years, surveys and sighting at open slopes along the Bolshie Ury River were done on foot (Novikov, 1949). The above mentioned river is the biggest within the rangelands populated by this animal group; along this river, Siberian ibex is found within 25 km from the water reservoir. The river's left bank is represented by open slopes providing excellent visibility of the neighborhood (high vantage points); these slopes are suitable for the ibex, whereas the on the right, densely forested bank, Siberian ibex does not occur (excluding part of the bank flooded during the high-water season). The surveyors walked along the river up to the eastern border of the range, viewing the open slopes with binoculars. The sighting was performed in the morning hours, from 7 am till 11 am in 2 sites (14 and 11 km), recording the number of animals in each group and sex-age structure. Each sighting site has been examined at least twice and highest values were into account (Novikov, 1949). In 2014 and 2016, seasonal surveys along the Bolshie Ury were undertaken in spring and summer period, in 2017 and 2019 — in the autumn (during the rutting period).

The authors based their surveys on the methodology of Siberian ibex sighting (visual sighting) proposed by Lineitsev (2005) when sighting the animals from near the reservoir. This technique has been developed particularly for the nature reserve, where a motor boat could be used for sighting ibex herds on the reservoir banks during two seasons — spring to early summer and autumn. The sighting and recording was performed in fine weather with clear skies at two constant sites located on the shoreline between conspicuous landmarks (mountain ridges, mouths of tributaries). Each site was surveyed in one day, with total length of the survey route being around 90 km. In the survey, two researchers simultaneously scanned the terrain for the animals from the motor boat moving at 12–15 km per hour about 100–150 off the shore in the morning (from 7 am till 10 am). Animals spotted with unaided eye were taken into account and recorded. Binoculars were used to make the animal count more accurate and clarify the sex-age structure of the herd. The distance for visual scanning appeared to be approximately 500 m from the water edge. One of the researchers visually examined the nearshore slope within 300 m, the other one — in the range from 300 to 500 m. In the recording sheet, time of sighting, head count, sex and age structure as well as the distance to each group were indicated.

In the second half of May and early June, nursing dams with that year's brood (young) are tightly bound to drinking places so they crowd along the shorelines of the reservoir — the largest water body — and its tributaries (Fedoseenko, 2003; Lineitsev, 2005). This fact allows us to identify density of females and the youngsters using data of motor boat sighting from along the shoreline. Drinking places visited by females in spring time were revealed using the data obtained in pedestrian and motor boat surveys, as well as those of forest management fieldworks done in 2015. Thus, the number of females and young individuals was identified as the number of sighted individuals multiplied by the adjustment coefficient (equaling 1 + the share of missed drinking sites) was:

$$k_i = 1 + \frac{q_i}{Q_i};\ N_i = n_i \times k_i;\ N_0 = \sum_{i=1}^{m} N_i,$$

where k_i — adjustment coefficient, Q_i — area of examined drinking places in the surveyed area, q_i — number of drinking places not included in sighting, N_i — estimated number of animals at the site, n_i — headcount of sighted animals at the site, N_o — total headcount in the group, m — number of sites where animals were sighted.

In autumn, during the rutting season, the ibex gather in mixed herds at open spaces in the lower and middle parts of the mountains (Fedoseenko, 2003; Lineitsev, 2005). This enables us to describe the group's sex-age structure using Lineitsev's method of animal sighting from the motor boat. Having identified the proportion of males in the ibex population and knowing the number of females and the young from the spring sighting, one can calculate the number of males by means of proportion method. The sighting was performed in October to early November in 2017–2019.

On the basis of data collected in all surveys and sighting, the herd (or flocking) index was calculated as the ratio of all recorded animals number to the number of groups at the site; also, the number of this year's brood per 100 females (kid and female ratio) at the site was identified.

Sighting was performed in the nature reserve, where the impact and intervention in the natural processes is minimal. Therefore, visual observations appear to be the only technique suitable for such studies. Moreover, the investigated terrain is known for its ruggedness and hardly passable montane routes and landscapes with the slopes equal of exceeding 45°, thus making other sighting methods almost inapplicable.

Results

Spatial distribution

Uniting the ranges of animal sighted during pedestrian observations (both direct and feces) that took place in different seasons of the year and coarsening them to approximate to the borders of Siberian ibex's habitats, the range of the left-bank pre-Yenisei ibex population where animals can be observed in different seasons (Fig. 1). Total area of the left-bank pre-Yenisei population group of Siberian ibex (belonging to the nature reserve) equaling approximately 470 sq. km has been calculated.

The studied ibex population group's range is bordered by Sayano-Shushenskoe water reservoir on the east; not a single occurrence of the animals crossing the water reservoir has ever been recorded in any season. In the north, the range is bordered by the Kara-Kem river valley. To the north of this borderline, in the Kara-Kem river basin and further to the Talovka river, the habitat conditions are unsuitable for the species. Within seven years of observations, solitary episodes of ibex entering the area towards the Talovka river mouth have been proven. The range's northern border fully coincides with the upper border of Siberian ibex rangelands: steep rocky areas adhering to steppificated south-exposed slopes. From the Kara-Kem river, the borderline crosses the Srednyaya Kyzyl-Khaya river in 2 km from its mouth, going further inland from the reservoir shoreline. Then, it crosses the rivers Madarlyk, Sarly, Bolshaya Kerema, Shignota in 4–5 km from the mouths, the river Uzun-Sug — in 5–6 km and the Malye Uvy River — in 7 km from the mouth. Following the Bolshye Ury river, the range forms a projection along the southern slopes of the river valley, distancing 25 km from the water reservoir to the Otuk-Sug tributary, then moving towards the water reservoir crossing rivers: the Khemterek in 7 km from the mouth, the Cholbak-Mys and Kolbak-Mys in 4–6 km from their mouths. The southern border runs along the watershed ridge of the Taldazhil river.

Population size

The data obtained during observation from the surface of the water reservoir in spring and autumn as well as during pedestrian observation along the Bolshye Ury are presented in Tables 1–3.

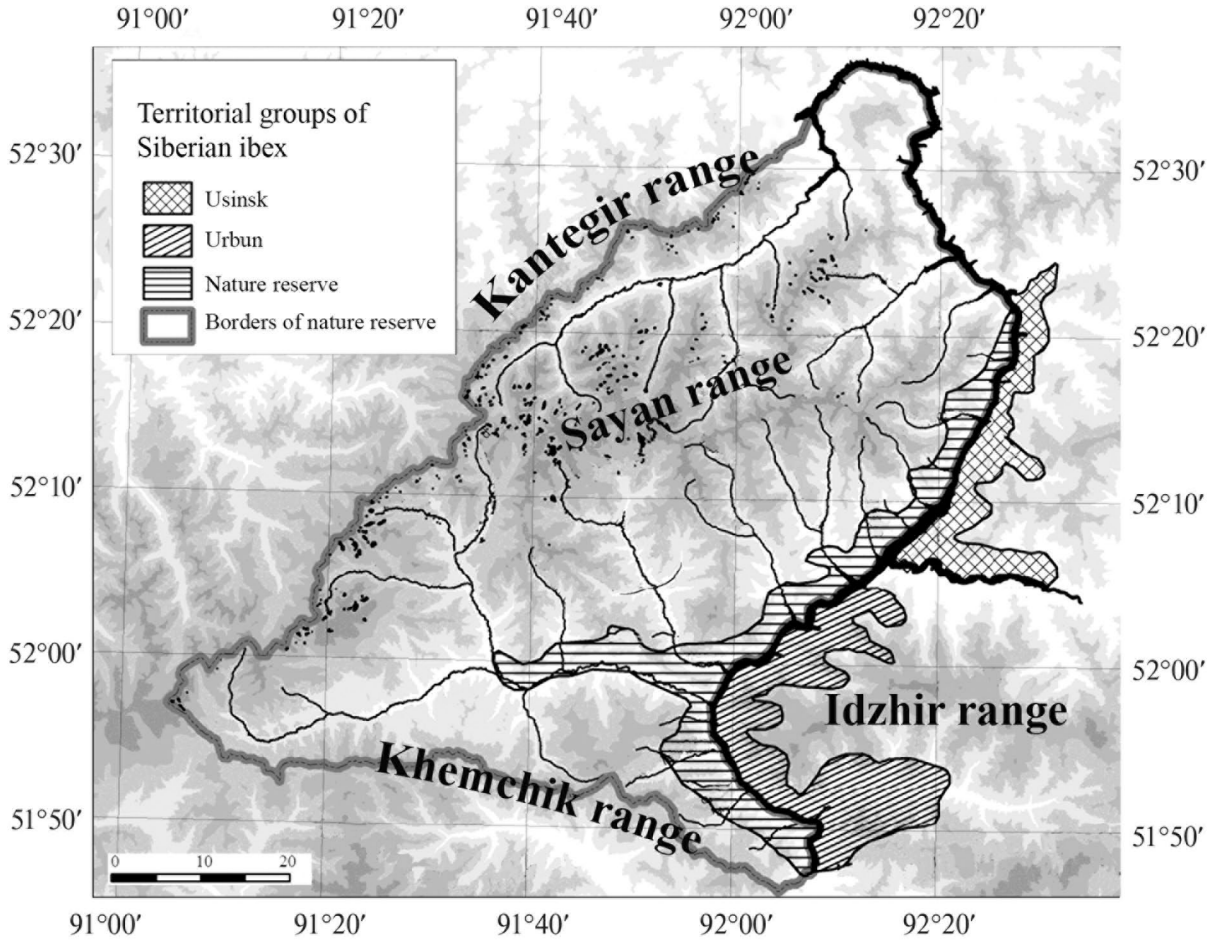

Fig. 1. Territorial groups of Siberian ibex in the part of the West Sayan adjacent to the Yenisei.

Total area of the survey belt along the water reservoir coastline for the first site was 17.5 sq. km, for the second and the third ones — 12.5 and 15 sq. km respectively. For each surveyed site, pedestrian sighting was followed by revealing drinking places, visited by ibex in springs and invisible to the surveyors during the motor boat sighting. In the first site, the area of drinking places not accounted in the sighting records, was 8.5 sq. km (parts of the rivers Srednyaya Kyzyl-Khaya, Madarlyk, Sarly, Malaya Kerema and Bolshaya Kerema), for the second site — 7.5 sq. km (parts of the rivers Shignota, Uzun-Sug and Skalistyi stream), for the third one — 26 sq. km (parts of the rivers Malye Ury, Bolshye Ury, Khem-Terek-Tig, Irgar, Chalban-Mys and Taldazhil). Data of the sighted ibex count during spring motor boat surveys together with the identified share of the unaccounted drinking places were used to calculate the number of females and young individuals. When counting the population in 2014 and 2016, in the third site, the authors based on the data of the spring pedestrian survey along the Bolshie Ury River, the area of unaccounted drinking places being 13.5 sq. km those years. The calculation results were rounded to whole numbers and presented in Fig. 2.

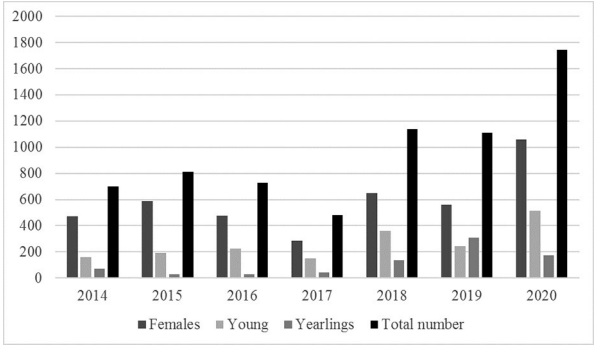

Fig. 2. Number of females and young individuals based on the spring sighting (2014–2020) data extrapolation.

Table 1. Summary spreadsheet of spring sighting data in the coastal zone of the Sayano-Shushensky Nature Reserve in 2014–2020.

Date	Number of herds	Total animals	Including				Herd index	Number of young per 100 females
			Males	Females	Young (this year's brood)	Yearlings (last year's brood)		
Site 1 Kara-Kem River–Kerema River (35 km)								
10.06.2014	11	178	18	89	48	23	16.2	53.9
23.06.2015	9	51	3	41	7		5.7	17
04.06.2016	17	93	6	51	28	8	5.5	54.9
08.06.2017	25	78	15	35	17	11	3.1	48.6
11.06.2018	30	119	21	54	33	11	4	61.1
05.06.2019	13	157	2	86	39	30	12	45.3
12.06.2020	39	212	27	95	63	27	5.4	66.3
Site 2 Kerema River–Malye Ury River (25 km)								
11.06.2014	9	137	1	92	35	9	15.2	38
21.06.2015	13	84	6	59	18	1	6.5	30.5
05.06.2016	8	59	7	35	15	2	7.4	42.8
12.05.2017	13	50	14	25	8	3	3.8	32
13.06.2018	27	185	32	84	51	18	6.8	60.7
06.06.2019	13	192	22	84	44	42	14.8	52.3
13.06.2020	19	143	12	69	50	12	7.5	72.4
Site 3 Malye Ury River–Shugur River (30 km)								
13.06.2014	5	83	7	54	10	12	16.6	18.5
19.06.2015	23	245	11	166	58	10	10.7	34.9
06.06.2016	17	220	2	149	63	6	12.9	42.3
11.05.2017	12	131	6	74	42	9	10.9	56.7
12.06.2018	26	304	12	168	89	35	11.7	52.9
07.06.2019	26	270	27	119	47	77	10.4	39.5
14.06.2020	29	491	14	303	131	43	16.9	43.2
Total at all sites								
2014	47	587	64	353	116	47	12.5	32.9
2015	45	380	20	266	83	11	8.4	31.2
2016	68	495	19	307	150	19	7.3	48.9
2017	50	259	35	134	67	23	5.2	50.0
2018	83	608	65	306	173	64	7.3	56.5
2019	52	619	51	289	130	149	11.9	45.0
2020	87	846	53	467	244	82	9.7	52.2

Table 2. Summary spreadsheet of autumn sighting data in the coastal zone of the Sayano-Shushensky Nature Reserve in 2017–2019.

Date	Number of herds	Total animals	Including			Herd index	Number of young per 100 females
			Males	Females	Young (this year's brood)		
Site 1 Kara-Kem River–Kerema River (35 km)							
31.10.2017	22	117	34 (29%)	50 (42.8%)	33 (28.2%)	5.3	66
09.11.2018	12	35	16 (45.7%)	16 (45.7%)	3 (8.6%)	2.9	18.7
30.10.2019	19	96	41 (42.7%)	40 (41.6%)	15 (15.7%)	5	37.5
Site 2 Kerema River–Malye Ury River (25 km)							
31.10.2017	25	158	46 (29.1%)	71 (45%)	41 (25.9%)	6.3	57.7
28.10.2018	19	124	41 (33%)	52 (42%)	31 (25%)	6.5	59.6
04.11.2019	23	151	61 (40.4%)	58 (38.4%)	32 (21.2%)	6.5	55.1
Site 3 Malye Ury River–Shugur River (30 km)							
03.11.2017	9	36	8 (22.2%)	17 (47.2%)	11 (30.6%)	4	64.7
26.10.2018	18	215	26 (12.1%)	121 (56.3%)	68 (31.6%)	11.9	56.2
05.11.2019	18	72	28 (38.9%)	27 (37.5%)	17 (23.6%)	4	63
Total at all sites							
2017	56	311	88 (28.3%)	138 (44.4%)	85 (27.3%)	5.6	61.6
2018	49	374	83 (22.2%)	189 (50.5%)	102 (27.3%)	7.6	54.0
2019	60	319	130 (40.8%)	125 (39.2%)	64 (20%)	5.3	51.2

Table 3. Summary spreadsheet of spring and autumn sighting data along the Bolshye Ury River.

Date	Number of herds	Total animals	Including					Herd index	Number of young per 100 females
			Males	Females	Young (this year's brood)	Yearlings (last year's brood)	Sex not determined		
Pedestrian sighting from the Bolshye Ury River mouth to "Solontsy" winter cabin (14 km)									
20.05.2014	16	140	31	92	10			8.7	10.9
11.06.2016	11	71	2	44	25			6.4	56.8
04.11.2017	22	104	32	38	23		11	4.7	60.5
02.11.2019	15	115	41	55	19			7.7	34.5
Pedestrian sighting from "Solontsy" winter cabin to "Otug-Sug" post (11 km)									
19.05.2014	6	59	7	26	13	3	10	9.8	50
14.06.2016	15	52	2	28	19	3		3.5	67.8
05.11.2017	7	34	20	8	6			4.8	75
03.11.2019	12	38	20	13	5			3.2	38.5
Total in all sites									
2014	22	199	38	118	23	3	10	9.0	19.5
2016	26	123	4	72	44	3	0	4.7	61.1
2017	29	138	52	46	29	0	11	4.8	63.0
2019	27	153	61	68	24	0	0	5.7	35.3

Using the data of autumn motorboat sighting conducted in 2017–2019, the sex-age structure was identified. Thus, we were able to calculate the total population size (headcount) using the proportion method. The results were rounded to whole numbers and displayed in Table 4.

Discussion

In the part of Siberian ibex range adjacent to the Yenisei, supposed number of ibex population in mid-1980s was 1500, out of them 650–700 — in Sayano-Shushensky Nature Reserve (left-bank group) (Syroechkovsky & Rogacheva, 1988). By late 1980s — early 1990s, the estimated population of ibex exceeded 2000, out of them around 1600 individuals — in the nature reserve (Fedoseenko, 2003).

According to the data obtained in the present research, the population of ibex, given the amounts of surveying works are comparable, appears to undergo considerable fluctuations, which can indirectly indicate the presence of dynamic processes in the ibex population during the

Table 4. Number of Siberian ibex females, young individuals and males in the population group based on spring sightings data extrapolation correlated with autumn sightings data.

Date	Females with the young (spring sighting)	Share of males (autumn sighting)	Males	Total animals
Site 1 Kara-Kem River–Kerema River (35 km)				
2017	94	29.06%	27	121
2018	146	45.71%	67	212
2019	230	42.71%	98	329
Site 2 Kerema River–Malye Ury River (25 km)				
2017	46	29.11%	13	59
2018	196	33.06%	65	261
2019	218	40.40%	88	306
Site 3 Malye Ury River–Shugur River (30 km)				
2017	342	22.22%	76	418
2018	798	12.09%	97	895
2019	664	38.89%	258	923
Total in all sites				
2017	481	—	117	598
2018	1140	—	228	1367
2019	1112	—	445	1557

study. Climatic factors and predators have the greatest influence on the number of mountain goats in the reserve (Fedoseenko, 2003). According to our observations, the population size appeared to be the lowest in the years with the snowiest winters. Deep snow prevents animals from foraging (Fedoseenko, 2003). So, in the winter of 2016–2017, in the habitats of mountain goats, the height of the snow depth exceeded 30 cm in some areas. During this period, we found several mountain goats that died from exhaustion. The corpses were not damaged, they came across throughout the range of the group of Siberian ibex. Almost all of the bodies found belonged to male. Probably, the animals were not able to make up for the energy losses after the breeding season. We rarely met the corpses of females that died from exhaustion. However, in snowy winters, we have observed increased pressure from wolves. The depression of 2017 was followed by a more than twofold increase in the number of ibex in 2018. The increase in the number of animals is associated with increased fertility of females and high survival rate of young animals in the snowless winter of 2017–2018.

During the work, undercount the animals was possible. The undercount is more pronounced on hiking routes, because animals can notice researchers from afar and hide. The undercount is less when sighting the animals from near the reservoir, because the animals do not perceive the boat as a living object and let it close to them. In some years, some undercount of underyearlings is possible due to a shift in the term of birth of females.

Despite the species' very high reproduction potential (Danilkin, 2005), the number of the young (this year's brood) per 100 females in the investigated sites ranged from 17 to 72, on average 0.45 kids per female. Each female mainly gives birth to one kid, rarely (no more than 2–3%) twins are born (Lineitsev &Volkov, 2012). Data on the number of embryos per female are not available. The young to yearling ratio varies considerably and indicates different survivability throughout the years and high mortality rate among the young during the first months of life.

Literature sources report the variability of sex-age structure in Siberian ibex herds populating the West Sayan: males — 27.4–39.8%; females — 35.2–48.1%, kids — 16.3–24.5% (Zavatskyi, 1990; Fedoseenko, 2003; Lineitsev & Volkov, 2012). Autumn sighting, conducted to identify the sex-age structure of the population, demonstrate a slightly different picture in certain surveyed sights: males — 12.1–45.7%, females — 37.5–56.3%, kids — 8.6–31.6%. In the entire animal group, the shares over the years were as follows: males — 22.2–40.8%, females — 39.2–50.5%; kids — 20.1–27.3%.

Siberian ibex is a social animal living in herds. The size of herds and animal groups, as well as their altitude and biotope distribution, depends on the season, phase of reproductive cycle, size of suitable rangelands and population density that is why the herd characteristics range widely (Razmanikhin, 1977; Fedoseenko, 2003). In spring and early summer of 2014–2020 (Tab. 1), solitary animals, as well as groups up to 79 individuals were sighted, at the same time, the herd index ranged from 3.1 to 16.9. The biggest herd, consisting of 73 females and young individuals, was recorded on June, 5th, 2016 at the site between the rivers Malye Ury–Bolshye Ury. In autumn period, the herd index ranged from 2.9 to 11.9, and the biggest herd ever of 119 animals was recorded on October, 28th, 2019 at the site between the rivers Malye Ury–Bolshye Ury. In the conditions of rugged terrain and mosaic distribution of suitable rangelands, large herds are short-term formations, lasting for a few days only that is

why encountering such a herd is a rare occasion. These herds are mostly formed prior to the rutting season and soon break into smaller groups. A usual size of a rutting herd is 7–15 individuals (Sokolov, 1979; Lineitsev, 2005). Larger herds are known from literature record, too. Thus, in September, 1967, a mixed herd of 140–150 ibex individuals was seen near the mouth of the Bolshye Ury.

In summertime, according to our observations and other scholars' data (Sokolov, 1979; Fedoseenko, 2003; Lineitsev, 2005), most males and females keep in separate, isolated groups. Herds consisting of females with the young are the most conservative in terms of composition and number. Sometimes, young or grown-up males join these herds but they do not keep together for a long time. In the hottest period, females with the young form herds quite great in head count, keeping near the waterline.

Conclusion

The total area of the rangelands populated by the left-bank Pre-Yenisei Siberian ibex group in the West-Sayan- Yenisei part of the species range is shown to be 470 sq. km, while estimated summary population of the animals ranges from 598 to 1557. Averaged data on the sex-age structure are typical for populations not affected by hunting or trapping: males ≈ 22–41%, females ≈ 40–50%, kids (unrelated to gender) ≈ 20–27%. In the summer period, most males and females keep in isolated groups, while herds consisting of females and young individuals appeared to reach the number of 80 animals. In October–early November, the animals form rutting herds with average number of 7–15 individuals per herd, but larger gatherings exceeding 100 animals have also been recorded. All in all, the Siberian ibex population in Pre-Yenisei part of the West Sayan is in stable condition. The animals populate all suitable habitats, from steppified low-hill terrains and broadleaf forest areas to alpine tundra sites.

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