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The Musk deer Moschus moschiferus in USSR

A.G. Bannikov,
S.K. Ustinov, P.N. Lobanov

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FOREWORD

The musk deer is a small, primitive cervid that occurs in wet mountainous forest regions of east and central Asia, from Siberia and Sakhalin Island in the north, through Manchuria, Korea and China to the Himalayas and northern Burma, in the south. Neither sex possesses antlers, but the male has long upper canine teeth and a musk-secreting gland, the precise biological function of which is uncertain, in the lower abdomen.

Musk has been used since time immemorial in the preparation of oriental medicines and as a fixative in perfumes. Synthetic alternatives exist and are used in the perfume industry but would have no place in the oriental medicine trade. Most deer in Asia have been hunted heavily but, in the musk deer, hunting pressure has been intense because it provides not only meat and hides but also musk, which has commanded very high prices in recent years and is worth more than its weight in gold.

In the southern part of the musk deer's range, there is little doubt that drastic declines have occurred in populations in recent decades and, in 1974, the Himalayan race was entered into the Red Data Book of world threatened species.

Many governments have responded to this situation by totally protecting the musk deer by law and by banning the trade in musk. But to enforce protection in the isolated mountainous areas in which the deer occurs and eradicate smuggling of the extremely valuable and easily concealed musk, are very difficult tasks. In the People's Republic of China, experimental farming of musk deer and extraction of musk from the living animal has apparently been undertaken successfully but these techniques require refinement and the social behaviour of the musk deer may still present a serious impediment to regular successful reproduction in the captive state. In any case, from the conservation view-point, retention of a wild species in permanent captivity is no substitute for maintenance of free ranging, viable populations in their natural environment.

In the northern part of the musk deer's range populations had been seriously reduced through uncontrolled hunting by the turn of the present century. A fortuitous reduction in the demand for musk and subsequently improved conservation measures has since restored populations to the point where it has been possible to reintroduce licensed hunting and regular trade in musk. It has also enabled detailed ecological studies to be made of the musk deer which are of great potential significance to the study and management of the deer in other parts of its range, where scientific data are presently lacking.

In early 1977, following previous discussions of this topic, the Survival Service Commission's Deer Specialist Group invited its Soviet member, Professor Andrei Bannikov, to prepare a monograph on the musk deer, to provide an up-to-date summary of Soviet research and management experience on the deer. The present publication is the result of this request.

The senior author of the monograph, Professor Bannikov, has long been actively associated with the work of IUCN as the Chairman of the SSC's Wild Horse Specialist Group; in 1972, he became a Vice-President of IUCN. He is presently the Head of the Zoology Department of the Moscow Veterinary Academy and the author of several hundred scientific publications on a wide range of vertebrate studies. Dr. Ustinov and Mr. Lobanov are both members of the Irkutsk Wildlife Management Institute. Dr. Ustinov's doctoral thesis was concerned with the winter ecology of the musk deer in East Siberia and Mr. Lobanov is presently completing his Ph.D. thesis on population structure and reproduction of musk deer. Both post-graduate studies were made under Professor Bannikov's supervision.

IUCN gratefully acknowledges the help of Sir Peter Scott, Chairman of the Survival Service Commission, who arranged for a grant to finance the translation of the original manuscript into english. It trusts that this publication will meet its intended purpose of stimulating further interest in the conservation of the musk deer throughout its range, and of providing an authoritative text to aid etho-ecological research on the deer as a basis for more effective management.

Colin W. Holloway

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RESUME AND RECOMMENDATIONS

The Northern half of the musk deer area is spread across the U.S.S.R. and contains more than 90% of their world population, which is about 100,000 animals. The population density, taking into account all suitable habitat is about 6 animals per 1000 ha. The musk deer range is like mosaic, and the distribution of population density is very uneven. 20% of the ranges in the U.S.S.R. have a population density of more than 14 animals per 1000 ha. On some ranges population density reaches 40-60 and even more animals per 1000 ha. Such distribution of densities is determined by the food supply.

The narrow specialization in feeding on arboreal lichens is characteristic for the musk deer. It possesses a number of morphological, ecological and ethological adaptations permitting the musk deer to use food resources from the extremely small ranges. Some peculiarities in feeding behaviour of the musk deer accounts for their settled way of life and the small sizes of individual home ranges. The population of the musk deer in the U.S.S.R. at the beginning of the 20th century was sharply diminished as a result of over hunting. However, the drop in demand for musk and conservation measures adopted by U.S.S.R. helped to restore the size of the population. Musk deer hunting is licensed and is limited by time and methods. Absolute protection of the musk deer is provided for in six reservations.

At the present time 5,000 musk deer are harvested annually in the U.S.S.R., however for biological reasons this number can be increased 4-5 times, i.e., to 20-25,000 musk deers annually.

INTRODUCTION

The musk deer is a primitive representative of the Cervidae. It belongs to the subfamily of Moschinae and quite possibly deserves to be singled out into a special family, a very specialized one which, apparently, represents an ancient ungulate lineage. However, the paleontological data on the musk deer is very scanty and there is no data to judge the evolutionary-geographical development of Moschinae. The earliest finds of the musk deer belong to the Upper and Middle Pleistocene and they all come from places in China (Teilhard de Chardin, Leroy, 1942; Colbert, Hooijer, 1953) and from the south of the Soviet Far East (Vereschagin, 1966). In Siberia the musk deer became known only from the late Neolithic Quaternary deposits (Gromov, 1948), which indicates its late penetration into this region (Figure 1).

These data, the analysis of geographical changes in musk deer distribution, its biological timings testify to its ancient connection with eastern Asia. In confirmation of this is the discovery of a parasitical two-winged <u>Cordylodia inexpectata</u> from the tropical subfamily of the Auchmeromyinae in the musk deer from Sikhote Alin which is absent in the musk deer from Siberia. There is also the fact that the most primitive race "berezowski" which retained mixed features of southern and northern races is found in eastern Asia.

Thus, the musk deer evolving in the mountain forests of eastern Asia spread widely since the Pleistocene in the mountain regions of Central, South-East Asia and in the north it spread to the south of the Soviet Far East. The musk deer also inhabited Sakhalin Island before its separation from the continent during the Quaternary period. However, the spread of musk deer in western and north-western Siberia occured later. This, in V. J. Tsalkin's

(1947) opinion, is testified by the slight morphological differences of Siberian musk deer from the musk deer of the Far East, and also by the fact that it did spread to North America in contrast to other ungulates of Siberia and the Far East which used the Bering Land connection during the Pleistocene.

Since the musk deer has been ecologically closely connected with the coniferous mountain and mixed forests, it is closely adapted to specific floral mountain communities. This resulted in a mosaic geographical distribution of the species. For this reason the antropogenic landscape changes during historical times, combined with hunting pressure, led to even greater gaps in the musk deer distribution in many regions. The musk deer has largely dispersed from the densely populated eastern China; it was almost completely destroyed in India, and is preserved only in a few regions, mainly in national parks, in Nepal (Damwal, 1972; Green, 1977). A number of subspecies of the musk deer are threatened and are included in the Red Book.*

The musk deer is not well studied, which makes the development of measures for its conservation and national harvest rather difficult. The present survey summarizes the data on the musk deer in the U.S.S.R. in the northern half of its range, where the species is better preserved than in other areas.

1. TAXONOMY

Musk deer taxonomy is very complicated. This can be explained due to insufficient amount of material collected from the south part of its range. However, the available data and contemporary conception of the species permit one to count the genus *Moschus* as monotypical and containing only one species *Moschus moschiferus* (L., 1758).

* IUCN's Red Data Book follows Whitehead's (1972) systematic classification of the musk deer, which recognizes three ~~species and~~ five subspecies, as follows:

Moschus moschiferus moschiferus	Northern India, Himalayas, etc.
M. m. sifanicus	West, central and southern China
M. sibiricus sibiricus	Siberia, north Mongolia and Korea
M. s. sachalinensis	Sakhalin Island
Moschus berezovskii	Zsechwan, China

The Himalayan musk deer (*Moschus moschiferus moschiferus*) is included in the Red Data Book in the vulnerable category.

The most thorough revision of the genus Moschus, carried out by V. Tsalkin (1947) showed no grounds to segregate sifanicus and berezowski (=chrysogaster) as independent species. The work of S. P. Grooves (1975), which mentions the noticeable difference in hide colour and the insignificant difference in skull structure, confirms the monotype of the species and disagrees with the author's conclusion about the presence of three species in the ~~family~~ genus.

We would like to mention, without going into detail, that the species Moschus moschiferus is very diverse on its large range and splits into 7 or 8 geographical races (subspecies). In the northern part of the range live forms with moderately large body size, long extremities, dark colouring and distinct spots. The skull of this species is characterized by a short facial part. In southern sections of the region, body sizes and skulls of the musk deer are larger, the colouring is lighter and the spotting is less pronounced.

The northern and southern species are connected by transitional forms within the limits of individual variability. Furthermore, the species "berezowski" from western China features all the signs of the southern and northern species.

All species of the musk deer are geographically allopatric except "berezowski" which is, however, ecologically segregated from "sifanicus." The former inhabits the forest regions, the later the shrub belt in the subalpine (Berezowski, Bianki, 1891; Engelmann, 1938 and others).

It is necessary to mention that the type species of M. m. moschiferus L. described from the Altai ("Tataria versus Chinem") was correctly identified by many authors (Tsalkin, 1947; Heptner et. al., 1961). There are no grounds to consider northern India (the Himalyas) as a typical region, this leads only to confusion (Flerov, 1952; Kenneth Whitehead, 1972).

In the U.S.S.R. the following forms are found, according to contemporary views.

1. Moschus moschiferus moschiferus Linné, 1758 (syn. sibiricus, altaicus, arcticus).

Relatively large race with the greatest length of skull - up to 164 mm. Nasal bones are long, up to 41% of skull's length. The metapodia are long: forelegs up to 144 mm, hind legs up to 206 mm. The colouring is dark. It inhabits all of the eastern Siberian part of the region up to the Amur River. Outside of the U.S.S.R. it can be found in northern Mongolia (Kentei).

2. M. m. parvipes Hollister, 1911 (syn. turovi).

This subspecies differs from the type race by a smaller body and skull size and more intensive dark brown colouring; metapodia are shorter.

It is distributed in the south of the Soviet Far East (Ussuriisk region). Outside the U.S.S.R. one finds them in Korea and north-eastern China.

3. M. m. sachaliensis Flerov, 1928.

A relatively small race with a skull length up to 151 mm. In skull structure and metapodia length, it resembles the previous race, but the colouring is much lighter. It has well marked spots, and around the eye it usually has a light ring, much as in southern races.

It is found on the Sakhalin Island.

These subspecies are not sharply differentiated, especially against the background of large population variability. Thus, taking into consideration the colouring, skull and metapodia size one can find a distinction between the musk deer from Altai and the musk deer from the East Sayan (Ustinov, 1971).

Musk deer from the East Sayan are not of the same type in size and colouring. The animals from the western regions ("Stolby" ~~sanctuary~~ Reserve) are larger and darker than those from the Irkutsk region (Lobanov, 1977).

Musk deer from the north-eastern and southern regions of Yakutia differ noticeably (Egorov, 1965, 1971). One can observe certain differences in animals from the south and central regions of the Far East.

2. SOME ADAPTIVE FEATURES OF MUSK DEER MORPHOLOGY

The musk deer is a small ungulate. The length of its body measures up to 100 cm and it weighs up to 15 kg. Its general appearance is typical for an animal highly adapted to jumping; the frontal part of its body is much lower and smaller than the hind parts (height at withers up to 68 cm, at the sacrum up to 80 cm); the spine is bent like an arch. The dew claws (II and V) are comparatively well developed, and mobile; when the musk deer jumps on steep slopes the dew claws help it to stop suddenly. The hoofs are narrow, the toe muscles well developed, the pelvis straight and elongated, the head of the femur is also elongated. These morphological peculiarities are very important for a musk deer living in a thick forest with an abundance of fallen trees and stones making locomotion difficult. They permit an animal to make sharp turns and unpredictable jumps. Musk deer propel themselves away from the ground with all four legs at the same time, and land with all four legs bunched together; they decelerate instantly. Moreover, the musk deer is able to alter the body plane for landing while suspended in mid air during the jump, and without loosing time to turn and jump off in another direction. This gives it a great advantage over a pursuer.

The musk gland of the buck is located in the abdomen between the anus and the sex organs. It is enclosed in a leathery pouch, covered with short coarse hair. The glands of an adult buck weigh about 50 g maximally, changing during the year to a low of 10-15 g. The gland's cavity is filled with thick brown secretion and large quantity of compacted matter. The most probable function of the gland is in marking a territory. This is logical in view of the limited supply of specific food and the solitary life of individuals. The latter makes a search for a partner during the rut difficult.

The hair cover of the musk deer consists of long hairs, wavy in its distal half, elastic, with considerable air cavities and therefore quite brittle. The longest hair is on the sacrum and reaches up to 95 mm in length; at withers hair length is 65 mm, at sides about 50 mm, and even shorter on the abdomen, neck, head and legs. The undercoat is poorly developed; the hairs are thin, short and light. The long hairs are weakly attached to the skin and remain in the claws and mouth of a predator during the attack.

The musk deer sheds its hair once a year; shedding is spread from the end of winter until fall. In this period the shedding of old hair and the growth of new ones occur. This process is most intensive in the spring, and therefore at the beginning of the summer the hair cover is short and thin.

3. GEOGRAPHICAL DISTRIBUTION IN THE U.S.S.R.

Musk deer are found only on the Asian territory of the country, to the west up to the Yenisei River. They occupy large regions: the Altai, Western and Eastern Sayan, mountain ridges around Baikal Lake, the ridges of Transbaikalia, Yakutia, Far East, northern half of the Sakhalin Island. Inside these regions the populated areas are patchy and there are breaks in the continuity of the distribution.

The south western boundary passes along Kurchum and Narym ridges (South Altai) including the upper reaches of Bukhtarma River. The boundary in the north passes through the upper reaches of Ob River to the right bank of Yenisei River and continues along the river approximately to 66° parallel.

Further, the northern boundary of the range passes from the Lower Tunguska River estuary including the upper reaches of Kochuma River and middle reaches of the Kotui River with gradual elevation to the Yan River; here it possibly reaches up to the 70^{o} parallel. The boundary then drops sharply and comes to the middle reaches of the Indigirkà River and Kolyma River. The boundary rises again for 200-300 km along the Kolyma River Valley. Before the upper reaches of Penzhina River it comes down to the western coast of Taigonos Peninsula in the Shelekhov Bay. There are no musk deer in Central Yakutia, except the Lensk area. It has to be mentioned that the north boundary is given only approximately as there are no exact data.

The eastern boundary passes along the coasts of Okhotsk and Japan Sea, including North Sakhalia. The Sikhote Alin's part of the range is isolated from the western part by a large plain devoid of forest of the south Far East along the Amur River and its tributaries, spreading approximately for 2,000 km toward the West. Musk deer are found within the U.S.S.R. on the Yablon ridges of Transbaikalia. Their distribution is then interrupted by the plains of Dauria of western Transbaikalia, along the eastern and western Sayan and Altai. In the south the musk deer range leaves the boundaries of the U.S.S.R. (Figure 2).

4. DISTRIBUTION AND HABITATS

Distribution of musk deer inside their range is very patchy. Very often one can find isolated distributions measuring from 6-8 km^2 to 100 km^2 and more. Such distributions are determined by the character of arboeal lichen distribution, presence of cliffs, and other specific requirements of the musk deer.

In the U.S.S.R. musk deer live in the mountain forests but not above an elevation 1600m above sea level.

The typical habitat of musk deer in the southern part of the area, from Altai to Sakhalin, appears to be steep mountain slopes, covered by thick, mature dark coniferous forest interspersed with cliffs, and open coniferous forest along the river terraces. Typical is the presence of almost impassible sections, covered by a tangle of fallen trees, thick shrubs and undergrowth. In such a forest one might miss detecting a musk deer at the distance of 3-4 meters.

Musk deer, besides inhabiting the dense coniferous forests of the south part of their range, also inhabit open coniferous forests. These forests spread over a rugged terrain and have a lot of shade, wind-fallen trees, bushes, and undergrowth. Habitats of such type are characterized by clearings with various grasses, arboreous lichens, rock outcropping and watering places.

The second type of habitat prevails in vast regions of Yakutia. These forests consist of Larex daurica. Arboreal lichens, the most important food resource of the musk deer in the south part of their range in the U.S.S.R., are replaced here by ground lichens. Important feeding places for the musk deer in such regions are the poplar-willow forests on the alluvial spits and the islands with well developed herbage (Egorov, 1965).

On the vast Vitimsk plateau the most prefered musk deer habitat is Rhododendron dauricum shrub community found in deciduous forests.

The typical feature of any musk deer habitat in the eastern Siberia is the presence of a single cliff or steep rock outcroppings. In such places, in well selected inaccessible sites, the musk deer takes shelter from four-legged predators.

As an example we will give a description of one such shelter. The site is located on the slope of a mountain with 55^0 steepness, flanked by very steep walls. One of such walls has a slanting ledge measuring 40 cm x 20 cm. A musk deer chased by predators (dog) cautiously makes its way to this ledge. It stops and stands with the frontal part of its body bent downward, squatting on its hind legs. Here the musk deer stands firmly, feeling itself in complete safety. Should the dog reach the animal it would inevitably fall, because the musk deer locates itself always at the edge of the barely possible not only for a four-legged predator but also for itself. In this place the musk deer remains motionless - like a statue. It only turns its head slowly looking at the barking dog standing some 2-3 m from it.

A very typical phenomenon is the use of the same shelters and also the same approach to it by all musk deer living on a certain area. It is not clear how the animals, especially young ones, are informed about such places. One can assume that appropriate information is contained in the path leading to the shelter.

5. POPULATION SIZE AND METHODS OF DETERMINING IT

5.1 Population Size and Density

In ancient times the musk gland of the musk deer had been very popular in Tibetian medicine, and later on also in European pharmacology. The hunters were well paid and this led to extensive musk deer hunting. The hunters in search of musk deer penetrated remote mountain areas. Here, without any control and using all possible methods, they hunted male musk deer.

Musk deer were hunted most intensely in the middle of the 19th century. Their popularity at that time was not less than that of sable, and the musk deer populations rapidly diminish~~ing~~ed. According to N. S. Shchukin (1847) an annual slaughter of males for only the regions of "Yenisei and Lena Rivers" reached 18,000, and the total of does, young ones and adult bucks reached 54,000. L. Lvov (1849) mentioned that in Transbaikalia 15,000 musk deer including 3,000 bucks were slaughtered yearly. According to A. A. Silantév (1898) 3,420 musk ~~pouches~~ pods were stored during a three year period in the Irkutsk province in the middle of the last century.

This trade reached its maximum development in 1855 when 81,200 musk ~~pouches~~ pods were officially registered. Since then the volume of trade started to decline, and at the beginning of the 20th century came almost to an end. No musk ~~pouches~~ pods from Yakutia have come since 1895 (Iokhel'son, 1898). Events took such a turn that A. F. Middendorf who had been on the Stan ridge in Yakutia in 1869 forecast a "fast and final annihilation" of musk deer in this region.

Besides intensive hunting, a mass mortality of musk deer from unknown diseases was recorded. Thus, in 1919 many hunters in the Altai found dead musk deer in Taiga. This mass mortality has also been recorded on the ridges of the Eastern Sayan, ridges of Eastern Baikal region and in Primorski Kpai.

Among the first measures for the conservation of the animal world in the U.S.S.R. was the prohibition of musk deer hunting. Since then the restoration of their populations has begun.

It has to be mentioned that in spite of strong hunting pressure, the main boundaries of the musk deer range changed very little. Population density decreased sharply. Only in some very remote and almost unaccessible mountain ridges has the population density remained very high. Owing to this the musk deer population was restored quite fast.

The musk deer population and its density were restored in former distributions in eastern Siberia in the fifties (Timofeev, 1949). At the same time, hunters, hunting in the vast territories bordering to the south with Yakutia, got up to 70 musk deer per season (Skalon, 1951). From 1960 onwards, the same number was procured during the season in the southern parts of the eastern Sayan ridge.

According to N. T. Zolotarev (1936) there were "a lot" of musk deer in the thirties on Sikhote Alin. In the next decade the population grew even more. However, a mass infection of musk deer by a "hypodermic parasite" happened after that and it led to a mass mortality (Abramov, 1963). The musk deer population in many regions of Sikhote Alin ridge probably did not reach the previous level. According to S. P. Kucherenko (1975) population density of the musk deer in the best habitats of Sikhote Alin, in spruce-fir forests reaches at the present time 15-20 and on the rocky terrain to 30-40 animals per 1000 ha; in cedar and deciduous forests it reaches up to 2 animals per 1000 ha, on the left bank of the Amur River, in deciduous forests, it varies from 2 to 8 animals for the same area.

It seems that the highest density of musk deer was never reached in Yakutia. According to O. V. Egorov (1965) 50,000 animals live on 200,000 km^2 area in Yakutia with an average density of 2-3 animals per 1000 ha.

The musk deer population density is considerably higher in the Altai, in eastern and western Sayan and on the ridges around Lake Baikal. Here in some optimal habitats ("Stolby" ~~sanctuary~~ nature reserve, north-eastern part of Ikat ridge, and others) the population density reaches 70 (even to 200 animals) per 1000 ha.

Between-years fluctuations in the population density are not large. Thus, the census taken on the eastern Sayan during ten years (1966-1974) for two areas measuring some 600 km^2 showed that for the first area the density varied from 25 to 40 animals, and for the second from 65 to 70 animals per 1000 ha. In both cases the drop in density has been accounted for by the harsh winter in 1960/70. Moreover, this has noticeably affected the less dense population of musk deer living on the first area (Lobanov, 1975).

The musk deer population density on Barguzin ridge, Altai, Khabarovsk region reaches 10 animals per 1000 ha.

The contemporary musk deer population in the U.S.S.R. consists of ca. 100,000 animals.

5.2 Methods of Population Size Evaluation

Methods of population size evaluation developed for other taiga ungulates are hardly applicable to the musk deer; it might be explained by pecularities of musk deer habitat, its settled way of life, and its ability to hide itself.

In the last century the researchers got a notion about musk deer populations based on the amount of stored musk deer ~~pouches~~ pods ready for trade. But this was only a relative measure and only for bucks; data about does and young ones did not reach the researchers.

In the forties of the 20th century, in the Altai and Primorski Krai, musk deer were censused by track counts, and also by using "noisy drives" to chase musk deer from their hiding places. Later on, on the ridges around Baikal, "silent drives" were used. A census strip of arbitrary length and predetermined direction was chosen. The width of the census strip, depending on the thicket of the forest, was from 30 to 80 m. The length was determined by the size of the musk deer habitat. Counting was done on foot after preliminary investigation of the peculiarities of musk deer habitat and their distribution. Population size evaluation by "silent drives" took into account the ability of musk deer to hide. Since musk deer, hearing the observer, would hide or disappear from the census strip, noise en route was avoided as much as possible. This method detected musk deer visually as well as the fresh tracks left by the animal suddenly frightened off at close range.

In the Altai the attempt was made to evaluate musk deer population density by counting their droppings (Shaposhnikov, 1940); however, this work was never finished. After investigating this method we came to the conclusion that it could only be used at low or average population densities. At high densities the error might be considerable. Thus, evaluations in eastern Sayan showed that at high density (established by other method) namely 40 animals per 1000 ha, there were for 1 km of census route in the proper places some 20 "lavatories". However, these could be used by several musk deer living on the neighbouring or partially overlapping home ranges.

The evaluation of musk deer population size by aereal census is possible only in deciduous forests, for example in Yakutia, and requires the heightened attentiveness of the observer.

6. ECOLOGY AND ETHOLOGY

6.1 Individual Range, Diurnal Moving

Individual home ranges of the musk deer, where it spends most of the year, is spread from 150 to 300 ha. Diurnal movements of the musk deer cover from 10 to 30 ha.

The size and outline of a home range change according to its accessibility, food distribution, security of the habitat, weather conditions and snow cover. In the rutting season the range size increases because of a sharp increase in the animals activity; during the period of lactation and suckling of the young ones it decreases.

Individual home ranges on comparatively even terrain with uniform vegetation do not have a definite form, but on a jugged terrain with various types of trees, the outline of a home range is close to a rectangle. Such a range usually includes a strip of fir trees (~~fir~~ spruce groves, cedars) along a stream, a slope with open coniferous forest or aspen groves, and cliffs.

The musk deer visits its range irregularly, depending on food distribution. Thus, in the first half of the winter when on the middle parts of slopes, the main food of musk deer (arboreal lichens [Usnea] growing usually only on tree crowns) is not accessible, the musk deer moves quickly along the trails and feeds in ~~fir~~ spruce groves along the streams, where there is enough food on the tree trunks.

In the second half of the winter snow falling from the branches knocks down a lot of lichens. Then the middle slopes become feeding places and the musk deer remains here.

The length of diurnal movement of musk deer depend on the food supply and on the snow depth. This is illustrated in Table 1, which was compiled from musk deer track data in the eastern Sayan.

Table 1

Length of Diurnal Movement of Musk Deer in Eastern Sayan

Date	Sex	Type of Forest	Supply of Accessible Food (g per 1 ha)	Depth of Snow (cm)	Depth of Musk Deer Immersion in Snow (cm)	Length of Diurnal Movement (m)
February 15	doe	~~fir~~ spruce	266	37	30	1616
February 17	doe	~~silver~~ spruce fir	128	37	22	1987
February 26	buck	pine	1033	45	23	1278
March 13	doe	cedar	2096	66	45	349
March 15	doe	cedar	2096	70	35	256

As one can see from Table 1, the longest diurnal movements were observed on the range with the least forage. The musk deer must move more in search of food and the possibility of its habitation here depends further on the snow depth. With abundant food, snow depth does not affect greatly the possibility of musk deer inhabiting such ranges. Clearly, musk deer sinking deeply in snow, combined with an abundancy of food, leads to short length of diurnal movements.

Diurnal movements of the musk deer, except for some straight sections, looks usually like a winding line crossing many times, and with many loops often superimposing on each other. Such configuration of movement in the second half of winter is determined mainly by the food distribution, amount of snow on the habitat and location of shelters on cliffs where the musk deer can hide itself from predators. The configuration of movement is influenced also by degree of the range safety, forest type, time of day, weather, presence of frozen snow-crust, the character of the terrain, and the animal's age.

Examining musk deer diurnal movement charts one notices that more or less straight movements (jumps) alternate with sections of very twisted feeding trails (steps) (Figure 3). Straight movement can be noticed in the middle of a diurnal movement but more often the musk deer starts with it or finishes with it. Consequently, the diurnal movements on the chart consists of initial jumps through forest areas with little food, then short steps and stops in feeding places (sections with very twisted, sometimes tangled, lines of tracks, reminiscent of a ball of yarn), and then again one sees jumps (Figure 4a).

It happens that sections of straight and twisted lines coincide with the ranges of mixed forests. Such diurnal movement points to a demarcation and alteration of feeding and resting places. Such movements are typical on rocky ranges with various types of vegetation.

Different types of diurnal movement are observed in entirely uniform types of vegetation and on comparatively level terrain. They are characterized by the absence of "empty spans" represented by straight lines, that is, jumps from the resting places to the feeding places (Figure 4b).

Such characteristics of diurnal movements indicate that musk deer rest in the same limited places where they feed. We found five different resting places located on a small hill and not far from each other.

Thirdly, some very peculiar diurnal movements were found by us on the south spurs of the eastern Sayan and Barguzin ridge in almost pure cedar forests. The configurations of movements here were determined by the character of food distribution. In these places (upper reaches of the left tributaries of Inkut River) there is an abundance of wind-fallen trees, thrown by storms in much the same direction. Such windfalls are distributed like "nests." The crowns of fallen cedars contain a lot of lichens (Figure 4c). Trails connect these "nests." Musk deer stay here for a long time (several hours), feeding and resting there.

Thus, the configurations of diurnal movement patterns identify the manner by which an animal masters this or that type of habitat. In other words, a definite type of habitat causes typical diurnal movement patterns, which reveal a rational form of habitat exploitation by the animal (Ustinov, 1965).

The diurnal movements of the musk deer on the chart looks like rosary beads - steps, then jumps (musk deer do not run). The musk deer jumps when it escapes from a predator, or is in a hurry to reach a tree with lichens, or to see what is going on around, or jumps over an obstacle, or accelerates through a place without forage. It often jumps to a lichen lying on the snow (sometimes being deceived by a branch of a coniferous tree; this indicates that the animal was feeding here at dusk).

The longer the diurnal movement of the musk deer, the greater the number of jump and walk sections. However, the average length of such sections does not depend on the length of diurnal movement.

The date cited above was obtained mainly in eastern Sayan. The length of diurnal movement in the "Stolby" ~~sanctuary~~ nature reserve was 3.8-4.3 km (Shcherbakov, 1953). In Yakutia, a length of diurnal movement of 2-3 km was determined by O. V. Egorov (1965).

6.2 Food, Feeding

6.2.1 Food composition

The first information about musk deer feeding habits was obtained by P. Pallas (1786), who wrote that "Musk deer feed on lichens and march grasses."

The following observations show that musk deer feed more on arboreal lichens (Usnea, Parmelia, Evernia) and less on ground lichens (Cladonia, Cetraria). Especially important are arboreal lichens in winter when they make up 70-90% of the musk deer's stomach content by weight. Lichens were predominant in the musk deer forage in the Altai from September till May (Shaposhnikov, 1956). In the "Stolby" ~~sanctuary~~ nature reserve lichens were found in the stomachs of all 31 musk deer observed in winter. In 50% of the musk deer observed in summer, lichens were also found, but they made up a small portion of the stomach content. Winter observation of musk deer in the eastern Sayan showed that in 99.4% of the cases, musk deer were feeding on lichens.

Almost 20% of main volume of consumed food is made up of mushrooms: milk-agaric, honey agaric and others (Shcherbakov, 1935; Shaposhnikov, 1956).

The musk deer greatly favours mushrooms and scents them under the snow up to a depth of 25 cm. It digs them up with front legs just like a reindeer does. In Yakutia, musk deer were observed foraging on mushrooms stored by squirrels (Egorov, 1965).

Among the musk deer forages conifers are important. The tops and buds of fir trees are taken and less frequently those of Siberian cedars and pine trees. This type of food is taken constantly but usually in small quantity.

In musk deer habitats there are some areas with little snow that are rich in grasses and their dry remains even in winter. In the South Siberia such are found on the steep banks of the Menza, Irkut, Belaja, Kitoi, and many rivers. Such localities are also found in the north of Transbaikalia and in many areas of Yakutia. Here, besides the dry remains of flowering plants, the musk deer feeds on leaves and suckers of Rhododendron daurica, bilberries and cowberries.

An analysis of 16 stomach contents of musk deer, obtained in the winter in the south of eastern Siberia, showed that lichens made up 62%, dry grass 29%, browse and leaves from the bushes 6%, ~~pine~~ fir needles 1% of the content. These foods occurred at a frequency of 81%, 68%, 31%, and 6% (Ustinov, 1969).

The following picture of food consumption was found in an analysis of the musk deer feeding signs during its diurnal movements (Table 2).

Table 2

Musk Deer Food Deduced by Tracking

Date	Sex	Food (in %% from the Amount of Diurnal Consumption)			
		Lichens	Flowering Plants	~~Pine~~ fir Needles	Mushrooms
February 15	Doe	77.5	-	17.3	4.8
February 15	Doe	62.0	-	17.0	20.3
February 22	Buck	64.0	18.0	10.0	-
February 27	Buck	73.0	6.6	3.0	13.0

In summer the musk deer feeds over a large area on grasses (Shcherbakov, 1953 and others). Feeding on more than 130 plant species was recorded, from which often some 20 species were more intensively used. In Yakutia ground lichens continue to play a big role in musk deer feeding even in summer. They can be found in 83.4% of stomachs; in food volume they make up 20.8%. Horse-tails (Equisetum) have a great importance as food; they were observed in 66.6% of stomachs, where they made up to 14.6% of the food contents (Egorov, 1971).

We mentioned more than once that musk deer feeds on arboreal lichens and ground lichens in eastern Sayan and Transbaikalia.

6.2.2 Distribution and availability of forage

Distribution and availability of forage is very important for musk deer during periods of heavy snow, and is determined by the type of forest and terrain relief. In some mountain regions food distribution is affected by strong winds which create jumbles of wind-~~falled~~ blown trees.

Arboreal lichens are available to the musk deer: 1) on tree trunks not higher than 110-130 cm from the ground; 2) in the crowns of fallen trees; and 3) on the snow cover when lichens are knocked down by snow or wind.

This food, except for clumps of wind-~~felled~~ blown trees, is always somewhat dispersed and can be found in the form of single small clumps. However, there are areas with dense forage concentration. Thus there are more lichens on the shaded side of a tree trunk, in moist places and in terrain depressions. Lichens knocked down by snow, and lying on the snow, are usually found in large quantities on the lower part of a slope and also in the dense forest sections. This can be explained by the fact that on the areas open to the winds (mountain tops, upper parts of slopes), snow does not stay long on the tree crowns. It is blown away before it hardens into clumps which could knock the lichens down while falling to the ground.

The availability of dry grasses to the musk deer is determined by the location of meadows and the snow depth. Dry grass forage can be found mainly on the primary river terraces, on the bottom of gorges, and among birch and aspen groves in an open forest.

In open forests on steep slopes, which are exposed to the winds from the north-eastern coast of Lake Baikal, and covered by rich vegetation and little snow, musk deer can feed all winter on dry grasses.

6.2.3 Food supply and different types of forest

The supply of arboreal lichens available to musk deer was measured by us in different types of forest. All lichens (partly fresh growth eaten by musk deer) were removed from the tree trunks and from the snow cover and weighted (Table 3).

Table 3

Amount of Lichens in Different Types of Forest in Areas Accessible to Musk Deer

Type of Forest	Supply (in g) per 900 m^2		Average Supply per 1 ha
	on snow cover	on tree trunks	
Pine ~~wood~~	6.3	20.0	288
Fir-~~tree forest~~	40.5	2.7	477
Fir-~~pine wood~~ Spruce	11.9	32.7	500
Cedar wood (wind-fallen trees)	0.9	540.0	6011

It can be seen from Table 3 that the clumps of wind-fallen trees in cedar forests contained the largest food supply. Musk deer concentrate on wind-falled trees in their habitat; besides the rich forage the animal finds good cover here. Supplies of lichens are also considerable in fir forests and in fir-~~pine~~ Spruce woods, since fir tree bark is good substrate for lichens (Table 4).

Table 4

The Amount of Lichens on Tree Trunks

Type of Forest	Average Supply (in g) per 1 tree				
	Pine	Birch	Fir	Spruce	Cedar
Pine with birch adjacent to dense coniferous forest	0.5	0.3	-	-	-
Fir and pine	0.2	-	0.3	-	-
Spruce-fir	-	-	1.3	0.1	0.5
Cedar and fir	-	-	2.3	-	1.0
Pine	0.05	-	-	-	-

One can see from Table 4 that pine in pure stands have barely any lichens, while at the edge of dense coniferous forests, or interspersed within it, pine will carry a suitable supply of lichens.

The crowns of fir and spruce trees, inaccessible to musk deer, contain up to 1000 g and more lichens per tree, against 200 g per pine and 50-60 g per larch tree.

The results of research on food items while tracking musk deer in their diurnal movements, emphasize the special role of dark coniferous (spruce-fir) forest as a feeding habitat of musk deer (Table 5).

Table 5

Pine and Spruce-Fir Forests as Feeding Places

Type of Forest	Length of Feeding Movement (m)	Number of Feedings	Consumed Lichens g	Consumed Lichens %
Pine	430	70	6.93	25
Spruce-fir	330	66	20.66	75

The length of feeding movement is slightly larger in pine forests than in the spruce forest (430 vs. 330 m). The number of feedings in these forests is almost the same, but the amount of consumed food varies sharply. The weight of one lichen strand in pine forests is 0.16 g and in spruce-fir forests 0.23 g. As a result, the amount of food obtained by musk deer in the spruce-fir forest was 3 times larger but the track 100 m shorter.

The supply of lichens on the snow cover changes with time. The supply diminishes as musk deer eat it and as the snow melts (in March lichen falling on the snow sink in three days to a depth unaccessible to musk deer).

Heavy snowfalls combined with wind, reduce the forage available to musk deer, since the snow sticks to the tree trunks on the sides exposed to the wind, and approximately ¼ of a trunk becomes covered by it.

Crusted snow completely disappears in the first half of March. Lichens are knocked down from the tree crowns by wind gusts; sometimes these break off large branches. At this time, the food supply may increase sharply compared to previous months. The dynamics of the lichen supply on the snow cover are illustrated by Table 6.

Table 6

Changes of Lichens Quantity on Snow Cover in Different Types of Forest

Type of Forest	Date	Number of Single Lichens	Weight (g)
Pine	February 13	-	6.3
	February 22	42	4.75
	March 28	122	26.79
Fir	February 13	-	40.5
	February 22	234	25.74
	March 28	225	22.5
Spruce	February 21	132	23.55
	March 29	104	29.08
Cedar	January 19	-	0.9
	March 14	20	8.61

As is apparent from Table 6, the food supply in pine forests increases sharply in the spring. This can be explained by the fact that the pine forests are open and the winds blow freely through the trees knocking down crusted snow and branches with lichens. In dense dark coniferous forests this does not happen, because the wind does not blow freely in such forests.

The manner in which crusted snow falls off branches is also significant. Lichens are distributed in pine tree crowns mainly close to the trunk. The branches of ~~pine~~ fir and spruce trees are broad (like a bears paw) and bent downward. Here the accumulated snow slides and falls almost outside the crown boundary, touching only the branch tips and knocking down few, if any, lichens. In the ~~fir~~ pine trees crusted snow falls along the trunk knocking down new snow masses, which carry along lichens. Crusted snow falls in the same way from the cedar trees. Pine tree branches are brittle and break easily under the weight of snow, falling down with their load of lichens.

Thus, even if the crowns of pines do not have an abundance of lichens, in spring the relatively heavy fall of lichens on the snow is available to musk deer. This illustrates the great importance of pine trees within dense coniferous forests for musk deer.

It should be mentioned that crusted snow knocks down lichens only in the second half of winter. This controls the existence of musk deer in a number of habitats. In the first half of winter the snow lies loose on tree branches and in falling is scattered over the tree crowns.

When the snow depth is high the musk deer cannot gather lichens in sufficient quantities, even if the supply is large, because of the difficulties entailed in moving. Most of the diurnal movements in such areas occur along well beaten trails, be it its own old tracks, or the tracks of other ungulates. In such cases musk deer occupy limited areas thick with wind-felled trees and use these for a long time. This we observed on the Baguzin ridge, Irkut River and other localities (Ustinov, 1969).

6.2.4 Availability of food and feeding habits

Distribution and availability of lichens - the main winter food of the musk deer - are related to some behavioural adaptations of this animal.

In musk deer habitats on ridges in the Baikal region, snow cover, some 60-80 cm high, covers the lichens on the ground and the lichens growing on the tree trunks close to the roots. During deep snow the forage area can be reduced by 80% (musk deer can take food at the average height of 110-130 cm from the ground).

The animals do not sink through the total snow depth; under their hoofs there remains a layer of compressed snow which raises the animal above the ground. Therefore, snow depth can be divided for a moving animal into two layers: a) a layer of snow the animal sinks through, b) a layer remaining under the animal's hoofs and supporting it. The latter is greater the more compact the snow and the less the weight of an animal in its tracks.

During the winter the snow becomes compressed, and the height of the layer supporting the animal increases. Some such data for the musk deer is given in Table 7.

Table 7

Changes of Musk Deer Immersion into the Snow During the Winter

	November December	January	February	March	April
Snow depth (cm)	35	41	43	52	to 50
Immersion					
in cm	26	27	23	21	to 0
in %	74	65	53	40	to 0

As the winter progresses the musk deer gradually obtain the forage previously inaccessible when there was less snow; the area of forage accessibility creeps upward (Table 7).

Thus, in December with snow depth of 35 cm the upper feeding zone appears to be 9 cm higher than in the absence of snow, in January - 14cm, in February - 20 cm, and in March - 31 cm. In April, due to the frozen snow crust which supports musk deer, the total snow layer is transformed into a hard platform and area of food availability moves up 50 cm.

The existence of hard snow layer's permits access to forage not used by the musk deer at other times. For musk deer leading a sedentary life this is very important since in essence it permits a sedentary way of life.

Musk deer climb at every opportunity on wind-felled trees, stones and other objects and walk about on them. This behavioural peculiarity permits deer to obtain food (lichens from the tree trunks) from a greater height. In areas with wind-felled trees, a musk deer may walk 66% of its diurnal movements on fallen trees. This kind of movement requires less work, since the snow depth here is 21 cm less than below, and musk deer sink to a level some 12 cm above the surface of the fallen trees (Ustinov, 1965). Besides, the snow on wind-fallen trees is more compact.

The small weight loading of its tracks, the spreading hooves, the use of its own old, frozen tracks and tracks of other ungulates, the use of fallen trees, grazing on arboreous lichens by standing on its hind legs, selection of areas relatively free from snow - all these create a system of adaptations toward making accessible all of the food growing on comparatively limited area.

The constant fall of lichens broken by winds makes this food also available on the same home range. Besides, during any one grazing bout the musk deer takes very few lichens from one tree or bush (not more than 1 g, or from 2 to 40% of possible); returning to the same place it always finds food.

In this way the feeding trails came into being which, once established, make it easier for the animal to move in deep snow. For instance, an animal tracked by us on March 14th, walked for 62% of the total distance it covered in 24 hours using its own old tracks, but once frightened by us, it galloped in the old tracks, increasing the percentage of use of former trails to 84%.

6.2.5 Food intake and forage capacity of home ranges

It was calculated that a musk deer feeds daily in winter on approximately 179 lichen bunches (from 134 to 224), and thus takes in not more than 180 g of food.

The average weight of stomach contents of musk deer (16 specimens) was 523 g (from 280 to 900 g). The stomachs content is determined by consumed food: fine ground blades of grasses, lichen's stems and sprouts of pine trees, and 2-4 mm (till 30 mm) thick, leaves of Rhododendron dauri~~a~~ca, which remain intact.

According to our analysis, the moisture content of stomach contents was 85%, and the gas/solid matter 14%. Consequently, water in stomach contents makes up some 450 g, and gas/solid matter 73 g. It appears that the arboreal lichens have moisture and gas/solid content matter of 45 and 55% respectively. Consequently, musk deer average daily food intake is some 135 g of lichens. Further calculation showed that together with the lichens the musk deer obtains some 60 g of water and consumes 390 g water in the form of snow.

According to A. G. Kostin, musk deer in captivity consumed daily up to 800 g of lichens. The large amounts of moisture in the stomach is probably related to the low-moisture content of lichens in winter and their high hygroscopic property. It was found by experiments that the lichen Usnea barbate placed in water at 38°C temperature reaches maximum saturation in 10 hours, increasing its weight 3.5 times. This explains the necessity for musk deer of consuming large amounts of water in winter in the form of snow taken with lichens, or snow scooped off the snow surface, and in summer by visiting watering places.

By taking into account the lichen supply, change in their availability, and the amount of daily food consumed by one animal, one can give an approximate evaluation of forage capacity of musk deer habitat.

As we noticed earlier, the supply of lichens available to musk deer during the snow period per 1 ha is as follows: in pine forest - 288 g, in fir-tree forest 0 477 g, spruce-fir tree forest - 500 g; or per 1000 ha correspondingly 288 kg, 477 kg and 500 kg. In winter, one musk deer consumes daily ca. 140 g lichens. Thus, the calculation shows that 288 kg of available lichens in the pine forest will be sufficient for 2057 animal days, and during 5 months (December - April) 14 musk deer can live on 1000 ha of pine forest, 24 musk deer on 1000 ha of fir tree forest, and 25 musk deer on 1000 ha of spruce-fir tree forest.

Due to changes in forage availability, the food supply does not get exhausted during the winter. This makes it possible for musk deer to live on a limited area.

The density of musk deer reaches 65 and more animals per 1000 ha on some habitats on the ridges of the southern part of East Siberia. These habitats are extremely rich in available foods, reaching 6000 kg per 1000 ha.

In Sikhote Alin the amount of available lichen in cedar-broad-leaved forest lies between 100-200 g per 1 ha; it reaches 550-3322 g per ha in dark coniferous forests (Zairsev, 1977). This allows the existence of 10 to 50 and more musk deer per 1000 ha.

Thus, in most musk deer habitats in East Siberia, the food supply permits 14-25 animals to live on 1000 ha, and on a comparatively small area, approximately 10% of the whole musk deer range, 60 and more animals can exist on 1000 ha.

6.3 Diurnal Activity

The literature indicates that musk deer are dusk and nocturnal animals. We noted nocturnal activity to prevail in musk deer, but occasionally, especially in winter, musk deer were also seen feeding during day time on sunlit slopes.

The rhythm of musk deer diurnal activity was not studied sufficiently. We determined two resting periods of some 4-5 hours duration. One ended at approximately 14 00 hours, the second started at approximately 16 00 hours. In Sikhote Alin, V. A. Zaitsev (1975) determined a diurnal feeding activity of some 4-6 hours.

Consequently, one may consider musk deer as a polyphasic animal.

Musk deer activity changes according to weather, state of the snow cover, type of forest, and the presence of bloodsucking insects. The activity depends also on an animals sex and age.

Snowfalls suppress musk deer activity; they do not leave the shelter during bad weather for several days. We noted changes in musk deer activity with snow density especially in spring during formation of ice crusts.

Frozen snow crusts in April do not stay frozen the whole day. The crust thaws at noon, toward the evening it starts to freeze, and it is hardest in the morning. The time at which the snow crust freezes or thaws varies for different types of forest. In pine forest the snow crust can support musk deer from 24 00 or 2 00 hours to 10 00 to 11 00 hours. Then comes the weakening of the snow crust and between 15 00 to 17 00 hours it disappears.

In the dark coniferous forest the frozen snow cover disappears 1 - 2 hours later.

The conditions for existence change sharply during the formation of ice crusts on snow. Thus, the noise made by movements on breaking through the crust give the animal away. In view of this musk deer avoid moving at this time and start to feed at such hours when the ice crust becomes softer and does not rustle, but still can support the animal.

At the beginning of the frozen snow cover period, the animals rest between 11 00 and 24 00 hours and feed from 0 00 to 10 00 hours. In fir tree forests they rest between 0 00 and 12 00 hours and feed between 13 00 and 24 00 hours. As the snow cover hardens in April, the picture changes: in both types of forest the animals feed and rest at about the same time. Changes in activity can be explained by the necessity to adapt to the possibilities for movement.

Time of activity in winter and summer varies; in winter the animal rests ca. 15 hours daily, in summer ca. 20 hours.

Bloodsucking insects are one of the powerful regulators of musk deer activity as they are for other ungulates of the taiga. The considerable lowering of activity in summer during daylight is determined by the abundance of bloodsucking insects. In the evening, when it gets colder, insect activity is reduced and musk deer come out to feed. On East Sayan and on Baikal region ridges (depending on absolute height) the time of insect flying decreases between 22 00 and 24 00 hours. In the morning mosquitoes fly out at sunrise.

The activity of musk deer depends greatly on their age. Young animals, which are less cautious, feed more often than the adults in the open sections of forest and during the daylight. Thus, we met in October in open coniferous forest, 8 musk deer during one day; 6 of them were young of the same year.

Sex differences in activity are also noticeable. Thus, lactating females feed relatively more often but for short periods, and they do not go far away from their young. Imitating the call of the young brings her back in 30-60 seconds (it was produced with the help of a special device).

6.4 Resting Places

One finds the resting places of musk deer everywhere in their habitat.

Musk deer choose different resting places depending on weather conditions, type of habitat, terrain relief and time of day. During incessant rain, musk deer search for dry resting places, be it under trees with thick crowns, or under thick slanting tree trunks, or under cliffs. However, it has to be such a place from which the animal can oversee a considerable part of the surrounding area.

In winter musk deer wait out heavy blizzards in the most sheltered places. We were fortunate to find two such shelters. One was a lot "tent" created by the thick lower branches of a fir tree bent down and filled by snow. In the second case, musk deer found a shelter at the base of a strongly bent thick cedar. The sides of the trunk were deeply covered by snow creating a small space with one opening through which musk deer crept in and out.

During clear, cold windless days, musk deer rest on small elevations (wind fallen trees, ant hills, etc.), in order to have a better view and to hear what is going on in the surrounding area. Musk deer do not normally scratch the snow from their resting place.

In spruce or fir groves musk deer do not care very much about shelter, however in open pine forests musk deer make resting places under wind-fallen trees, or in a heap of thick branches. In open pine forests in Bol'shaia River Valley and on Barguzin ridge we found musk deer resting places in a dense new pine growth.

Terrain relief also determines the location of resting places. Musk deer do not rest on a steep slope with its head down or up unless there is a level projection from the general slope. On steep slopes a musk deer rests horizontally with its body along the slope.

The favorite resting places are flat areas measuring 1-2 m^2 and located at the top of a cliff. Such places permit an animal good hearing and a good view of the surrounding area.

In the second half of winter in the East Sayans, we found 7 resting places during the diurnal movement of a doe and three for a buck. V. A. Zaitsev observed in Sikhote Alin 6-11 daily resting places used by musk deer.

6.5 Defecation Places

Musk deer defecate daily from one to eight times (from 2 to 498 pellets are deposited at one time) at specific places - forming "lavatories" or fecal piles. A fecal pile occupies usually a circle or rectangle from 900 cm^2 to 3600 cm^2 in size. Fecal piles are located outside winter either on the trails or on sheltered sites free from grass along rocky ridge crests. In winter fecal piles are often placed directly on the open spaces of a feeding range.

Musk deer use the same fecal pile for a long time (in one case from fall until the end of March). One fecal pile may contain more than 10 defecations. Often an animal uses not one but several fecal piles, even in time of danger. V. A. Zaitsev (1975) noted 7-10 fecal piles in Sikhote Alin to be used by a musk deer.

Musk deer note fecal piles from a distance of 10 m. Sometimes the animal deposits only 2-3 pellets on the fecal pile. Defecation and fecal piles act as a signal of territory occupation.

We investigated the degree of attachment by musk deer to their fecal piles by destroying some of them. After 3-4 days, the site, used previously for defecation, contained fresh fecal pellets again.

Fecal piles, scent markings probably formed by using the musk pods, and trails, create an information field, the importance of which is considerable, if we take into account the musk deer's feeding specializations and the limited food supply of these solitary animals.

6.6 Movement Patterns and Scanning for Danger

Musk deer are always on the alert during feeding. Their movements are precise and quick. They minimize the duration of movements and noise, and maximize the time for the scanning of the surrounding area. Thus, according to our observations, an adult female during a 20 minute period spends 4 minutes (20%) to chew it, and the rest of the time, 11 minutes (55%), to stand and listen. The amount of time spent on scanning the surrounding area during feeding depends on weather and the type of forest. When it is windy and the forest is open, musk deer become restless and spend more time listening.

To maximize security the typical locomotion of musk deer via discrete, short jumps interspersed with frequent stops is also advantageous. After a sharp stop silence sets in instantly.. Even when pursued, the animal moves with frequent stops during which it determines the location of the pursuer. Thus, a very frightened male bounded 100 m through broken country with a 35^{o} rise in elevation in 20 seconds; he made 49 jumps and 2 stops of one second duration each.

During a flight musk deer may jump on elevations (tree stumps, wind-fallen trees, boulders, ant hills) to overview the surroundings. Irregular long jumps in a habitat with an abundance of fallen trees, rocks and other obstacles is the most optimum method of insuring security. It minimizes the duration of self-generated noise and provokes an immediate pursuit by a predator discovered in time by a musk deer (Ustinov, 1970).

Frightened musk deer often start to "tangle" their own tracks. A musk deer, after running some distance, turns around and, without losing speed, retraces its own trail. Then, after galloping some tens of meters, makes a turn and jumps off at an angle to its former line of travel, running again in a straight line. It repeats the same manoeuvre twice and only then follows a straight path and begins feeding.

The ability to shake off a pursuer within a small area, to misdirect the pursuer, as much as possible away from its own course, to confuse a tracker, to choose sheltered resting places - all these are important adaptations of a dweller with a small individual home range. Also, the excellent knowledge of the surroundings by musk deer is directly related to their sedentary way of life.

The biological meaning of all this lies in the musk deer's intensive striving for security. These security measures were selected during evolution and perfected toward a timely discovery of predators.

Of the predators which discover musk deer visually, the latter has command over such effective means of avoiding the predator that the predator could be put off the tracks over a small area without the musk deer leaving its own territory.

6.7 Trails and Their Importance

With the coming of a snow cover trails appear on the habitat of the musk deer. Some trails are used often, others seldom. The deeper the snow the more trails and the more musk deer use them. In the second half of winter the use of trails by musk deer account for some 66% of the length of its diurnal movements. If a musk deer is frightened, then the pursued animal will run 92% of its way on top of old trails. In such a case the musk deer's route runs on top of a trail at various angle to the path of the predator, and even crosses the predators tracks. The flight path follows old trails that run at various angles.

Undoubtedly, the regular movements along old trails is an adaptation to deep snow, which allows the animal to live on a limited area. Besides, in deep snow only trails (with their hard snow) allow the animal to generate sufficient speed to escape from predators.

A careful study of musk deer trail patterns reveals that trails connect three important areas: 1) feeding places, 2) resting places, and 3) shelters from danger, that is cliffs.

Musk deer orient very well by means of their trails in their individual territory. No matter where it is, if frightened it jumps at once on one of its trails, which from any point leads the animal to the cliffs. We observed, for instance, how a musk deer startled by a dog happened to be not far from a cliff, but outside of a trail. The animal preferred to jump on a trail, and in a roundabout way return to the cliff. The distance covered by the musk deer was 3 times longer than if it would have been had it moved directly to the cliffs without using the trail.

The ability to avoid danger on a small individual range and at the same time not leave it is one of the remarkable abilities of musk deer. It is fostered by the good location of trails and a determination to use them.

In the snowless period, the frightened musk deer uses the shortest distance to escape cover to avoid danger. Then the animal tries to take shelter behind tree trunks, stumps, wind-fallen trees, etc. without betraying its presence.

6.8 Seasonal Migrations

Since musk deer habitat is covered at the beginning of December by some 40-50 cm of comparatively loose snow, the animals begin to restrict their home range (Ustinov, 1961). It is an unobtrusive process since it results in the animal's moving only a short distance of some 2-3 km away from its earlier area of occupation. It is in essence a tightening of home range boundaries and a concentration on a territory with optimal conditions.

On one of Mana River tributaries (north extremity of East Sayan) we located in January a musk deer some 1.9 km from the river's mouth; in February the same musk deer was located 1.7 km away, and in March 0.7 km from the river's mouth. On the same range we found in summer the tracks of probably the same musk deer at a distance of 5 km from the river's mouth.

There is reason to think that a change in opportunities to escape, hide, or find shelter, is one of the reasons for the seasonal migration of musk deer, forcing them to search for more sheltered places. In favour of this contention we find that fall migration coincides usually with first snowfall which diminishes sharply the safety of the habitats. Snowfall covers all shetlers: wind-fallen trees, stumps, stones, crowns of new growth, and the tree trunks.

In Yakutia (Egorov, 1971) seasonal migrations of musk deer were observed to span a distance of 12 km and as an exception up to 35 km.

6.9 Reproduction

6.9.1 The rut

In Altai, Transbaikalia, East Sayan, Takutia, the musk deer rut occurs at the end of November or in December (Shaposhnikov, 1956; Solov'ev, 1920; Kozhannikov, I., 1924; Shcherbakov, 1953). Apparently the rut of musk deer in the Far East occurs at the same time, though there are indications for earlier (Salmin, 1972) and later dates (Emel'ianov, 1927). In Yakutia the rutting period falls on the second half of December - beginning of January (Egorov, 1965).

In the Altai musk deer assemble in groups of 3-7 animals; these groups remain until the beginning of January (Shaposhnikov, 1956). Smaller bands of 3-4 animals were observed in the Minusinsk taiga (Kozhannikov, L., Kozhannikov, I., 1924). A male may mount several does and one doe may be chased by several bucks. Buck start to discharge musk. According to the observation of A. N. Shcherbakov (1953) this leads to strong responses in does. Stronger bucks chase away weaker one but fights among the bucks are rare.

According to our eight years of observation, the rut in Easy Sayan starts in the middle of December and lasts for 2-3 weeks. In this period the animals start to pair off and very occasionally one doe will be chased by two bucks. In 1965 in Transbaikalia apparently a very slack rut was observed by S. K. Ustinov in December, as there were no bands. Only pairs were noticed and the buck was not very persistent in following the does. In 1969 the rut was observed in the first half of December.

6.9.2 Period of sexual maturation

Information about the beginning of sexual maturation is contradictory. According to A. N. Shcherbakov (1953), and O. V. Egorov (1965) musk deer become sexually mature at 15-18 months of age; according to other sources (Flerov, 1952; Gur'ev and others, 1963), it occurs toward the fall of their third year of life or even at the age of 3-5 years. That is obviously not correct.

According to our data does in East Sayan reach sexual maturity at the age of 16 - 17 months, though it is possible that some of them did not participate in reproduction at that age.

6.9.3 Pregnancy, fertility

Musk deer gestation lasts 185-195 days (Shcherbakov, 1953; Shaposhnikov, 1956; Salmin, 1972). The birth occurs in May-June. The doe gives birth usually to two, rarely to one, and exceptionally to three young ones. According to O. V. Egorov (1965) from 16 does, 8 had 2 embryos and 8 had one. On the "Stolby" reserve, from 13 does, 9 had 1 embryo each, and only 4 had 2. Barrenness was observed in 7.1% of the does (Shaposhnikov, 1956). In Sikhote Alin barrenness was observed to be as high as 16.6 - 33.3% (Abramov,, 1954).

Among 90 does from the East Sayan (Lobanov, 1975) observed by us during 1966-1974 - 50 had 2 embryos each, 28 - one, and 12 does - 3 embryos each. The average fertility is 1.82.

6.9.4 Growth and Development

Before birth an embryo weighs 460-500 g (East Sayan), or 635 g in Yakutia (Egorov, 1965). Newborn fawns found in Sikhote Alin weighed 470-486 g; the body length was 33 cm (Salmin, 1972). On the "Stolby" reserve a 3 month-old fawn weighed 4-4.5 kg and a 5 month-old 6-7 kg (Shcherbakov, 1953; Shaposhnikov, 1956). The fawns, at least up to the age of 2 months, stay in a sheltered location and do not accompany the mother. The doe is feeding in close proximity of the young, usually not further than 100-150 m. An imitated cry of the fawn brings back the doe very quickly. Sometimes a buck comes also. Lactation continues at least for 2 months (possibly for 3 months). Three month-old fawns feed independently, follow the doe, but hides in the case of danger while the doe tries to lead the enemy away. Milk fat reaches 19%.

6.10 Population Composition

6.10.1 Population composition according to age

In order to study the population structure on two locations in East Sayan we captured all musk deer (60 animals).

Knowing the time of an animal's capture and counting cement layers in the incisors, the animal's age could be determined accurately to within 1-2 months. According to our data the average age of musk deer during 1966-1969 in the population in East Sayan on the location first investigated was 3.2 years; on the second - 3.0. In 1970 it was on the first 3.5 and on the second 4.0. Newborns in the same year made up, on the first location, 27.2%, on the second - 23.6% of the population. In 1970 there was a hard winter with heavy snow which accounts for a heavy mortality of young animals. A doe, captured on

October 2nd, 1967 (Lobanov, 1970) was 9 years old - the highest age recorded.

Musk deer age can also be determined by the weight of the dry crystalline eye lens (Beali, 1962). This method is based on the peculiarity of the lens to grow during the life span of the individual and slow the growth rate toward old age. Using data from the weights of dry crystalline lenses, we made a chart using this index and isolated 8 age groups (Table 8).

Population structures determined by the use of these two methods give similar results. However, the large amount of labour entailed in using the first method makes it of limited use (Lobanov, 1970).

Table 8

Structure of Musk Deer Population According to Age in the East Sayan

Age Groups	Weight of Dry Crystalline Lenses mg			No. of Yearly Cement Layers of Incisors w/o Dark Cement Layers	No. of animals %% (n=60)
	Minimum	Maximum	M ± m		
This year's birth	162	195	175.5 ± 3.1		18.9
1+	220	243	233.8 ± 3.5	1	13.5
2+	257	289	274.3 ± 2.6	2	32.4
3+	306	327	315.5 ± 2.8	3	16.2
4+	339	375	353.3 ± 3.5	4 - 6	18.9

6.10.2 Population composition according to sex

The same locations in East Sayan revealed a population by sex structure of 51.7% bucks and 48.3% does on the first study area. The second study area had 57.2% bucks and 42.8% does. The average fertility on both locations was 1.79 - 1.82, and population growth was about 64%.

6.11 Predators

The musk deer is a victim of many predators, such as wolf, wolverine, lynx, fox, bear and marten (Martes flavigula). However, the impact of predators in various regions differ noticeably.

In the north of Yakutia the main predator of musk deer is the fox (Egorov, 1965). On the coast of Baikal Lake foxes also cause great losses to musk deer populations. However, they do so only in a coastal belt and only in winter. Usually a pair of foxes hunt a musk deer, driving it out of the forest.

Lynx can be the main predator of musk deer in the Altai and East Sayan (Dul'keit, 1953; Shaposhnikov, 1956). A. N. Shcherbakov (1953) found musk deer remains in 43% of the lynx excrements (117 instances) on the "Stolby" reserve. It has been noted that lynx populations may depend on the abundance of musk deer. In the Baikal region, on a transect of some 10 km in length, 6 remains of musk deer killed by lynx were counted. Lynx usually stalk musk deer in their resting places, or during feeding. This predator stalks to within 3-4 paces of its prey, and avoids a lengthy pursuit. In all excrements of 5 lynx in East Sayan we found the remains of musk deer. In the Altai reservations, in 8 excrements of lynx collected in July-November, 50% were found to contain musk deer remains (Shaposhnikov, 1956).

Wolverine in East Siberia have almost the same importance as a predator of musk deer as do lynx. On the "Stolby" reserve the remains of musk deer were found in 50% of wolverine excrements; in Yakutia 37% of the excrements contained the remains of musk deer. This predator usually chases musk deer for a long time. In all places where stray dogs are found these also pursue the musk deer, killing an animal when it leaves the cliffs, where it finds safety; chases may cover more than 3-5 km. Musk deer are seldom victims of wolves who are not found often on musk deer habitats. Musk deer very rarely fall prey to bears. In the Far East individual cases of tiger predation on musk deer are known (Kaplanov, 1948).

Intensive pursuit of musk deer is done by martens (Martes flavigula) in the Far East. All researchers mention this fact (Zolotarev, 1936; Bromlei, 1953, 1956 and others). Especially in their studies of the relationship between marten and musk deer, G. F. Bromlei (1956) and then E. N. Matiushkin (1974), reported that musk deer account for some 50% of this predator's food. Marten hunt in in groups of 2-5 animals and when the victim is found they try to chase it on ice. According to G. F. Bromlei (1956), on the Sikhote Alin reservation the remains of musk deer killed by marten could be found on each 2-15 km of river ice. Musk deer cannot escape in cliffs from the dexterous and swift marten. This method of escaping predators, typical for the Siberian subspecies (where the marten is absent) is not known of musk deer from Sikhote Alin. Thus, the presence of cliffs is not necessary for musk deer habitats in the Far East.

According to G. F. Bromlie (1956) there are 150-200 musk deer to one marten in Sikhote Alin. Considering that 3 predators feed monthly on 4-6 victims, they destroy during 5 winter months some 20-30 musk deer, taking 3-7% of a population. E. N. Matiushkin (1974) thinks that the losses suffered by musk deer populations in Sikhote Alin from marten predation do not exceed 8-12% of the annual production. Thus, for the Far East, the predation pressure upon musk deer is mainly determined by the activity of martens. For other predators in this region the musk deer is an occasional and rare prey.

6.12 Parasites

Musk deer in Altai and East Sayan have usually ticks Ixodes persulcatus and Trombidiidae (to 116-170 specimens per one animal) (Shaposhnikov, 1956; Ustinov, 1966), fleas Cerathophylla, Trichodectes, Bovicola, deer's bloodsuckers

Lipoptena. Near to 230 specimens of hypodermic gadfly Hypoderma were found in musk deer of Transbaikalia. In the Far East the ticks Dermocenter silvarum, Ixodes, sp., and also Lipoptena, and the larva of tropical hypodermic gadfly Cordylodia (Pavlosvskiomyia) inexpectata were found in the musk deer; under the skin of musk deer were found up to 2000 larvae of this dipteran. Infected musk deer were very exhausted (Abramov, 1956). Everywhere the musk deer is attacked by the blood sucking insects. Larvae of flies Xanthocalliphorines were also found in musk deer.

Thirteen species of helminth were found in musk deer living under natural conditions and 21 species in those living in zoological gardens. In musk deer living in natural conditions 5 species of Cestodes were found (Altai, East Sayan, Yakutia, Far East), and one species of Trematoda (Transbaikalia, Far East, East Sayan, Yakutia). The musk deer is more often infected by Setaria cabargi and Pneumcaulus kadenazii. Musk deer in Altai have usually Cysticercus taenuicollis, and Dyctyocaulon (Kadanatsi, 1958; Shaposhnikov, 1956). In musk deer from the East Sayan Armocappilaria moschiferi was found (Ustinov, 1971). Musk deer from Sikhote Alin has usually Setaria cabargi, Taenia hydatigina, Moniza expansu, Cysticercus sp., Thysaniezia ovilla (Kostin, 1940). In musk deer from the "Stolby" reserve Dicrocoelium orientalis was found (Shcherbakov, 1953).

From time to time a mass mortality from unknown diseases happens in different parts of the area populated by musk deer. Such epidemics were observed in the Altai, in the environs of Teletsk Lake, where tens of dead musk deer were found, also in Tofalari, eastern Baikal region and the Far East. It is assumed that in the Far East musk deer mortality happened from the excessive infection by "hypodermic parasite," and in the ridges in the eastern Baikal region from anthrax, when "near any mountain stream one could find dead ungulates" (Anomin, 1929).

There are places where various pathogenic organisms are localised on musk deer habitats. These are resting places, fecal piles and trails. In such places usually solitary living animals come in contact with each other.

6.13 Relation with Other Ungulates

Besides musk deer the reindeer, Izubr stag, moose, snow sheep and some other animals also feed on lichens. However, typical habitats of these animals do not adjoin, and at the present time there is no competition for food between them. On the contrary, the presence of moose, Izubr stags, or reindeer on the musk deer habitat makes life easier for musk deer. They move along the deer trails picking up branches with lichens knocked down by other deer. Bears in the Altai, climbing cedars to reach cones, also knock down branches with lichens which are used by musk deer.

Large deer leave trails in snow which are used constantly by musk deer.

7. HUNT AND UTILIZATION, CONSERVATION

7.1 Hunt

In the past the musk deer were hunted mainly for their musk pods ~~pouch~~. Decrease in musk deer populations and also decline~~s~~ in the demand for musk produced sharp curtailment in hunting.

In previous times snares were widely used in catching musk deer; snares were placed in the fence passages. Such fences were made of fallen trees and branches to a height of 1-1.5 m and 50-60 m in length (up to 300 m). In these fences 8-10 passages were made and snares and traps placed within. Snares and various traps were also placed on trails. Rifles were also used in musk deer hunting in combination with a dog, which would drive musk deer onto cliffs. In summer, imitating the cry of a young would attract adult musk deer, buck as well as does. During a season a hunter would kill 15 - 20 (up to 50) musk deer.

At the present time, hunting with calls to imitate the cry of a young, as well as the use of snares and traps, is forbidden. Musk deer are hunted at the same season as other ungulates, squirrel, sable, and other game animals; hunting is licensed.

7.2 The Number of Musk Deer Harvested

In the sixtieth-seventieth century in Transbaikalia, 1400 - 1800 musk deer were harvested annually; in Yakutia it was up to 1000 and in the Far East ca. 12-0 musk deer annually. Altogether some 5000 musk deer are obtained in the U.S.S.R. every year which accounts for some 5% of the total population. Taking into account the high reproductive potential of the musk deer, one can see the possibility of increasing the take by some 4-5 times to 20 - 25,000 animals annually.

7,3 Output

Musk deer ~~pouches~~ pads are obtained from the bucks and are used in the perfume industry. They are also used by the hunters to scent baits for trapping predatory fur-bearing animals. From the musk deer's hide "buckskin" is made, which is used for gloves and other products. The meat is not of high quality and is often used by the hunter as a bait for the fur-bearing animals, or as a food for dogs.

7.4 Conservation

The hunting period in most regions is limited. It stretches from September 1 to March 1 and in some regions from October 1 to February 15.

On Sakhalin Island and in a number of Altai regions districts musk deer hunting is prohibited. Musk deer hunting is prohibited in the Altai, Barguzin, Baikal, Lazov, Sikhote Alin reservations, and on the "Stolby" reserve.

The nursery on the "Stolby" reserve maintained in 1951-1954 11 musk deer; 2 does had young. Earlier, at the end of the thirtieth and the beginning of the fortieth century, several musk deer were kept in open-air cages on the Altai reservation. According to D. K. Solov'ev (1922) hunters kept musk deer at the beginning of the twentieth century in Ussuriisk region in enclosures in order to obtain musk from them.

BIBLIOGRAPHY

Abramov, K. G. Kopytny Zveri Dal'nego Vostoka: Okhota na nikh. Vladivostok, 1963.

Berezovskii, M. M., Bianki, V. L. Ptitsy Jan'suiiskogo puteshestviia G. N. Potanina, 1884-1887. SPb., 1891.

Bromlei, G. F. Znachenie kharzy kak khishchnika i sposoby ee unichtozheniia v Primorskom krae. V kn.: Preobrazovanie taung pozvonochnykh nashei strany. M., 1953.

Bromlei, G. F. Materialy po ekologii sobolia i kharzy, rasprostranennyk v Primorskom kzar. - V. kn.: Sbornik materialov po izucheniiu mlekopitaiushchikh v gosudarstvennykh zapovednikakh. M., 1956.

Vereshchagin, N.K. Fragmenty istorii teriofauny Ussuriiskogo kraia. V kn.: Materialy IV Zoogeograficheskoi konferentsii. Odessa, 1966.

Geptner, V.G., Nazimovich, A.A., Bannikov, A.G. Mlekopitaiushchie Sovetskogo Soiuza. T. I. Parnokopytnye i neparnokopytnye. M., 1961.

Gromov, B. I. Paleontologicheskie i arkheologicheskie obosnovaniia stratigrafii kontinental'nykh otlozhenii chetuertichnogo perioda na territorii SSSR. - Trudy In-ta geologii AN SSSR, vyp, 64, 1948.

Egorov, O. V. Dikie kopytnye Yakutii. M., 1965.

Egorov, O. V. Parnopalye. - V kn.: Mlekopitaiushchie Yakutii. M., 1971.

Dul'keit, G. D. Znachenie rysi i rosomakhi kak khishchnikov v prirodnon komplekse Altaiskoi taigi. - V kn.: Preobrazovenie tauny pozvonochnykh nashei strany. M., 1953.

Emel'ianov, A. A. Promyslovye zveri zemli ozochei po dannym ekspedifsii 1924 g. - V kn.: proizvodstvennye sily Dal'nevostochnogo kraia, vyp. 4. Khabarovsk - Vladivostok, 1927.

Zaitsev, V. A. Osobennosti ispol'zovaniio territorii i struktura territorial'nogo informatsionnogo polia kabargi. - V kn.: Kopytnye fauny SSSR. M., 1975.

Zolotarev, N.T. Mlekopitaiushchie basseina r. Iman (Ussuriiskii krai). M. - L., 1936.

Zaitsev, V. A. Pishchevaia aktivnost' kabargi (Moschus moschiferus). - Sb. Upravlenie povedeniem Zhivotnykh. M., 1977.

Iokel'son, V. L. Ocherki zveropromyshlennosti i torgovli mekhami v Kolymskom okruge. - Trudy Yakutskoi ekspeditsii. Otdel 3, t. 10, ch. 3. SPb., 1898.

Kadanatsi, A. N. K poznaniiu gel'mintofauny Kabargi (Moschus moschiferus L.) Trudy In-ta zoologii AN Kaz. SSR, t. 9, 1958.

Kozhanchikov, L., Kozhanchikov I. Promyslovaia okhota i rybolovstvo v Minusinskoi taige. - Ezhegodnik Muzeia im. Mart'ianova, t. 2, vyp. 2, Minusinsk, 1924.

Kucherenko, S. P. Kabarga v Primoz'e i Priamur'e. - V kn. - Kopytnye fauny SSSR. M., 1975.

Lobanov, P. N. Osobennosti razmeshcheniia, structury i vosproizvodstua populiatsii kabargi v Vostochnom Saiane. - Zhurn. Ekologiia, no. 6, 1970.

L'vov, L. O. zverovodstve Zabaikal'skogo kraia. - Zhurn. Ministerstua gosudarstvennykh imushchestv, ch. 33, no. 10, 1898.

Matiushkin, E. N. O vzaimootnosheniakh Khavzy (Martens flavigola Bodo) i kabargi (Moschus moschiferus L.) v szednem Sikhote-Aline i istoriia formirovaniia ikh biotsenoticheskikh sviazei. - Sb. Teriologiia, t. 2. Novosibirsk, 1974.

Middendorf, A. F. Puteshestvie na sever: i vostok Sibiri. ch. 2, otd. 5. SPb., 1869.

Pallas, P. S. Puteshestvie po raznym provintsiiam Rossiiskoi imperii. ch. 2. SPb., 1786.

Salmin, IU. A. Obraz zhizni ussuriiskoi kabargi v tsentral'noi chasti Sikhote-Alinia. - Biull. Mosk. o-va ispytatelei prirody. Itd. biologiia, T. 47, vyp. 4, 1972.

Silant'ev, A. A. Obzor promyslovykh okhot Rossii. SPb., 1898.

Skalon, V. N. O nekotorykh promyslovykh mlekopitaivshchikh Bodaibinskogo raiona Irkutskoi oblasti. - Buill. Mosk. o-va ispytatelei prirody. Otd. biologiia, t. 36, vyp, I, 1951.

Solov'ev, D. K. Promysel kopytnykh zvernei i lesnoi dichi v Rossii. - Ezhegodnik Vseros. sviuza okhotnikov. M., 1922.

Timofeev, V. V. Zveri nashei oblasti. Irkutsk, 1949.

Ustinov, S. K. Territorial'noe i statsial'noe raspredelenie kabargi na Barguzinskom khrebte. Trudy Barguzinskogo zapovednika, vyp. 3, 1961.

Ustinov, S. K. K. biologii kabargi Pribaikal'ia i Zabaikal'ia. - Sb. "Okhotinch'e - promyslovye zveri," vyp. I, M. 1965.

Ustinov, S. K. Zimnee pitanie kabargi na Vostochnom Saiane. - Zool. zhurnal, t. XLVIII, vyp. 10, 1969.

Ustinov, S. K. Nekotorye adaptatsii kabargi k snezhomu nokrovu. - Trudy Mos. vet. akademii, t. 55, 1969.

Ustinov, S. K. Geograficheskie osobennosti nekotorykh storon biologii kabargi. - Izvestiia Vostochno-Sibirskogo otd. Geogr. o-va SSSR, t. 68, Irkutsk, 1971.

Flerov, K. K. Fauna SSSR. Mlekopitaiushchie, t.1, vyp. 2. Kabargi i oleni, M.-L., 1952.

Tsalkin, V. I. Sistematika kabargi. - V kn.: Oleni SSSR. M., 1947.

Shaposhnikov, F. D. Materialy k ekologii kabargi severo-vostochnogo Altaia. - Zool. zhurnal, t. 35, vyp. 7, 1956.

Shcherbakov, A. N. Kabarga, ee ekologiia i khoziaistvennoe ispol'zovanie. Avtoreferat diss. M., 1953.

Shchukin, N.S. Zverovye promysly v Vostochnoi Sibiri.- Zhurnal Ministerstva vnutrennikh del, ch. 19. SPb., 1847.

Foreign bibliography - see p. 49 of the Russian manuscript.

Bibliography

Abramov, K. G. The ungulates of the Far East and their hunting. Vladivostok, 1963.

Berezovskii, M. M., Bianki, V. L. Birds of Gan'sui found during G. N. Potanin's expedition, 1884-1887. SPb., 1891.

Bromlei, G. F. The significance of marten as predator and means of its extermination in the Primorye Territory. In Transformation of the vertebrates of our country. M., 1953.

Bromlei, G. F. Ecology of sable and marten spread in the Primorye Territory. In Study of mammals in the state reservations (Symposium). M., 1956.

Vereshchagin, N. K. Fragments of teriofauna history in the Ussuriisk region. In Transactions of the IV Zoological conference. Odessa, 1966.

Geptner, V. G., Nazimovich, A. A., Bannikov, A. G. Mammals of the U.S.S.R. Pt. 1. Artiodactyla and perissodactyla. M., 1961.

Gromov, B. I. Paleontological and archaeological aspects of stratified continental deposits of Quaternary period in the U.S.S.R. In Transactions of the Institute of Geology AS of U.S.S.R., v. 64, 1948.

Egorov, O. V. Wild ungulates of the Yakutia. M., 1965.

Egorov, O. V. Artiodactyla. In Mammals of the Yakutia. M., 1971.

Dul'keit, G. D. The significance of lynx and wolverene in the natural complex of the Altai taiga. In Transformation of the vertebrates of our country. M., 1953.

Emel'ianov, A. A. Game animals in the Land of Orochi according to the data of expedition, 1924. In Production capacity of the Far East region. v. 4. Khabarovsk - Vladivostok, 1927.

Zaitsev, V. A. Peculiarities in the habitat use and the structure of the musk deer's territorial information field. In The ungulates of the U.S.S.R. M., 1975.

Zolotarev, N. T. The mammals of the Iman River Basein (Ussuriisk region). M. - L., 1936.

Zaitsev, V. A. Feeding activity of the musk deer (Moschus moschiferus). In Animal behaviour control (Symposium). M., 1977.

Iokel'son, V. L. Studies of the fur industry and fur trade in the Kolymsk region. In Transactions of the Yakutsk expedition. Section 3, v. 10, pt. 3. SPb., 1898.

Kadanatsi, A. N. On the helmintofauna of the musk deer (Moschus moschiferus L.). In Transactions of the Institute of Zoology AS Kaz. SSR, v. 9, 1958.

Kozhanchikov, L., Kozhanchikov, I. Hunting and fishing in the Minusinsk taiga. Yearbook of the Mart'ianov Museum, v. 2, pt. 2. Minusinsk, 1924.

Kucherenko, S. P. The musk deer in the Primorye Territory and the Amur River region. In The ungulates of the U.S.S.R. M., 1975.

Lobanov, P. N. Peculiarities of the spread, structure and reproduction of the musk deer population in the East Sayan. Ecology, no. 6, 1970.

Lobanov, P. N. Musk deer population in the East Sayan. In The ungulates of the U.S.S.R. M., 1975.

L'vov, L. On the fur farming in the Transbaikalia. Journal of the State Ministry of Inventory. pt. 33, no. 10, 1898.

Matiushkin, E. N. ON the interrelation of marten (Martens flavigola Boddo) with musk deer (Moschus moschiferus L.) in the middle Sikhote Alin. Teriology, v.2. Novosibirsk, 1974.

Middendorf, A. F. Journey to the North and East Siberia. Pt. 2, section 5, SPb., 1869.

Pallas, P. S. Journey to the various provinces of the Russian Empire. Pt. 2. SPb., 1786.

Salmin, IU. A. Diurnal activity of the musk deer in the central part of the Sikhote Alin. Bull. of the Moscow Natural History Society. Section: Biology, v. 47, no. 4, 1972.

Silant'ev, A. A. A survey of hunting in Russia. SPb., 1898.

Skalon, V. N. On some game mammals of the Bodaibinsk region, Irkutsk district. Bull. of the Moscow Natural History Society. Section: Biology, v. 36, no. 1, 1951.

Solov'ev, D. K. Harvest of the ungulates and forest game in Russia. Yearbook of the All-Russian Union of the Hunters. M., 1922.

Timofeev, V. V. The animals of our region. Irkutsk, 1949.

Ustinov, S. K. Territorial and stationary spread of the musk deer on the Barguzin ridge. Transactions of the Barguzin reserve v. 3, 1961.

Ustinov, S. K. On the biology of the musk deer in the Baikal region and the Transbaikalia. Game journal. v. 1. M., 1965.

Ustinov, S. K. Winter feeding of the musk deer on the East Sayan. Zoological journal, v. XLVIII, no. 10, 1969.

Ustinov, S. K. On some adaptations of the musk deer to the snow cover. Transactions of the Moscow vet. academy, v. 55, 1969.

Ustinov, S. K. Geographical peculiarities of some aspects of the musk deer biology. The News of the East-Siberian Section of the Geographical Society of the U.S.S.R., v. 68. Irkutsk, 1971.

Flerov, K. K. Fauna U.S.S.R. Mammals, v. 1, pt. 2. Musk deer and deer. M. - L., 1952.

Tsalkin, V. I. Musk deer taxonomy. Deers of the U.S.S.R. M., 1947.

Shaposhnikov, F. D. Materials concerning the ecology of the musk deer of the north-eastern Altai. Zoological journal, v. 35, nO. 7, 1956.

Shcherbakov, A. N. Musk deer, its ecology and utilization. Avtoreferat diss. M., 1953.

Shchukin, N. S. Hunting in the East Siberia. Journal of the Ministry of Internal Affairs, pt. 19. SPb., 1847.

BIBLIOGRAPHY

1 Abramov, K. G. Kopytnye Zveri Dal'nego Vostoka i Okhota na nikh. Vladivostok, 1963.

2 Berezovskii, M. M., Bianki, V. L. Ptitsy Gan'suiiskogo puteshestviia G. N. Potanina, 1884-1887. SPb., 1891.

3 Bromlei, G. F. Znachenie kharzy kak khishchnika i sposoby ee unichtozheniia v Primorskom krae. V kn.: Preobrazovanie fauny pozvonochnykh nashei strany. M., 1953.

4 Bromlei, G. F. Materialy po ekologii sobolia i kharzy, rasprostranennyk v Primorskom krae. - V kn.: Sbornik materialov po izucheniiu mlekopitaiushchikh v gosudarstvennykh zapovednikakh. M., 1956.

5 Vereshchagin, N.K. Fragmenty istorii teriofauny Ussuriiskogo kraia. V kn.: Materialy IV Zoogeograficheskoi konferentsii. Odessa, 1966.

6 Geptner, V.G., Nazimovich, A.A., Bannikov, A.G. Mlekopitaiushchie Sovetskogo Soiuza. T. I. Parnokopytnye i neparnokopytnye. M., 1961.

7 Gromov, B. I. Paleontologicheskie i arkheologicheskie obosnovaniia stratigrafii kontinental'nykh otlozhenii chetvertichnogo perioda na territorii SSSR. - Trudy In-ta geologii AN SSSR, vyp, 64, 1948.

8 Egorov, O. V. Dikie kopytnye Yakutii. M., 1965.

9 Egorov, O. V. Parnopalye. - V kn.: Mlekopitaiushchie Yakutii. M., 1971.

10 Dul'keit, G. D. Znachenie rysi i rosomakhi kak khishchnikov v prirodnom komplekse Altaiskoi taigi. - V kn.: Preobrazovanie fauny pozvonochnykh nashei strany. M., 1953.

11 Emel'ianov, A. A. Promyslovye zveri zemli orochei po dannym ekspeditsii 1924 g. - V kn.: proizvodstvennye sily Dal'nevostochnogo kraia, vyp. 4. Khabarovsk - Vladivostok, 1927.

12 Zaitsev, V. A. Osobennosti ispol'zovaniia territorii i struktura territorial'nogo informatsionnogo polia kabargi. - V kn.: Kopytnye fauny SSSR. M., 1975.

13 Zolotarev, N.T. Mlekopitaiushchie basseina r. Iman (Ussuriiskii krai). M. - L., 1936.

Zaitsev, V. A. Pishchevaia aktivnost' kabargi (Moschus moschiferus). - Sb. Upravlenie povedeniem Zhivotnykh. M., 1977.

15 Iokel'son, V. L. Ocherki zveropromyshlennosti i torgovli mekhami v Kolymskom okruge. - Trudy Yakutskoi ekspeditsii. Otdel 3, t. 10, ch. 3. SPb., 1898.

16 Kadanatsi, A. N. K poznaniiu gel'mintofauny Kabargi (Moschus moschiferus L.) Trudy In-ta zoologii AN Kaz. SSR, t. 9, 1958.

17 Kozhanchikov, L., Kozhanchikov I. Promyslovaia okhota i rybolovstvo v Minusinskoi taige. - Ezhegodnik Muzeia im. Mart'ianova, t. 2, vyp. 2, Minusinsk, 1924.

18 Kucherenko, S. P. Kabarga v Primor'e i Priamur'e. - V kn. - Kopytnye fauny SSSR. M., 1975.

19 Lobanov, P. N. Osobennosti razmeshcheniia, struktury i vosproizvodstva populiatsii kabargi v Vostochnom Saiane. - Zhurn. Ekologiia, no. 6, 1970.

20 Lobanov, P. N. Sostoianie populiatsii kabargi v Vostochnom Saiane

21 L'vov, L. Ob zverovodstve Zabaikal'skogo kraia. - Zhurn. Ministerstua gosudarstvennykh imushchestv, ch. 33, no. 10, 1898.

22 Matiushkin, E. N. O vzaimootnosheniakh Kharzy (Martens flavigola Bodd) i kabargi (Moschus moschiferus L.) v srednem Sikhote-Aline i istoriia formirovaniia ikh biotsenoticheskikh sviazei. - Sb. Teriologiia, t. 2. Novosibirsk, 1974.

23 Middendorf, A. F. Puteshestvie na sever i vostok Sibiri. ch. 2, otd. 5. SPb., 1869.

24 Pallas, P. S. Puteshestvie po raznym provintsiiam Rossiiskoi imperii. ch. 2. SPb., 1786.

25 Salmin, IU. A. Obraz zhizni ussuriiskoi kabargi v tsentral'noi chasti Sikhote-Alinia. - Biull. Mosk. o-va ispytatelei prirody. Otd. biologiia, T. 47, vyp. 4, 1972.

26 Silant'ev, A. A. Obzor promyslovykh okhot Rossii. SPb., 1898.

27 Skalon, V. N. O nekotorykh promyslovykh mlekopitaiushchikh Bodaibinskogo raiona Irkutskoi oblasti. - Buill. Mosk. o-va ispytatelei prirody. Otd. biologiia t. 36, vyp, I, 1951.

28 Solov'ev, D. K. Promysel kopytnykh zverei i lesnoi dichi v Rossii. - Ezhegodnik Vseros. soiuza okhotnikov. M., 1922.

29 Timofeev, V. V. Zveri nashei oblasti. Irkutsk, 1949.

30 Ustinov, S. K. Territorial'noe i statsial'noe raspredelenie kabargi na Barguzinsko khrebte. Trudy Barguzinskogo zapovednika, vyp. 3, 1961.

31 Ustinov, S. K. K biologii kabargi Pribaikal'ia i Zabaikal'ia. - Sb. "Okhotnich'e - promyslovye zveri," vyp. I, M. 1965.

32 Ustinov, S. K. Zimnee pitanie kabargi na Vostochnom Saiane. - Zool. zhurnal, t. XLVIII, vyp. 10, 1969.

33 Ustinov, S. K. Nekotorye adaptatsii kabargi k snezhnomu pokrovu. - Trudy Mos. vet. akademii, t. 55, 1969.

34 Ustinov, S. K. Geograficheskie osobennosti nekotorykh storon biologii kabargi. - Izvestiia Vostochno-Sibirskogo otd. Geogr. o-va SSSR, t. 68, Irkutsk, 1971.

34 Flerov, K. K. Fauna SSSR. Mlekopitaiushchie, t.1, vyp. 2. Kabargi i oleni, M.-L., 1952.

35 Tsalkin, V. I. Sistematika kabargi. - V kn.: Oleni SSSR. M., 1947.

36 Shaposhnikov, F. D. Materialy k ekologii kabargi severo-vostochnogo Altaia. - Zool. zhurnal, t. 35, vyp. 7, 1956.

37 Shcherbakov, A. N. Kabarga, ee ekologiia i khoziaistvennoe ispol'zovanie. Avtoreferat diss. M., 1953.

38 Shchukin, N.S. Zverovye promysly v Vostochnoi Sibir. - Zhurnal Ministerstva vnutrennikh del, ch. 19. SPb., 1847.

Foreign bibliography - see p. 49 of the Russian manuscript.

LEGENDS TO THE ILLUSTRATIONS

1. Distribution of musk deer.

    1. Boundary of range
    2. Spots where fossil remains were found

2. Spread of musk deer in the U.S.S.R.

    1. Places with high population density (more than 14 animals per 1000 ha.)

3. Musk deer movement (distance 3.2 km).

    1. Musk deer movement
    2. Starts
    3. Resting places
    4. Urinations
    5. Excrements
    6. Cliffs
    7. Terrain relief

4. Types of diurnal movements of the musk deer.

LEGENDS TO THE PHOTOGRAPHS

1. Typical habitats of musk deer on the eastern Sayan (Siberia).
2. Musk deer on the cliff escaping from predator.
3. Musk deer on the cliff escaping from predator.
4. Musk deer picks up lichens lying on the snow.
5. Musk deer in resting place in winter.
6. Musk deer in resting place in summer.