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GIS-BASED RANGE AND LONG-TERM MONITORING OF AMUR GORAL IN THE RUSSIAN FAR EAST

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Abstract

The use of Geographical Information Systems (GIS) for analysis of large quantity of wildlife data is very important in the study of rare species. The Amur Goral (*Nemorhaedus caudatus* Milne-Edwards, 1867) population monitoring took place from 1954 to 2008 in the Sikhote-Alin State Nature Reserve and from 1947 to 2008 in Lazovsky State Nature Reserve. The database consists of 1.808 observations of goral in Sikhote-Alin Reserve and 1.152 observations of goral in Lazovsky Reserve. The database was grouped by decades and used the tag method for making image of range. We used Arc View GIS 3.3 for constructing the goral range. The map of scale 1: 100 000 was base for plotting of X and Y coordinates. We constructed the 6 maps representing 10 year periods (1951-2008). In 1960's the goral range in the Southern and Central Sikhote-Alin was very small and occupied only the coast of the Sea of Japan. After foundation of Zheleznyakovsky Refuge in 1976 to the north from natural boundary of maternal grouping (Abrek Mt.), gorals started to move gradually on its rocks. Goral breeding in Refuge began in the 1980s. Thus, we can ascertain occurrence of two affiliated groupings to the north and to the south from natural boundary of parent grouping during 50 years of XX century and during 10 years of XXI century. We also observed movements of single males from a parent grouping on rock cliff on the sea coast and we carried out monitoring of their life, but females did not join to them. In the Lazovsky Reserve goral grouping has a linear structure of range along the Goral Mt. and Tumannaya Mt. The GIS-range map shows more than 30 points of visual observations of single gorals out of coastal habitats, so intensive goral movements are registered in South Sikhote-Alin.

Key words: GIS, goral, map, monitoring, range

Resumen

Título en castellano

Palabras clave:

Introduction

The Russian Far East is the north extreme of the range of Amur goral (*Nemorhaedus caudatus ruddeanus) as well as* other species in the genus *Nemorhaedus* total (Abramov 1939, 1963). The range of the Amur Goral in Russia consists of two separate parts, Primorsky Krai and southern part of Khabarovsky Krai. In the latter, a small number of goral inhabit Khingan Mountains along the border between Russia and China. The largest population of this subspecies is concentrated in The Primorsky Krai, where the goral occupies the Sikhote-Alin Mountains. To conserve biodiversity of Sikhote-Alin Mountains including the goral populations, two nature Reserves - Lazovsky and Sikhote-Alin with total area of 468,000 ha - were organized in 1935 (Figure1).

The Goral typically dwells in the broad-leaved mountain forest in 2 types of habitats: 1) rocky forests in mainland river valleys up to 800 m above sea level, and 2) rocky areas along the coast up to 600 m a.s.l.

The mosaic structure of the range of the goral subspecies *N. c. caudatus* in Russia (Weinberg *at al.* 1997) and South Korea (Yang Byeong Gug 2003) is specific to this species as a whole.

Figure 1. Locality of Lazovsky and Sikhote-Alin State Nature Reserves in Primorsky Krai, Russia.

The goral range has mosaic structure because of specific habitat preference. The characteristic feature of the goral habitat is the mix of open (rocks and meadows) and closed (oak forests) environments. Currently, gorals exist in the following 11 administrative districts of the Primorsky Krai: Khasansky, Ussuriysky, Partizansky, Anuchinsky, Chuguevsky, Lazovsky, Olginsky, Kavalerovsky, Dalnegorsky, Krasnoarmeysky, and Terneysky.

In the Primorsky Krai there are two main goral populations concentrated in Lazovsky and Sikhote-Alinsky Reserves where the population size is about 500 individuals. In addition, about 300 individuals occupy protected areas (refuges). The total number of the Goral in Russia is about 900 individuals at present and has remained stabilize over the past 20 years. The principal factors affecting population size are poaching and natural mortality, which can be high in years with heavy snowfall. Historically the major predator on goral was the wolf in the 1930s - 1950s, more recently it is lynx, and rarely tiger.

The objective of the study was to map the current and historic distributions of Goral in Russia.

Study area

In the Primorsky Krai there are three isolated areas of goral range including 1) the South-Western spurs of the Bureya Range, 48° 30' N , a small area near the Amur River, which is closed with the South-Eastern part of the Little Khingan Range in China; 2) the Sikhote-Alin Range, 42 ° 10' - 45 ° 50' N.; 3) Small area named Black Mountains (43° N) the South-West of Vladivostok City, occupying spurs of the Laoelin Range (in China).

The majority of goral in this subspecies are concentrated in the Primorsky Krai: South Sikhote-Alin 42-43° N, 137° E, and Central Sikhote-Alin 44-45° N, 137° E, where gorals occupy the Sikhote-Alin Mountains. G.F. Bromley (1956) recorded 57 sites occupied by gorals. Our investigations of goral habitats were conducted in 1975-1980. At that time there were 39 confirmed goral sites (Myslenkov & Voloshina 1989, Voloshina & Myslenkov 2002).

Methods

Long-term observations of mammal populations are the key to ecological monitoring in Lazovsky Reserve. The Goral investigations demonstrated continuity of many generations of researchers and we have accumulated long term monitoring data for the periods: 1) 1947-2008 in the South Sikhote-Alin and 2) 1954 to 2008 in Central Sikhote-Alin. All sightings were described by X and Y coordinates. The database consists of 1.779 staff visual observations of goral groups in the Sikhote-Alin Reserve and 1.152 observations in Lazovsky Reserve. In addition, we did goral surveys from a ships and boats from 1979-1996 in Abrek Mt. population and from 1978-1990 in Lazovsky Reserve population. The database of goral visual observations was compiled in Microsoft Excel program. The ranger's and researcher's staff of Lazovsky and Sikhote-Alin Reserves was relatively stable during these years and routes were constant and regular excluding 1950s. So we may to compare the different decades.

We constructed the distribution maps of goral of point range by decade in Arc View GIS 3.3 program. The range of the Goral for 61 years was constructed for Lazovsky Reserve and for 50 years for Sikhote-Alin Reserve.

In addition to available three protected areas (two reserves and one refuge) in the Primorsky Krai during 1980s were created 6 special refuges for goral protection (Nesterov, 1992). These refuges included goral habitats with small number of gorals. In the 1980s, the investigations on goral biology in both Reserves were carried out very intensively. The goral range, population dynamics, age and sex composition were studied. The grassland classification was conducted and 286 forage plants were exposed (Solomkina 1983, Myslenkov & Voloshina 1989, Shaulskaya 1992).

Results

Range of Goral in 1940s

Bromley (1963) studied the goral range and ecology from 1944 to 1948 and constructed the map of local distribution on Lazovsky Reserve. He was the first who described the maternal goral group in the cost of this Reserve. Except for the basic parent grouping, G. F. Bromley also recorded 22 places in Lazovsky Reserve where hunters described meetings or shot gorals (Bromley 1963). Bromley plotted a map of 37 points of observations (sightings) with single gorals in the Reserve.

Range of Goral in 1950s

The monitoring of goral population began 1958 in Lazovsky Reserve. From 1958 to 1960 only 31 observations of goral were recorded in the Reserve (Figure 2). The 24 observations were recorded by Inna Yurgens who worked specially on goral during that time period (Yurgens 1963). The first scientific report that contained dates of observations of gorals, and the first photos of goral naturally was presented in 1960. Yurgens also visited upper part of the Big Ifam Creek inland where she observed 2 individual goral. The basic visual meetings with gorals have taken place on cape Ostrovnoy. In 50th years with staff of Reserve it is confirmed except for a parent grouping of 8 places of dwelling gorals in a continental part of Reserve and one place on the coast of Sea of Japan, a rock of Sokolovka bay, it is marked for the first time. The Bromley's article on goral in Russian Zoological Journal (Bromley 1956) was published in this decade.

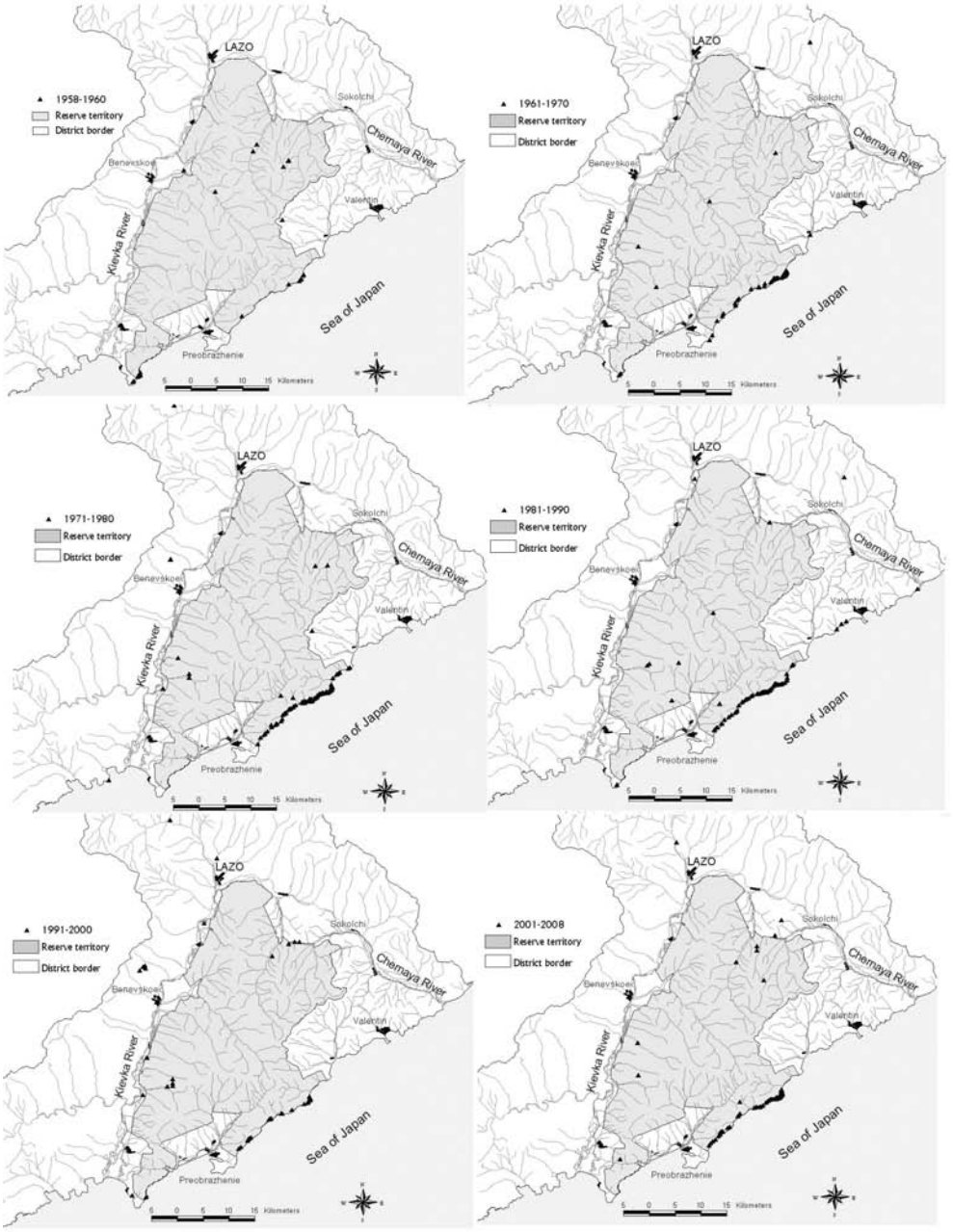

Figure 2. Distribution of gorals in Lazovsky Reserve in 1950s-2000s.

The goral range in 1950-th has had a chaotic structure because it has been very fragment investigated.

At the same time Sikhote-Alin Reserve entered monitoring from 1954. During the period from 1954 to 1960 54 observations of single gorals and goral groups were recorded (Figure 3). Henry Veinger studied the goral population in Abrek Mt. and published his findings in 1963. He provided the first goral survey by count-keepers (Veinger 1963). He marked a special indexed observation points on the rocks and used it by Reserve's stuff every year in winter during snow period. These observation points are still present today. The goral range had a linear structure and occupied the coast of the Sea of Japan.

Range of goral in 1960s

For 1960s a database of Lazovsky Reserve consists of 76 observations. Since 1969 on a permanent study of the goral population the scientific employee E.I. Sidun has been accepted. He provided 52 observations which basically have been concentrated on Tumannaya Mt. and Goral Mt. near the sea cost. His results were unpublished. We superimposed these data onto a GIS map of goral habitat (Figure 2) and the goral range in Lazovsky Reserve accepted the linear structure along the sea cost. As a consequence the data base increased more than 3 times, we can feel that this range more closely resembles the real situation. Thus, 9 places of goral stay inland were confirmed in 1960-th years, one place is marked for the first time, and the parent grouping was observed constantly on the coast.

Sikhote-Alin Reserve database for the 1960s decade has 109 visual observations. The Reserve administration provided the co-ordination of every year goral survey by staff of rangers from permanent observation points. The goral range confirmed a linear structure on Abrek Mt. and occupied the coast of the Sea of Japan (Figure 3). Several goral individuals emigrated 25 km to the south from Abrek Mt. to the Kalancha Rock and to the Schastlivy Cape (50 km). This is the first pulsation of goral range detected by regular monitoring. Two points of goral meetings inland were recorded in this decade.

We can see a linear structure of maternal range as a result for two Reserves and different number of continental sites.

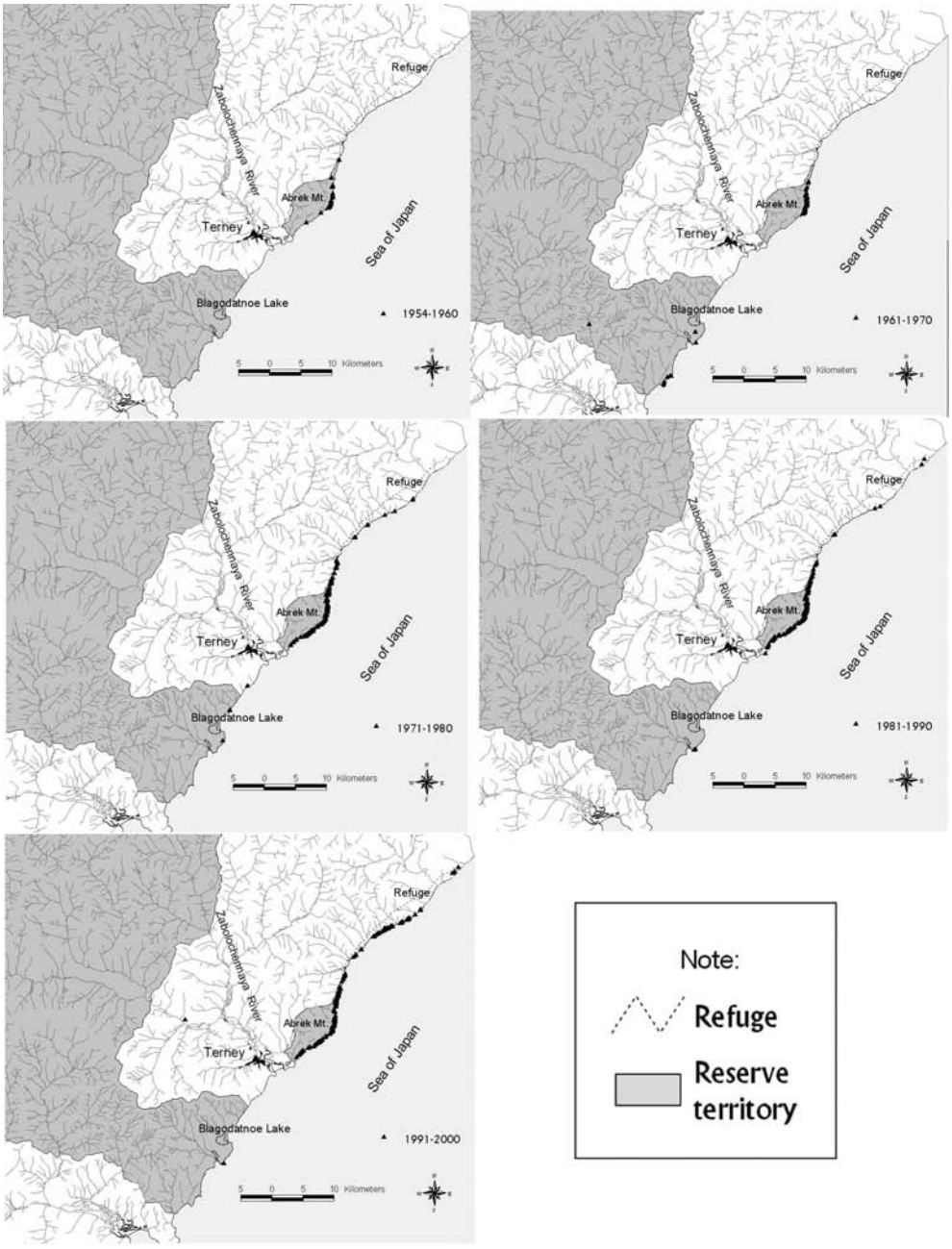

Figure 3. Distribution of gorals in Sikhote-Alin Reserve in 1950s-1990s.

Range of Goral in 1970s

During the 1970s the database of Lazovsky Reserve contains 641 observations of gorals. The quantity of the base increased more than in 10 times due to diligent and laborious work of two researchers; Valerij Glebov and Nelly Solomkina.

V. V. Glebov was the first in Lazovsky Reserve to use goral helicopter surveys which were carried out in 1976 and 1978. In addition, in 1975 a study was begun keeping gorals in captivity for which catching kids on rocks of a parent grouping was carried out, and also network catching of adults' gorals.

V. V. Glebov was also the first to plot a map of goral distribution on rocks of a parent grouping for every day of aerial survey (Glebov *et al.* 1976). It has enabled to define the coordinates of goral meetings and the GIS analysis of spatial distribution of a parent grouping. It was confirmed that the area of a parent grouping of goral is tape (Figure 2) and this grouping had the same structure as in 1960s. In addition, V.V. Glebov undertook expeditions, both on Lazo, and on next to areas Olga District with the purpose of investigating the goral distribution. For the first time he has established goral transition with Tumannaya Mt. on rocks of Zarya Bay in 1976, that has explained abolition of the Sika deer park. He also went on Razgradsky Cape and has established there staying of one goral. In 1977 he has confirmed goral local population on Kozy Cape and on Stone Creek. Thus, the goral range on coast has extended to the north up to rocks of Zarya Bay and to the south up to Razgradsky Cape. On check polling given observers and V.V. Glebov survey and confirm 8 places of goral dwelling, two new on the cost of the Sea of Japan.

During the same decade, Sikhote-Alin Reserve database increased up to 449 observations. The yearly goral survey was conducted by staff of rangers and researchers from 20 permanent observation points. After 1978, 37 observation points covered all goral habitats in maternal grouping (Myslenkov & Voloshina 1989). From 1979 the goral survey observation points were combined with the boat surveys. Motorboat moved very slowly along the rocky coast. Due to this combined method it was possible to take into account during 3 h 111 gorals on 14 km of rocky habitats. The goral range in a parent grouping occupied all Abrek Mt., keeping still linear character. Six times single gorals were observed in the

Refuge, which recorded the beginning of moving of a population to the North. Goral moving to the South is recorded only in three points (Figure 3).

In 1976 a special protected are for goral was created called Zeleznyakovsky Refuge located 4,749 ra to the north from Abrek Mt. on the coast of Sea of Japan. Validity of it has not been limited, and in 1998 it has received the status of the World Heritage of UNESCO.

Range of Goral in 1980s

For 1980s in Lazovsky Reserve 238 observations are collected. The aerial survey in March, 1981 was carried out. The map of productive day on March, 17 (46 individuals) has confirmed linear character of goral range in a parent grouping. The survey on April, 4 in 1984 carried out by A.A. Laptev (Laptev 1987) used the combined method from an observation points and from the sea by two motor boats. For the first time absolute number of 118 gorals in a parent grouping from Ezovaya Bay to Proselochnaya Bay (25 km) was obtained. The maximal goral numbers were recorded on the same area during the survey from motor boat on January, 20 in1987 when in a parent grouping 147 gorals during 3 hours were counted (Khokhriakov 1991). Unfortunately, in March 1987, the large goral mortality (41 dead bodies) on the Tumannaya Mt. was happened (Khokhriakov 1997). Only 10 gorals from them were killed by predators. The most of animals have been infected by protostrongilosis. Their lungs have been affected by larva most likely of *Protostrongylus andrejevi,* earlier revealed by parasitologists from same grouping of the Reserve (Schultz & Kadenacii 1950).

GIS map of parent grouping for this decade displays the pulsation of goral range to the South and to the North (Figure 2). In 80th years the goral survey inland on rocks of the Stone Creek and on rocks of Paramonovsky Creek were carried out also. The reserve staff has confirmed goral dwelling in 7 places, except for a parent grouping and it was found 3 new places of dwelling. Results have shown that besides the increase of numbers, gorals expanded the habitat area in 80th years a little. On the coast two affiliated groupings were fixed: on rocks of Zarya Bay, on rocks from a Kit Bay up to settlement Valentine. Almost all continental groupings existed and supported their numbers.

At the same decade Sikhote-Alin Reserve database increased up to 582 visual observations. The goral range kept linear character, and population density on Abrek Mt. was increased (Figure 3). There was a goral occupy a southern part of Abrek Mt. (on an area of abolished settlement) and gradual increase of density. The number of sightings with gorals in the Refuge was increased up to 105. In this decade the regular surveys from boats were begun in the Refuge both in the summer and in the spring. Settling of refuge in the first five years was slowly and was speed in the next years. The goral females have started to bring kids in the Refuge.

The most surprising phenomenon has taken place in 1990. On the western Sikhote-Alin macroslope on a rocky cliff of the Sinuncha River (Basin of Ussurka River) summer of 1990 was shot one goral. The ranger V.P. Sharov has informed about this place that is on continent more than 100 km from a parent grouping on the sea coast. These data speak about dispersal of gorals on western macroslope of Sikhote-Alin Mountains where they were earlier in 1930s.

Range of Goral in 1990s

In 1991 there was a disintegration of the USSR, and Primorsky Krai entered in territory of the Russian Federation. Then in Russia began crisis, reserve's husbandry fell into decay, and protection of Refuge has become worth.
Lazovsky Reserve has stopped to carry out the goral surveys. For 1990s the database contains only 43 observations on the goral. The GIS map (Figure 2) shows an interrupting area in a parent grouping. In the contrary, the continental places of goral dwelling achieved a maximum in this decade.

Constant continental places of goral dwelling have were confirmed during this decade in 14 places. Three new places outside of the Reserve were found where gorals were moved. Two sightings with gorals were to the north from Lazovsky Reserve, but urgent check of these places has shown absence of gorals. Probably, animals have been seen on a migratory way.

Crisis and disorder in Russia during 1990s affected on the Sikhote -Alin Reserve also, but the quantity of observations decreased insignificantly. For this decade there were 499 sightings with gorals, and 150 of them were recorded in

the Refuge. GIS map of parent grouping in this decade displays the pulsation of goral range to the north in the Refuge (Figure 3). The continuous area of a parent grouping of the Reserve was extended to the Refuge. One male occupied the Kalancha Rock (the south of Reserve) in 1988, and lived there up to the end 90s. Sightings with gorals on significant distance from the sea coast increased. On the eastern macroslope were 3 of them and on western there were 3 observations in the Columbe River basin. It means high density of gorals in a parent grouping that is cause of dispersal of young gorals on the western macroslope.

Range of Goral in 2000s

For this period in Lazovsky Reserve 102 observations are collected. It is not so small database as in 1990s, but not so large. The two surveys from motor boats in 2005 - 2006 demonstrated very low results: 31 and 21 gorals, that speaks about bad conditions for survey: absence of a snow cover in the goral habitat. In February, 2004 the aerial survey from the helicopter for all ungulates species in Lazovsky District has confirmed 2 continental places of goral dwelling: on rocks of Bolsherechenskaya Mt. were seen 5 gorals and 2 gorals were recorded by I.V. Voloshina in the Petrovsky Creek. Thus, for ten years of XXI century except for a parent grouping 9 places of goral stay in the Lazovsky District were confirmed, and the twice gorals has been seen on a migratory ways. GIS map of parent grouping in this decade displays no pulsation of goral range (Figure 2). In the contrary, the continental places of goral dwelling achieved a 10 last decade.

At the same decade Sikhote-Alin Reserve database decreased up to 115 visual observations. It is very small database for this Reserve. The Reserve administration deleted the goral surveys from scientific projects, and we can not to construct the GIS range for this decade. In the Sikhote-Alin Reserve the goral surveys were carried out annually during 38 years since 1959 on 1996. The discontinuance of monitoring of the goral population in the Sikhote-Alin Reserve is a crime against researches of diversity and studying of biology of rare mammalian species.

Discussion

We have considered 6 decades of monitoring of goral populations in two Reserves of the Primorsky Krai. It is established, that the continuous range the species it is formed only on rocks of the coast of Sea of Japan here again passes intensive breading of a species. Therefore, the internal structure of an area is a tape, which very narrow and stretches only on rocks of the coast. In both Reserves are observed homologous parent groupings, and they can pulse both to the north along the coast, and to the south depending on goral moving from it. Dispersal of gorals to continental places of dwelling every decade is observed. During 60 years of monitoring it was possible to establish some migratory ways on the continent and even on the western macroslope of Sikhote-Alin.

Each species within the limits of its range is distributed not entirely, and occupies only suitable habitats. It rather evidently shows the Goral in the Primorsky Krai. The exchange of individuals between separate groupings passes on so-called **the ecological channels**. The nature of them is not investigated yet, but there is an assumption, that they pass basically there where there are habitat chains, similar to the best habitats of the species. These habitats-parts are too small, for maintenance of existence of a local population, but sufficient to give a temporary forage and a refuge for moving individuals. In the American literature these chains of habitats refer to **as ecological corridors**. In ecological channels there are only separate individuals during the certain seasons of year, are short time, and, probably, do not form high numbers. A typical example of an ecological channel: upper parts of some creeks of the Kievka River. They create a chain of temporary habitats up to the upper part of the Lazovka River, whence gorals can migrate to the other ridge.

These migratory ways exist very much for a long time, and in some points gorals can stay for a long time or live constantly. It is very indicative, that plus to G.F. Bromley's 24 points the reserve's staff and the local people of Lazovsky District revealed more 12 places of goral stay. Only a few points (8) were are specified incorrectly or inexact and did not confirmed during all 60 years. For this there are some reasons. The first of them - lack of inspection of high mountains,

because these places during 60 years not visited by people. The second reason, that gorals has been met by accident on a migratory way, and then this way did not use.

In every decade goral stay in some places is not confirmed but from 1 up to 3 new places of dwelling it is revealed. This indicates not on reduction of places of goral stay, but on expansion of its range. From stated follows, these disappearances of places of goral dwelling in Lazovsky District a few. There are pulsations of some points with an interval of 5-10 years or 40 years, but they have property to renew.

Thus, goral as the species, has parent constantly existing groupings and affiliated groupings in the best habitats. Besides that, it has migratory ways and chains of seasonal habitats in which, probably, young and adult individuals are moved or there leave for a season.

The review of all decade results by Lazovsky Reserve shows that only one parent grouping of goral. Three others inhabit the rocks in Paramonovsky Creek, Korean Creek, and Kamenny Creek that are temporary habitats. Gorals often spent the winter in these places but not every year.

The review of all decade in Sikhote-Alin Reserve shows that a parent grouping can provide the affiliated groupings in the best habitats. Pulsations of an area are more characteristic for the population of Sikhote-Alin Reserve, as there less human settlements on the coast.

Periodicity of migrations, seasonal prevalence and quantity moved gorals are the most unexplored questions in goral population biology at the present time.

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References

Abramov K.G. 1939. Amur goral. Scientific-methodical a notes of Central administrative board Reserves. *Moscow*, 4: 198-201. (In Russian)

Abramov K.G. 1963. *Ungulate animals of the Far East.* Primorskoe knizhnoe izdatelstvo, Vladivostok, 132 pp. (In Russian)

Bromley G.F. 1956. The Goral (*Nemorhaedus caudatus raddeanus* Heude, 1894). *Zoologicheskij Zhurnal*, 35: 1395-1405. (In Russian)

Bromley G.F. 1963. Biology of the Amur Goral (*Nemorhaedus goral caudatus* Milne-Edwards 1867). *Trudy Sikhote-Alinskogo Zapovednika*, 3: 191-267. (In Russian)

Glebov V.V., Shaldibin S.A. & Zhivotchenko V.I. 1976. *Aerial survey of gorals and sika deer in Lazovsky Reserve. Ungulates of USSR fauna*. Nauka, Moscow, 8-10 pp. (In Russian)

Groombridge B. 1993. *IUCN Red List of Threatened Animals*. IUCN Gland, Switzerland and Cambridge, UK, 286 pp.

Myslenkov A.I. & Voloshina I.V. 1989. *Ecology and Behaviour of the Amur Goral*. Nauka, Moscow, 129 pp. (In Russian)

Myslenkov A.I., Voloshina I.V. & Borisenko M.E. 2005. *Results of research in Zheleznyakovsky Refuge from Primorye. Results of protection and research of the Sikhote-Alin natural landscape.* Primpoligraphkombinat, Vladivostok, 243-254 pp. (In Russian)

Nesterov D.A. 1992. *Distribution of goral in Primorsky Krai. Amur Goral*. Nauka, Moscow, 6-20 pp. (In Russian)

Khokhriakov S.A. 1997. Epizooty *Protostringylus andrejevi* in Amur goral population in Lazovsky Reserve. *III Far Eastern conference on reserve's business*. September 1997, Vladivostok, 124-125. (In Russian)

Khokhriakov S.A. 1998. Distribution Amur goral in Lazovsky District of the Primorsky Krai. *Zapovednoe delo, Moscow*, 3: 34-38. (In Russian)

Shultz R.S. & Kadenacii A.I. 1950. Helminthes of Far Eastern goral. *Proceedings of helminthological laboratories AS of the USSR*. V. III. Mocow - Leningrad, 950 pp. (In Russian)

Shaulskaya N.A. 1992. Goral pastures in Abrek Mountain and their productivity. Pp: 35-58. In: *Amur Goral*. Nauka, Moscow. (In Russian)

Solomkina N.V. 1983. About breeding of gorals in captivity. *Bulletin MOIP. Biol.*, 88 (3): 21-26. (In Russian)

Veinger G.M. 1963. Goral population of the Sikhote-Alin Reserve. *Trudy Sikhote-Alinskogo Zapovednika*, 3: 269-281. (In Russian)

Voloshina I.V. & Myslenkov A.I. 2002. Protected areas for Amur goral in Russia. *3rd World Conference on Mountain Ungulates*, Saragossa (Aragon, Spain) 10-15 June. 117 p.

Weinberg P.I., Fedosenko A.K., Arabuli A.B., Myslenkov A.I., Romashin A.V., Voloshina I. & Zeleznov N. 1997. Status and Distribution of Caprina in the Commonwealth

of Independent States (former USSR). *Wild Sheep and Goats and their Relatives.* IUCN, Gland, Switzerland and Cambridge, UK, 172-193 pp.

Yang Byeong Gug 2003. *Systematics, Ecology and Current Population Status of the Goral, Naemorhedus caudatus, in Korea*. Thesis Doctoral. Department of Biology, Graduate School Chungbuk National University, Cheongju, Korea. 132 pp. (Abstract in English)

Yurgense I.L. 1963. Goral population from Tha-Chin-Jan ridge. *Trudy Sikhote-Alinskogo Zapovednika*, 3: 283-297 pp. (In Russian)