Information and space technologies in the development of hunting and domestic reindeer husbandry

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Information and space technologies in the development of hunting and domestic reindeer husbandry

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Abstract. Based on an analysis of the results of using specialized collars with beacons of the Argos satellite system (manufactured by ES-PAS LLC) for wild reindeer movements, the possibility of using new beacons for remote monitoring of domestic animals grazing is considered. It is planned not only to select the optimal functioning parameters of the device for animal husbandry (location accuracy, frequency of data transmission to satellites, duration of autonomous functioning, etc.), but also to add new features that allow the use of satellite collars not only as a means of tracking animals, but also for studying the features of their behavior. Comparison of animal behavior information with Earth remote sensing data can be used to optimize pasture management. When forming the database, the possibility of organizing a system for managing the load on pastures, including an assessment of the overall potential for the development of livestock in a given territory, is considered.

1. Introduction

The Argos international location and data collection system is formed by government agencies in France, the USA, the European Union and India. It is designed to study and protect the environment. The system is able to regularly determine the coordinates of a moving object anywhere in the world based on signals of exceptionally low power emitted by a satellite beacon. Low energy consumption allows the use of miniature devices that can operate for many months.

Domestic and commercial reindeer husbandry are the basis of the vital activity of the indigenous population of the Northern part of the Russian Federation. However, the number of deer is declining, which adversely affects not only the quality of life of indigenous peoples, but also on agricultural production. The adopted subprogram “Development of the traditional industries of the North and the Arctic” is aimed at changing the current situation. At the same time, without using modern technical means, including information and space technologies, the tasks set seem to be hardly feasible.

Currently, one of such technical areas is equipping animals with satellite radio beacons used as part of the Argos system. Reindeer serves as a very favourable object for remote observation, since it mainly moves in open areas without dense vegetation. As a result, during most satellite passages, spacecraft are in the line of sight relative to the antenna of the beacon, and messages are transmitted unhindered to the satellites. In addition, deer observation projects are carried out mainly at high latitudes, where the number of daily passages of spacecrafts of the Argos system is significantly higher compared to the equatorial zone. Expanding the set of parameters obtained when introducing new radio beacons of the Argos/GPS/GLONASS satellite systems in combination with those already used, will allow solving fundamentally new issues of not only commercial, but also domestic reindeer husbandry.

The research objective is to analyze the possibilities and prospects of using collars with new radio beacons of the Argos/GPS/GLONASS satellite systems for the development of commercial and domestic reindeer husbandry in Central Siberia and the Republic of Sakha (Yakutia).

2. Materials and methods

Data of remote monitoring of animals with beacons of the Argos satellite system manufactured by ES-PAS LLC (Moscow) were obtained in 2015-2018 in the Krasnoyarsk Territory (Taimyr, Evenkia) and for the period 2018-2019 in the Republic of Yakutia (Sakha). We used both Argos radio beacons, which provided the determination of Doppler positions, and radio beacons with built-in receivers of GLONASS and GPS navigation systems. In total, information was received from 23 radio beacons. On the Krasnoyarsk Territory, deers were caught and tagged by employees of the Siberian Federal University, and in Yakutia, by employees of the Institute of Biological Problems of the Cryolithozone of the SB RAS under the direction of I.M. Okhlopkov.

Currently, ES-PAS LLC, together with the French company CLS, is developing a new type of satellite collar. The work is carried out as part of the SISMA (Space Innovation System to Monitor Animals) program, funded by the European Space Agency and involving the creation of a demonstration integrated reindeer management system based on navigation, data collection, communications and remote sensing satellites.

Along with previously published scientific papers, the article uses the most relevant materials of regulatory documents on the development of reindeer husbandry [1-3].

3. Results and discussion

Work on improving the used collars with radio beacons of the Argos satellite system (manufactured by ES-PAS LLC) is ongoing, in addition, they undergo rigorous field tests in high-amplitude conditions of both seasonal and daily temperatures. The maximum duration of signals from deer with satellite transmitters and using upgraded battery packs in 2015-2016 amounted to 438-444 days, in 2017-2018 - 539 days. The largest values of the total length of the deer along the tracks during the satellite direction finding were 9537.9 km. The speed of movement varied both in individual sections and in the seasons of the year, averaging 13.5 km/day, the maximum speed reached 45-72 km in azimuth.

With additional integration of a navigation receiver into the beacon, the location of the moving object was determined with higher quality. The beacon independently determined its coordinates using satellite navigation systems, and then put information about its location in messages transmitted to the spacecrafts of the Argos system. As a result, the remote user received both Doppler and navigation coordinates of the object under study.

The new Argos/GPS/GLONASS radio beacon, developed jointly with the French CLS company, is adapted to the tasks of remote monitoring of livestock grazing. It is planned not only to select the optimal functioning parameters of the device for animal husbandry (location accuracy, coordinate determination intensity, frequency of data transmission to satellites, duration of autonomous functioning), but also to add new interesting functions that will allow using satellite collars not only as a means of tracking animals, but also to study the features of their behavior.

The main difference between the device being developed and the existing beacons manufactured by ES-PAS LLC, used in the framework of ongoing scientific projects, is the ability to transmit to the remote user not only the current coordinates of the animal, but also information about its behavior. This requires the implementation of a number of preparatory measures.

At the first stage, a batch of collars is made, which fully correspond to standard beacons in weight and size, but instead of navigation and data transmission tools are equipped with a set of sensors (accelerometer, gyroscope, magnetometer), a miniature video camera and a storage device. Such devices are put into operation in various geographical areas, different landscapes and at different periods of the year. Over the course of several weeks, video clips and corresponding sensor readings accumulating in the storage device characterize the behavior of an animal equipped with such ~~a~~ collar.

Subsequently, the device is removed from the animal and all accumulated video fragments are analysed in order to determine the type of behaviour (immobility, walking, running, eating, etc.) in each of those time periods when shooting was performed. At the same time, each of the behavioural types defined in this way corresponds to sensor readings recorded in the same period of time. As a result, a database is formed in which each type of behaviour corresponds to sets of sensor readings collected by different animals in different conditions.

At the third stage, the generated database is used as a training sample for a neural network, designed to automatically determine the type of animal behavior solely on the basis of information about sensor readings and without the use of video clips.

After such training, the neural network and a set of sensors are integrated into the Argos/GPS/GLONASS radio beacon, which allows further identification of the type of its behavior at each location of the animal. As a result, it becomes possible to perform a detailed analysis of the daily life of the animal, accumulate relevant statistics and identify all kinds of anomalies. For example, a sharp change in the daily distribution of types of behavior (a sharp decrease in mobility or feed intake) may indirectly indicate a negative physiological state of the animal.

The issues of the dynamics of the number and condition of wild reindeer (commercial reindeer husbandry) are no less significant than the development of domestic reindeer husbandry. A reasonable balance between the two main components of animal husbandry in the North is extremely important both for increasing agricultural productivity and preserving, in some cases, unique wildlife populations. At the same time, it is important to assess both the size of a single population and the condition of individuals, the interaction of deer with predators and the need to control the number of predators, the possibility of withdrawing part of the population for household needs and the risks of population degradation under the influence of predators and hunting. Monitoring methods are needed that would make it possible to track changes in the routes of deer movement and the state of individuals in populations. Standard methods of accounting do not allow to obtain detailed information about the state of the studied animals. Moreover, in the conditions of Taimyr and Evenkia, ground-based abundance counts are extremely laborious and difficult.

In this regard, new approaches are needed to assess the state of individuals and the dynamics of deer populations. Thus, the use of data from annual counts of deer of the Taimyr-Evenki population made it possible to construct a model of the dynamics of the deer population (figure 1). According to this model, the population size N(i) in year i depends on the population numbers N(i-1) and N(i-2) in the previous two years and on the relative removal of individuals in the population W(i-1) per year(i-1):

$$L(i) = \ln N(i) = 0.319+1.55*\ln N(i-1) - 0.575*\ln N(i-2) + 0.072*W(i-1)$$

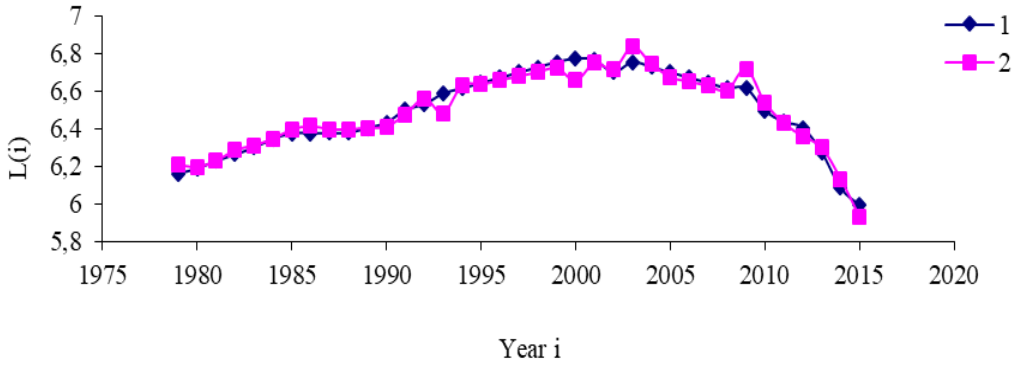

Figure 1. Field data (1) and model calculations (2) of deer abundance in the Taimyr-Evenki population.

Analysis of the model reveals the susceptibility and signs of relationships in the population. Thus, a positive feedback is characteristic of the relationship between the population numbers in years i and (i-1): the larger the number per year (i-1), the greater the number in year i. A negative feedback is characteristic of the relationship between the population numbers in years i and (i-2): the larger the number per year (i-2), the lower the number per year i. The population size in year i and the share of seizures per year (i-1) are also associated with positive feedback: the higher the share of seizures per year (i-1), the larger the population in year i. A similar effect may be associated with a decrease in competition for feed resources in the population. Apparently, to clarify the characteristics of the dynamics of the number of deer, it is necessary to proceed to the construction of models of the dynamics of local subpopulations.

An important task is the use of remote observation data using satellite monitoring and GPS collars. In this case, it is important to combine information on the movement of deer with the data of publicly available satellite observations of the state of the biota on the route of the deer (for this it is possible to use data from the MODIS and Sentinel satellites), available in open access NCEP Global Forecast System (GFS) (global numerical weather prediction developed by the National Center for Environmental Forecasting of the US National Meteorological Service) on current meteorological characteristics in the traffic zone and use digital three molecular weight of the earth's surface map from the motion of the individual. Using these methods together will allow one to:

- assess the trend of the local speed of movement of an individual depending on the length of time from the beginning of migration and indirectly evaluate the change in the physiological state of the individual by this indicator;
- establish the state of individuals by the speed of movement in landscapes of various types and explain the direction of local movement of individuals depending on the characteristics of the landscape and the characteristics of vegetation.

With an increase in the frequency of registration of the location of individuals by changing the speed of movement between two adjacent points of registration of the location of a deer, one can evaluate the mode of movement, the frequency and duration of rest and the feeding period.

It is important to evaluate the timing of the movement of deer in the herd. For this, it is necessary to use a certain number of collars for recording movement and calculate the cross-correlation functions of the time series of deer movement. In the future, it would probably be worth considering the possibility of creating a collar design with sensors for the pulse and body temperature of individuals. Information about the current pulse and body temperature of an individual will allow one to get additional information about its condition.

The natural conditions of the Krasnoyarsk Territory are favorable for the development of reindeer husbandry, which is based on the abundance of natural fodder vegetation. The total area of deer pastures in the region is 45,354.5 thousand ha, with a design deer capacity of 157 thousand heads [1]. According to the administration of the Taimyr Dolgan-Nenets municipal district, in the first half of 2019 the total number of reindeer was 12,7354 species [2].

The main centers of reindeer husbandry in the Krasnoyarsk Territory are concentrated: in the western part of Taimyr, 134 km north of the city of Dudinka - in the settlement of Karaul (121,196 species) and in the eastern part of the peninsula, on the right bank of the river. Khatanga in the rural settlement of Khatanga (6,153 species) (figure 2). In taiga reindeer husbandry on the territory of the Evenki municipal district, the number of domestic deer is small (1,600–2,500 animals), with a total deer capacity of pastures of 65 thousand animals. The main center of reindeer herding is concentrated in the village Surinda, in the interfluve of Podkamennaya and Lower Tungusok, 110 km to the north-east of the settlement Baikit. The total area of deer pastures is 12,150.8 thousand ha.

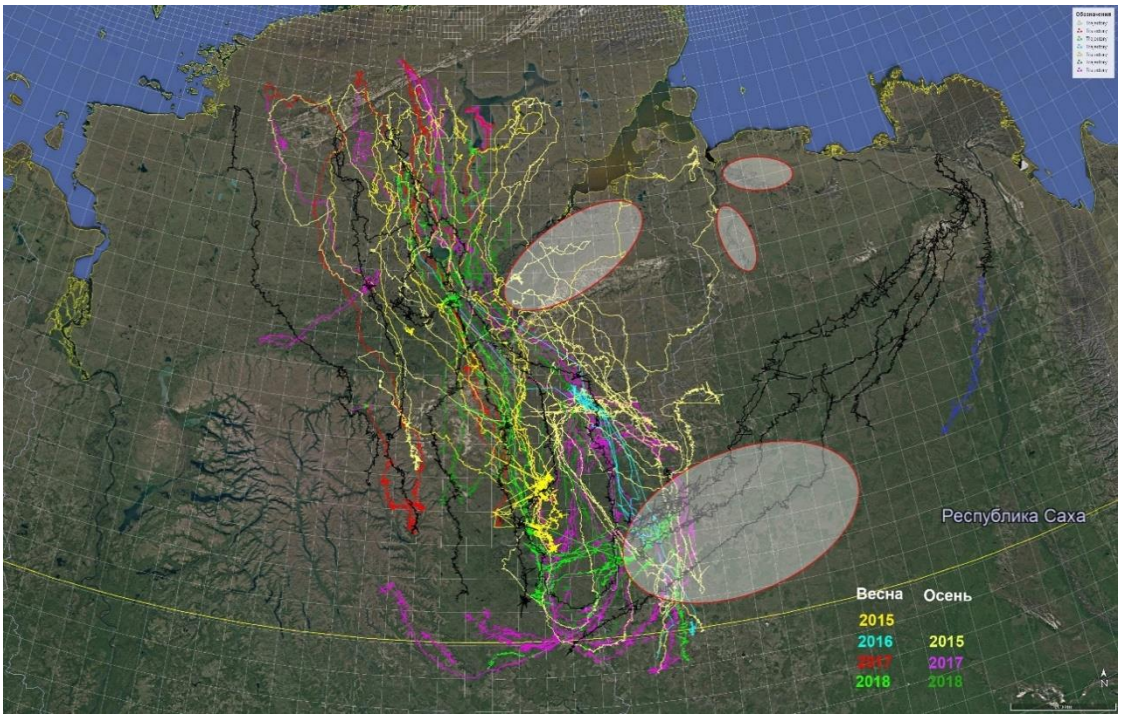

Figure 2. Seasonal movements of wild reindeers of the Taimyr-Evenki and Leno-Olenek populations (black tracks). Ellipses indicate the contact points of these wild and domestic deer populations.

The Republic of Sakha (Yakutia) is one of the leading regions of the Russian Federation in terms of the number of domestic reindeer. Reindeer husbandry is involved in 20 administrative districts (uluses) and reindeer husbandry occupies 80 million hectares of land [4]. As of September 1, 2019, the number of deer amounted to 163 thousand animals. There are 106 reindeer husbandry farms in the region, including 18 farms in the tundra zone, 3 in the forest-tundra region, 42 in the mountain taiga and 43 in the taiga. The highest growth rates of deer stock in recent years have been observed in farms of Anabarsky, Oleneksky, Zhigansky and Kobyaysky uluses [5].

Today, all reindeer husbandry farms experience a number of difficulties associated with such problems as degradation of reindeer pastures, the negative impact of industrial development in the areas where reindeer husbandry is located, the lack of production and technological infrastructure for processing venison, the lack of qualified personnel, and others. Significant damage to reindeer husbandry can be mixed domestic deer with herds of wild reindeer migrating.

For the Krasnoyarsk Territory, cases of wild savage domestic deer are characteristic of deer farms in the village Khatanga (Novorybnaya, Popigay, Syndassko), where domestic deer on summer pastures can contact both the western group of the Lenno-Olenek population and deer of the Upper Taimyr-Essenian group (figure 2). In the summer, the western (Anabar) group of wild reindeers is located on the Pronchishchev ridge and in the surrounding tundra from the coast of the Laptev Sea to the forest-tundra [5].

Most often, cases of the withdrawal of domestic reindeer are characteristic of reindeer husbandry located in the northwestern and western parts of the Republic of Sakha (Yakutia), in the basins of the Olenyok and Anabar rivers. So, at the end of October 2013, in the Oleneksky ulus, wild deer of the Taimyr-Evenki population took away about 1,500 domestic deer [6]. The visits of wild reindeer of this population to winter in Yakutia are confirmed by the tracks we obtained as a result of tagging animals with collars with satellite transmitters (figure 2).

In order to prevent the deer from moving from domestic herds, monitoring of the movements of both wild and domestic deer is necessary, as well as prompt informing of all interested parties. The most effective way to track wild reindeer migrations in real time is to use collars with satellite transmitters.

4. Conclusion

The collars used with beacons of the Argos satellite system manufactured by ES-PAS Ltd have already confirmed a high degree of reliability in extreme conditions of the Far North of the Krasnoyarsk Territory and Yakutia. Primary data on animal behavior for domestic reindeer husbandry are currently being collected. It is planned to form training samples for the tundra, taiga and mountain taiga zones. In addition, it is planned to carry out similar work to optimize the management of herd horse breeding.

It should be noted that the new satellite collars intended for domestic deer can be fully used by scientific organizations to intensify the work on the study of wild reindeer. Reducing the cost of equipment and especially the ability to remotely assess animal behavior will allow you to deploy much more extensive and high-quality work to study the state of wild deer populations, which are currently under the influence of a powerful anthropogenic influence and intense climate changes.

The quantitative values recorded in the database will allow the most accurate characterization of the spatio-temporal distributions of reindeer reflected on cartographic materials. The use of interchangeable collars for the population of domestic deer will allow a more detailed assessment of the behavior of individuals, to associate these data with data on the dynamics of the population. In addition, animal behavior information can be compared with other types of satellite data. An interesting task is to compare the statistics obtained from the collars with meteorological information. Identification of the dependence of behavioral patterns on weather conditions can be used to optimize livestock management based on meteorological forecasts.

Comparison of animal behavior information with Earth remote sensing data can be used to optimize pasture management. The superposition of animal motion trajectories on the results of optical satellite imagery and the subsequent unambiguous determination of the places where the animals ate open up opportunities for mapping precisely those landscapes that can be used as pastures. Based on such maps, a pasture management system can be organized, and the overall potential for expanding livestock production in a given territory can also be estimated.

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