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Lessons learnt from measures taken to prevent rabies introduction and spread into a long rabies free territory (case study of the Irkutsk Oblast)

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SUMMARY

Rabies is endemic on the considerable part of the Russian Federation, and it is associated with current natural outbreaks of the infection. The highest animal morbidity rates are reported in the central and southern regions of the European part of Russia and in the southern part of Western Siberia. The Irkutsk Oblast is among the few regions of our country, which are rabies free for several decades. The research was aimed at the analysis of factors aiding to the maintenance of the rabies free status of the region. Retrospective study of archive and previously published reports on human and animal rabies cases in the Irkutsk Oblast starting from 1954 was performed. Epidemics of urban rabies ceased in the region in 1970s. Sporadic rabies cases in dogs, reported in 1976 and later, could be imported or could result from the infection from bats. Diagnostic errors were also possible. Rabies is reported in foxes in the Subjects bordering the Irkutsk Oblast: Krasnoyarsk Krai and Republic of Buryatia. It is supposed that in case of the infection introduction the forest-steppe agricultural areas near the Angara River are likely to be affected due to high population of foxes. Relative geographic isolation of the Irkutsk Oblast favors to the long animal rabies freedom of this territory. The vast area of mountain taiga with low fox population serves as an ecological barrier. In 2007–2009 and in 2019, barrier oral vaccination was carried out along the border with the Krasnoyarsk Krai and on the west coast of Baikal Lake. Measures for anti-rabies vaccination of dogs and cats were intensified. Active virological monitoring is performed on a regular basis. The paper demonstrates cartograms of fox and wolf population density along with designation of sites, where oral vaccination of wild carnivores was performed.

Key words: rabies, rabies-free territory, oral barrier vaccination, vaccination of dogs and cats.

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Опыт мероприятий по предупреждению заноса и распространения бешенства на длительно благополучной территории (по материалам Иркутской области)

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РЕЗЮМЕ

Значительная часть территории Российской Федерации эндемична по бешенству, что в настоящее время обусловлено активностью природных очагов инфекции. Наиболее высокие показатели заболеваемости животных отмечаются в центральных и южных регионах европейской части России и на юге Западной Сибири. Иркутская область относится к числу немногих территорий нашей страны, свободных от бешенства на протяжении нескольких десятилетий. Целью исследования был анализ обстоятельств, способствовавших сохранению статуса благополучной по бешенству территории. Проведено ретроспективное изучение архивных и опубликованных ранее данных о регистрации бешенства среди людей и животных в Иркутской области с 1954 г. Эпизоотии городского типа в регионе прекратились в 1970-е годы. Спорадические случаи заболевания собак в 1976 г. и позднее, вероятно, могли быть завозными или возникать в результате заражения от летучих мышей. Не исключено также, что могли иметь место ошибки диагностики. Бешенство среди лисиц регистрируется в соседних с Иркутской областью субъектах – Красноярском крае и Республике Бурятия. Сделано предположение о том, что, в случае заноса инфекции, могут быть поражены сельскохозяйственные районы лесостепного Приангарья с высокой численностью лисицы. Длительному благополучию Иркутской области по бешенству животных способствует относительная географическая изоляция этой части ее территории. Экологическим барьером служат обширные пространства горной тайги с низкой численностью лисицы. В 2007–2009 и 2019 гг. проводилась барьерная оральная вакцинация лисиц на границе с Красноярским краем и на западном побережье Байкала. Усилены мероприятия по вакцинации собак и кошек против бешенства. Систематически проводится активный вирусологический мониторинг. В статье приведены картограммы плотности населения лисицы и волка с обозначением участков проведения оральной вакцинации диких плотоядных.

Ключевые слова: бешенство, свободная от бешенства территория, барьерная оральная вакцинация, вакцинация собак и кошек.

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INTRODUCTION

Rabies is one of the dangerous zoonotic diseases having the highest social and economic significance [1]. The damage posed by this lethal infection is associated with the loss of livestock and hunted animals, major costs of anti-epidemic measures including animal vaccination, diagnostic tests as well as preventive and post-exposure vaccination of humans. Risk of lethal disease cases still

exists even in case of well-organized rabies surveillance. Therefore, preventive measures should be taken in order to avoid the infection introduction into the rabies-free territories. These considerations govern the rabies control strategy and tactics in the regions with various epidemic statuses [2–4].

Rabies is endemic on the major part of the Russian Federation and it is currently associated with active natural outbreaks of the infection. The highest morbidity rates are reported in the central and southern regions of the European part of Russia and in the southern part of Western Siberia. Some Subjects of the Russian Federation, however, remain rabies-free for many years [5–7]. Occasional aggravations of the epidemic situation are typical for rabies, and such aggravations are accompanied by the transformation of the nosoarea boundaries. For example, early in this century the epidemics were for the first time reported in foxes in a number of regions of Eastern Siberia. As a result, for a number of years rabies has been reported in wild and domestic animals in previously free territories (southern part of the Krasnoyarsk Krai, Republics of Khakassia and Buryatia, Zabaikalsky Krai) [8–11]. The Irkutsk Oblast remains the only rabies-free Subject in Eastern Siberia.

The study was aimed at the analysis of the aspects contributing to the maintenance of rabies-free territory against the background of the epidemics affecting the neighboring regions.

MATERIALS AND METHODS

Retrospective study of archive and previously published reports on human and animal rabies cases in the Irkutsk Oblast starting from 1954 was performed [5, 12–15]. Sporadic cases mentioned in the statistical bulletins since 1975 were explored.

Currently taken preventive and surveillance measures are presented based on the data accumulated by the Irkutsk Oblast Veterinary Service. Results of virological monitoring performed in 2007–2019 were reviewed. Brain samples collected from hunted wild animals and rabid suspected, diseased or found dead domestic animals (n = 1002) were tested according to GOST 26075-2013 "Animals. Methods of Laboratory Diagnosis of Rabies".

Data on anti-rabies vaccination of dogs and cats are given according to the official records and reports compiled under Forms 1-Vet and 1-Vet A. The data submitted by the Oblast Animal Disease Control Station in 2018–2019 were used for the estimates of the numbers of the domestic dogs and cats as well as stray animals [16].

The barrier oral vaccination of foxes was carried out by vehicles and four-wheeler ATVs. "Oralrabivac" vaccine (FSE "Shchelkovo biocombinat", Russia) was distributed in 2007–2009; and "Rabistav" vaccine (FSE "Stavropol biofactory") was distributed in 2019 according to the manufacturer's instructions. Dynamics of the fox and wolf population number and density was analyzed basing on the data of winter censuses performed according to the methodical guidelines approved by the Order of the Ministry of Nature of Russia of January 11, 2012 No. 1. The census data were correlated with officially reported hunted volumes of these animal species.

Mapping was performed on the basis of the Natural Earth landscape and geographic map using QGIS 3.2.1 software. Rabies infected territories in the neighboring Subjects of the Russian Federation were mapped according to the data published in 2002–2019 [8, 9, 15].

RESULTS AND DISCUSSION

In the mid-twentieth century, urban rabies epidemics raged in the Irkutsk Oblast as well as in many other regions of Russia. This was evidenced by the morbidity patterns. In 1954–1970, 654 rabies cases were reported in animals (78.7% – dogs, 17.7% – farm animals, 3.8% – cats). No disease cases were reported in wild animals. Over the same period, 29 rabies cases were reported in humans with the maximum number to be reported in 1962. Different publications informed of 36 or 37 human deaths due to rabies [12, 14]. In all cases the source of infection involved domestic animals. Two epidemic peaks were reported: in mid-50s and early 60s. After 1963, the morbidity consistently decreased (see Table). Singular rabies cases were reported in animals after 1970: in 1976 – three cases, in 1998 – one case. In the current century, rabies was also suspected in animals basing on the disease clinical signs and dubious luminescent microscopy results. The diagnosis was not however confirmed by the results of the investigations as well as by the expert and laboratory tests. For example, in 2016 a report on a human being attacked by a wolf in the Ust-Ilymsky Raion was posted in Internet, but the investigation demonstrated that the bites were made by a dog, and laboratory test results did not confirm rabies. In 2007–2019, the regional veterinary laboratory tested for rabies a number of samples collected from 433 foxes, 115 wolves, 208 other wild animal species, 228 dogs and cats, 16 synanthropic rodents and 2 farm animals. The virological monitoring results demonstrated no rabies cases. Therefore, over the past 50 years, no rabies epidemics were observed in the Irkutsk Oblast. Sporadic rabies cases in dogs in 1976 could be imported or resulted from the infection from bats. It is well-known that Irkut lyssiavirus is circulating in the chiropterans in Eastern Siberia [17]. Diagnostic errors were also quite possible. Thus, one rabies case reported in a cat in Irkutsk in 1998 was not confirmed [13].

Since 2002, the rabies situation has dramatically changed in the Subjects of the Russian Federation bordering the Irkutsk Oblast. Since that time the epidemic has been persisting in foxes and involving domestic and farm animals mostly in the insular forest steppes in the south of the Krasnoyarsk Krai and Republic of Khakassia. In 2011–2019, fox rabies outbreaks were reported in the Republic of Buryatia and Zabaikalsky Krai. The outbreaks are occasionally reported in the Republic of Tyva [5, 8–11, 18]. The most geographically close to the Irkutsk Oblast rabies cases were reported in Kansk forest steppe and Angara River valley (Krasnoyarsk Krai) located just 50–60 km from the administrative border [9]. In the Republic of Buryatia, rabies spread along the Selenga River and its tributaries to the north up to Ulan-Ude city (approximately 150 km from the Olkhonsky Raion of the Irkutsk Oblast) [8]. This justified the assessment of possible rabies introduction into the Irkutsk Oblast and implementation of the additional preventive measures.

According to fur production volumes during the rabies epidemics in 1950–1965, the number of fox population in the Irkutsk Oblast was specified by low growth rates varied from 1.4–2.7 ths foxes/year. This once again confirms that there was no epidemic in foxes at that time. Thus, for example, in the Republic of Buryatia the number of fox population drastically reduced after rabies virus introduction in 2017 [19]. Maximal number of wolves (about 400 animals) was hunted in 1950 with progressive four-fold reduction by 1965. Due to a number of social and economic reasons there are no reliable data on fox

Table
History of animal and human rabies morbidity in the Irkutsk Oblast in 1954–1970 (archive data)

Таблица
Динамика заболеваемости животных и людей бешенством в Иркутской области за 1954–1970 гг. (архивные данные)

Category	Year																	
	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Animals	173	104	52	79	15	9	19	5	46	71	50	11	1	11	7	0	1	0
Humans*	0	2	0	2	1	1	2	2	9	4	4	1	3	0	0	0	0	0

* Human cases are reported by the date of infection

* Случаи заболевания людей приведены по дате заражения.

and wolf population for the later period (approximately from 1969 to 2000). After 2000, winter census data are available that are indicative of the growth of the population of wolves and mostly of foxes (Fig. 1). The main factor of the current growth of the fox population is apparently the reduction of the hunting pressure. The fox fur is out of demand, and foxes are currently hunted by amateur hunters while hunting hoofed animals. In 2011–2019, on average 489 animals, i.e. about 3% of the recorded number of the population, were hunted annually. As for the wolf, this parameter amounted to 232 animals and 4.8%, respectively.

According to the summaries of the Federal Hunting Reserve Inventory the highest fox population in Eastern Siberia is recorded in the Irkutsk Oblast [20, 21]. The most dense fox population is reported in the Irkutsk-Cheremkhovsk Plain specified by atropogenically transformed forest stepper topography. Mean values of the population density of this animal species are reported in Ekhirit-Bulagant forest steppe and in Taishetsky and Chunsky Raions bordering the Krasnoyarsk Krai. The highest wolf population is observed in the taiga areas (Fig. 2). Comparison of the data on the Irkutsk Oblast and Republic of Buryatia, where rabies has been continuously reported for over three years after it was introduced from Mongolia [19], demonstrates that mean volumes of the wolf population density are similar but mean density of the fox population is higher in the Irkutsk Oblast. The fox population is low in the taiga habitats adjacent to Lake Baikal. The wolf population here is however high due to high number of

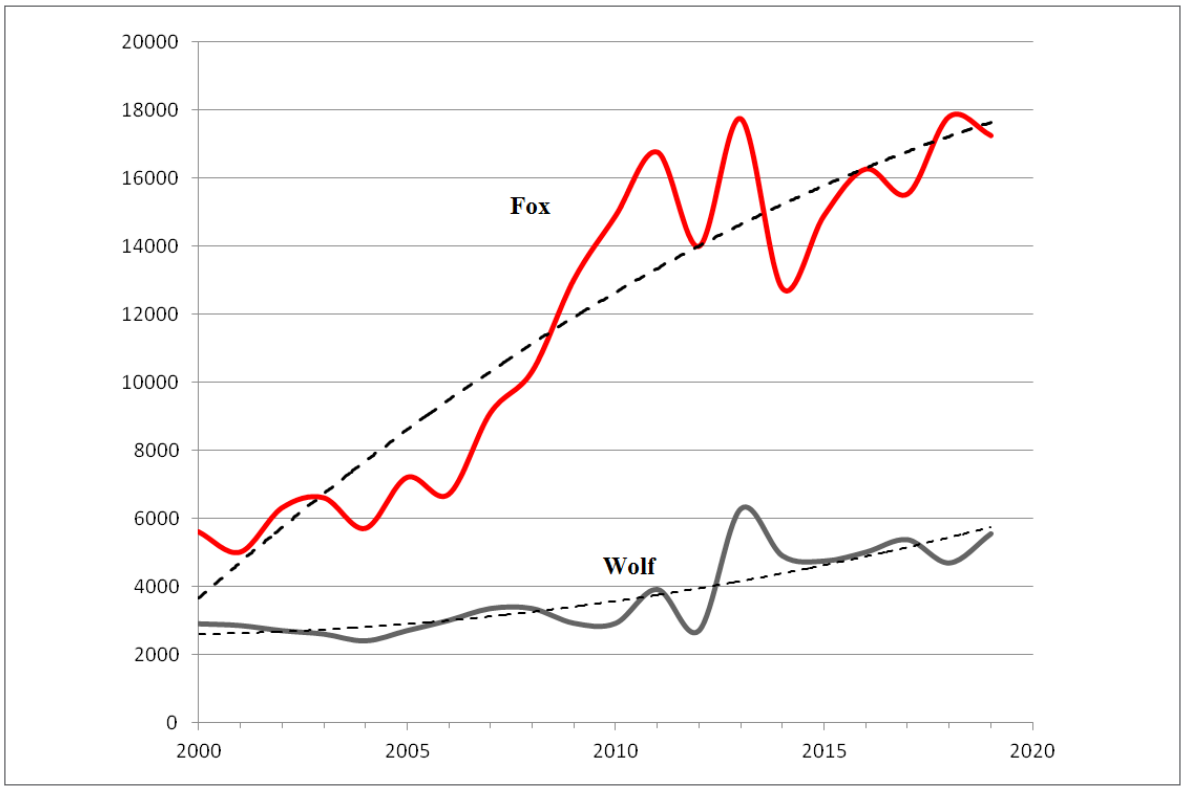

Fig. 1. Dynamics of fox and wolf population numbers in the Irkutsk Oblast by winter census data (number of animals, 2000–2019)

Рис. 1. Динамика численности лисицы и волка в Иркутской области по данным зимних маршрутных учетов (число особей, 2000–2019 гг.)

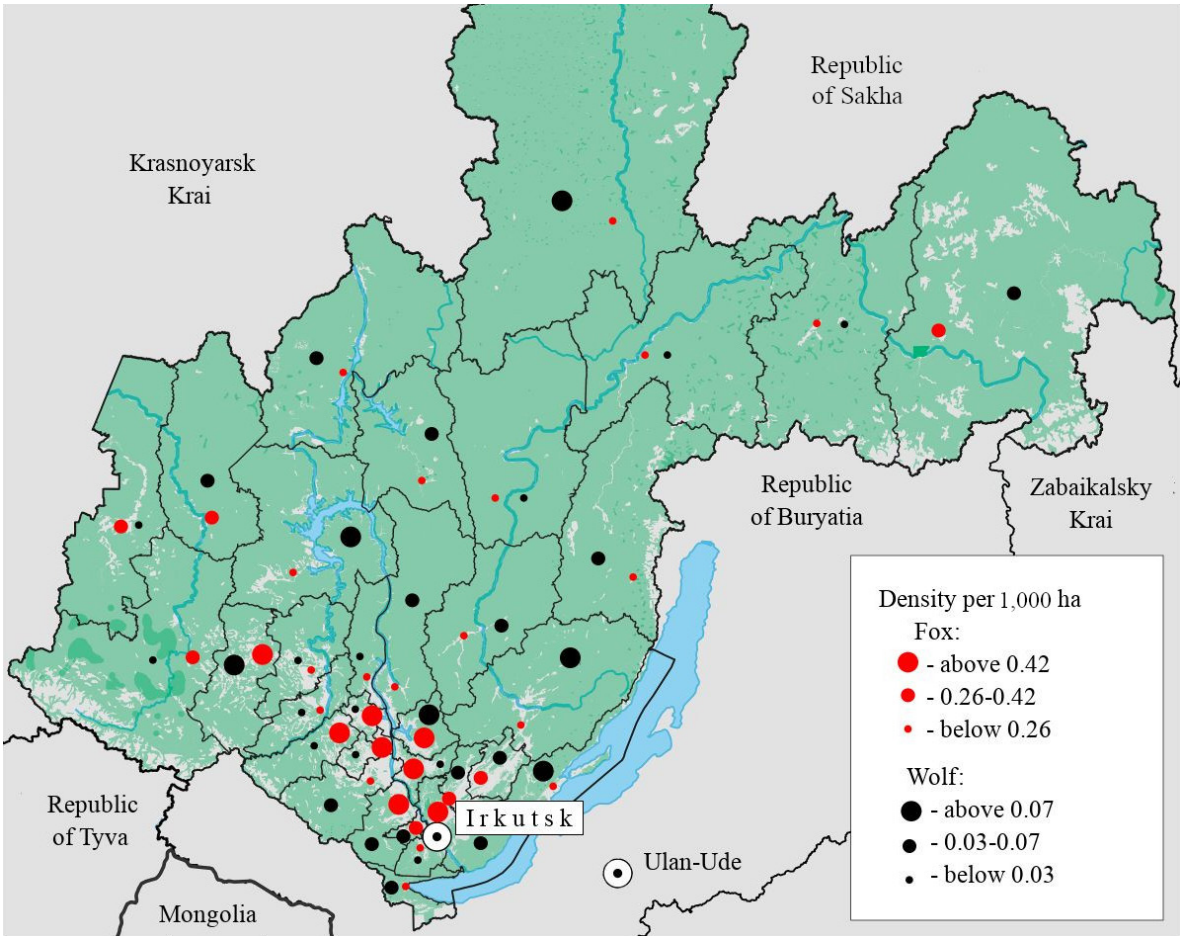

Fig. 2. Density of fox and wolf population in the Irkutsk Oblast by winter census data (average data for 2015–2019 per 1,000 ha of hunting reserves; light colored areas on the map – forest-free territories)

Рис. 2. Плотность населения лисицы и волка в Иркутской области по данным зимних маршрутных учетов (средние данные за 2015–2019 гг. на 1000 га охотничьих угодий; светлые участки на карте – безлесные территории)

wild hoofed animals (Fig. 2). There is low number of foxes on Olkhon Island and the animals mostly feed near the tourist camps and roads. Tazheranskaya steppe provides richer habitat for foxes but their number here is also not high. Pack of wolves (8–11 animals) continuously resides on Olkhon Island. Rare cases of the wolves crossing frozen Lake Baikal from the eastern coast to the western one are known. According to the census the number of foxes and wolves in the Cisbaikalia Natural Park and Baikal-Lena Nature Reserve is estimated within one order of magnitude (wolf – 36–101 animals, fox – 29–116 animals). Therefore, there is a possibility of the rabies virus introduction from the infected regions of the Republic of Buryatia into the specially protected natural areas located along Baikal's coast, but the conditions for further rabies spread in wild animals are minimal here.

Due to the threat of rabies introduction from the Krasnoyarsk Krai, for three years starting from 2007 the barrier oral vaccination was performed in the Nizhneundinsky, Taishetsky, Chunsky and Ust-Ilimsky Raions. The scope of vaccination was increased annually: 2007 – 7.3; 2008 – 37.28; 2009 – 118.0 ths doses. The vaccine was distributed along the 50 km-wide area adjacent to the administrative border. The efforts to form the buffer zone were resumed in 2019: 17 ths doses were used in the Taishetsky Raion along the border with the Krasnoyarsk Krai; three ths doses were distributed in the Olkhonsky Raion (Olkhon Island, southern part of the Irkutsk Oblast) and along the western coast of Lake Baikal (Fig. 3). While selecting the sites for the vaccine distribution the landscape patterns specifying possible habitat and migration of foxes were considered. In the Yenisei part of Siberia and Cisbaikalia, the rabies virus spreads mostly along the river valleys and intermountain forest steppe basins cultivated by humans [8–11]. It is well known that landscape patterns mostly defined the effectiveness of the first oral vaccination campaigns in Central Europe [22, 23]. The Irkutsk Oblast is separated from the Krasnoyarsk Krai, Republic of Tyva and Mongolia by the plexus of Eastern Sayan Mountains with maximal altitudes of over 3.3 ths MASL. Individual ridges with the altitudes of up to 1–2 ths m (Biryusinsky, Gutarsky, Yagi) extend to the north almost up to Taishet. The most probable routes of rabies spread from the west could include territories located northwards – along the Transsiberian railroad between Kansk and Taishet as well as along the Birysa, Chuna and Angara river valleys. In the south, Lake Baikal is an impassable barrier for the rabies virus in summer. However, during 3–4 month after the ice formation singular migrations of wolves from the Republic of Buryatia cannot be excluded. The narrowest part of Lake

Baikal (about 30 km) is in Selenga and Buguldeyka river station. Khamar-Daban and Cisbaikalia mountain ridges are also formidable barriers for foxes, and they protect the Irkutsk Oblast from the south.

Another area of activities involves prevention of the rabies virus introduction with domestic animals. Animal movements by public transport are controlled according to the Order of the Ministry of Agriculture of the Russian Federation of December 14, 2016 No. 635, and thus any possibility of importation of any non-vaccinated animals is nearly excluded. There is, however, a problem of intra-regional transportation by personal transport. For example, over 100 ths people annually come to Lake Baikal in the Olkhonsky Raion, and many of them bring dogs, cats, ferrets and other animals. This further increases the relevance of the vaccination of pets. There are no statistic data on the number of cats and dogs. According to the survey, there is at least one dog and one cat kept on each backyard in the rural communities. Total of 91.8 ths backyards were recorded in 2019, and the scope of the domestic animal vaccination is scheduled according to these data. Starting from 2014, over 80 ths dogs are vaccinated annually. In addition, the number of vaccinated cats has increased significantly (Fig. 4).

After rabies cases ceased to be reported in the Irkutsk Oblast, 3–4 thousand people annually sought medical attention due to injuries caused by animals (160–200 individuals per 100 ths people), and there was a growing trend of this parameter. In different years, from 30% to 77% of such people were vaccinated against rabies [5, 24, 25]. Veterinary monitoring of animals with known owners was performed for 10 days as appropriate and amounted to 75% of total number of cases. However, 25% of cases were due to injuries caused by unknown animals that implies full course of vaccination of the injured individuals. According to the official data, 13 ths stray dogs and cats were recorded in 2019, and Irkutsk accounted for about 10% of them. Of these, 9,855 animals were captured and placed into animal shelters. About 50% of such animals were released after they had been vaccinated, neutered and tagged (microchipping). Monitoring of compliance with animal keeping rules and control of the number of stray dogs and cats still remain intractable social problems.

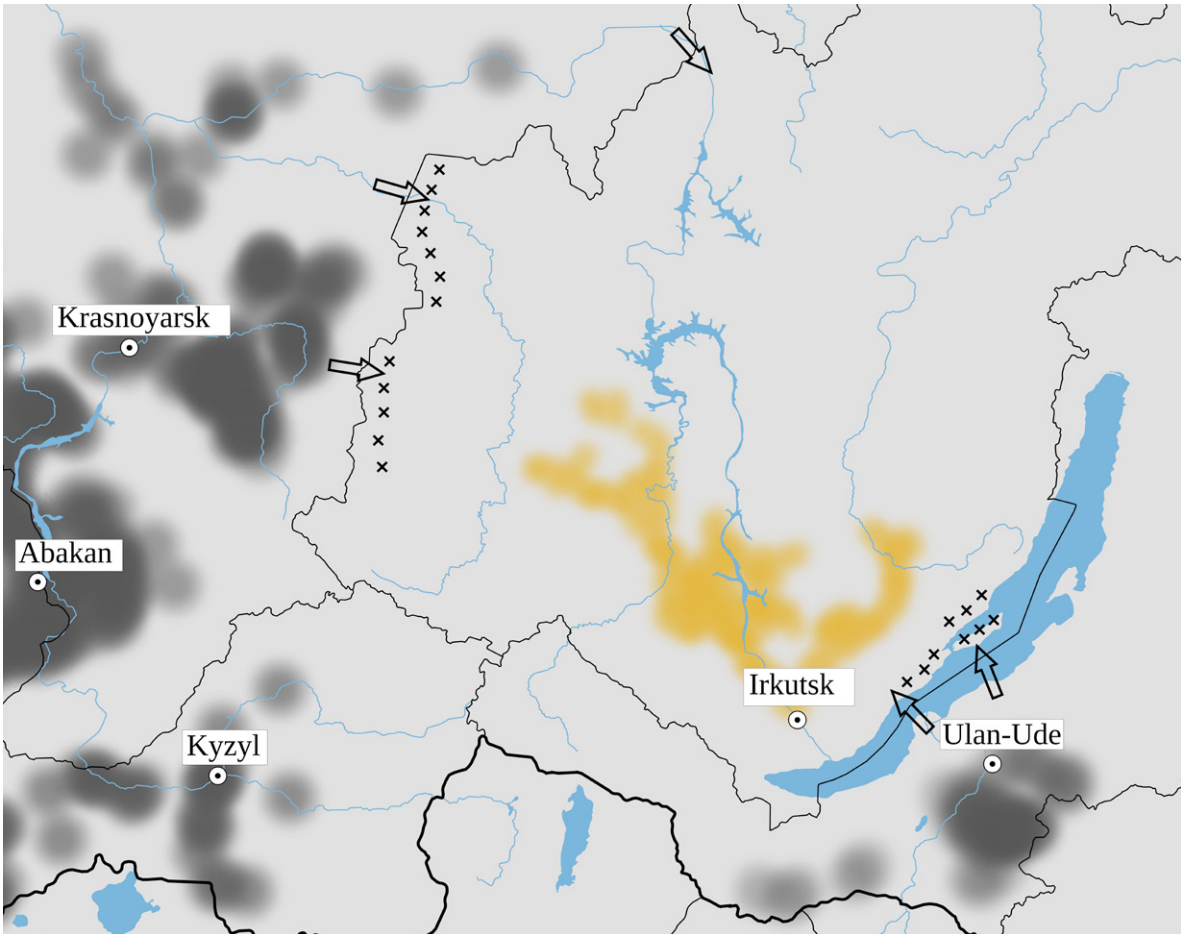

Fig. 3. Estimated probability of rabies introduction and spread in the Irkutsk Oblast and areas of barrier oral vaccination of foxes. Legend: crosses – sites of the vaccine distribution; gray paint – rabies infected neighboring territories; yellow paint – forest-steppe territories optimal for rabies spread in foxes; arrows – most probable routes of rabies introduction with wild animals.

Рис. 3. Оценка возможности заноса и распространения бешенства в Иркутской области и районы проведения барьерной оральной вакцинации лисиц. Легенда: крестики – места раскладки вакцины; серая заливка – неблагополучные по бешенству соседние территории; желтая заливка – лесостепные территории, благоприятные для распространения бешенства среди лисиц; стрелки – пути наиболее вероятного заноса бешенства дикими животными.

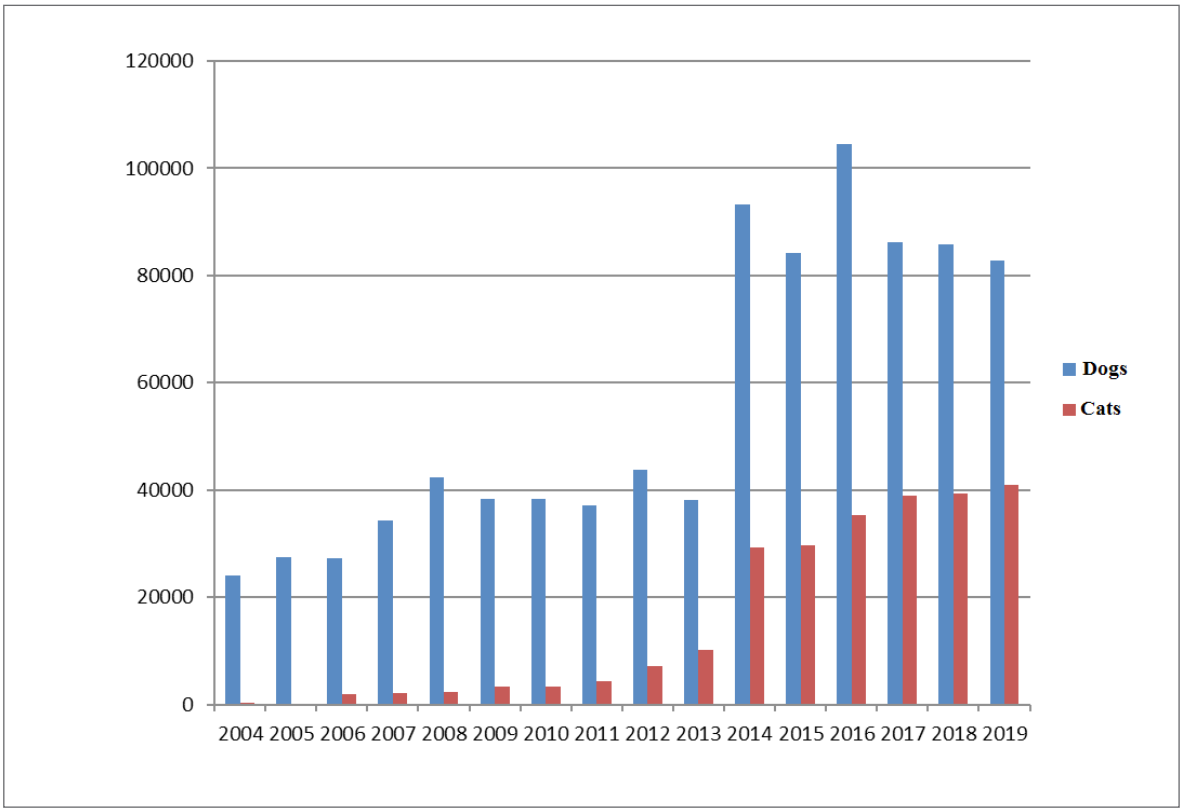

Fig. 4. Numbers of vaccinated dogs and cats in the Irkutsk Oblast (2004–2019)

Рис. 4. Объемы вакцинации собак и кошек против бешенства в Иркутской области (2004–2019 гг.)

CONCLUSION

The probability of rabies introduction into the Irkutsk Oblast has currently increased due to disease presence in the neighboring areas. In case of the infection introduction with the wild animals, the agricultural regions of the forest steppe areas near the Angara are the most likely to be infected due to high fox population. Long disease freedom of the Irkutsk Oblast is favored by relative geographic isolation of this part of its territory. Continuation of the barrier rabies vaccination and preventive measures in the settlements remain of topical significance in the context of Russia's participation in the Zero by 30 strategic plan initiated by the World Health Organization in order to end human deaths from dog-mediated rabies and with regard to the tourism development in the Baikal region.

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