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Population density of the Eurasian beaver (*Castor fiber* L.) (Castoridae, Rodentia) in the Middle Volga of Russia

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Abstract. The article presents research on the population density of the Eurasian beaver in the large, medium and small rivers of the Republic of Mordovia. The population density of the beaver in the large rivers of the region varies from 0.45 to 0.62 colonies per km (average 0.52). The population density in medium rivers ranges from 0.36 to 0.48 colonies per km (average 0.4). In small rivers, population density ranges from 0.2 to 0.94 colonies per km (average 0.46). The total number of beavers in the region is about 17,000 individuals as at 2016.

Key words: Eurasian beaver, *Castor fiber*, density population, colonies, European Russia, Mordovia.

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Introduction

Currently, the populations of the Eurasian beaver (*Castor fiber* L.) are being restored or will be restored in many regions in Russia. However, scientists in different countries need to ascertain population density in different parts of the area (Halley & Rosell, 2003). Beavers undoubtedly affect many ecosystems and knowing the state of their populations is an important task (Johnston & Naiman, 1990; Rosell *et al*., 2005). In 2009–2010, there were 572,500 individuals of the Eurasian beaver in the territory of Russia (Kolesnikov *et al*., 2011).

In Mordovia, river beavers were released in the Mordovia State Nature Reserve by zoological expedition S.S. Turov. This was carried out from 1936 until 1940 within the framework of the programme on re-acclimatisation. In total, 34 beavers were released. The Eurasian beaver was imported from the Voronezh Game Reserve. The release into the wild was carried out in small batches. The beavers were released into forest lakes, such as the Picherki, the Taratinskoe, the Kocheulovo, and the Inorki. As a result, the beaver population has increased rapidly. The beavers from the lakes spread throughout the rivers – the Pushta, the Uzhovka, the Satis, and the Yuzga. By 1950, the number of the growing population was estimated at 300 individuals. In 1956, 40 beaver individuals from the Mordovian reserve were released in the Zubovo-Polyansky District to accelerate settlement in the Vad River. In 1959, there were 600 beavers and in 1964, about 1,000 individuals (Borodina, 1966; Borodina *et al*., 1970) in the Moksha river basin. Since 1961, beavers' dwellings have

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been built (Borodin, 1970; Andreychev & Kuznetsov, 2012) in the Sura river basin.

Until the end of the 20th century, beavers in the region were hunted in all possible ways. As a result, they became extinct. Beaver traps have been prohibited since 2005 when they were included in the Red Book of the region. For a long time, scientific literature included no information on the number of beavers in the region. A small resurgence in beaver trapping has occurred recently. The aim of this work is to determine the density of the Eurasian beaver population in different rivers in one of the central regions of Russia.

Material and Methods

The Republic of Mordovia is located in the centre of the European part of Russia. Its extreme points are defined by geographical coordinates 42° 11′ – 46° 45′ E and 53° 38′ – 55° 11′ N (Figure 1). The maximum distance from west to east is 298 km and the distance from north to south is 57 to 140 km. The area of the republic is 26.2 thousand km^2. Features of the geological structure of Mordovia are determined by its location in the central part of the Russian Platform and the north-western slopes of the Volga Upland. In the western part of the Republic of Mordovia, the Volga Upland reaches the Oka-Don Lowlands.

The climate of the region is moderately continental with pronounced seasons throughout the year. The influx of direct solar radiation in Mordovia varies from 5.0 in December to 58.6 kJ/cm^2 in June. Total radiation throughout the year is 363.8 kJ/cm^2; the radiation balance is 92.1 kJ/cm^2. The average annual air temperature varies from 3.5 to 4.0 °C. The average temperature of the coldest month (January) is in the range of –11.5...–12.3 °C. Temperature drops down to –47 °C occur. The average temperature of the warmest month, i.e. July, is in the range of +18.9...+19.8 °C. Extreme temperatures in the summer reach 37 °C. The average annual precipitation in the territory of Mordovia is 480 mm. Over the course of observation lasting many years, periods of more and less humidification were noted, ranging between the minimum and maximum values of 120–180 mm. Distribution of precipitation across the territory is not very diverse. The average long-term value of evaporation is calculated to be in the range of 390–460 mm.

According to the research of botanists, there are more than 1,230 species of vascular plants from 495 genera and 109 families in the modern flora of Mordovia. These include 4 species of plains, 8 horsetails, 18 ferns, 3 gymnosperms, and 1,197 species of flowering plants. Herbaceous perennial and annual plants predominate. The number of species of woody forms is relatively small: trees – 24, shrubs – 45, shrubs – 7, semishrubs – 5.

The territory of Mordovia includes coniferous broad-leaf, broad-leaf forests, shrub steppes and meadow steppes. The main forest forming species are the Scots pine (*Pinus sylvestris* L.), Norway spruce (*Picea abies* (L.) Karst), European larch (*Larix decidua* Mill.), English oak (*Quercus robur* L.), common ash (*Fraxinus excelsior* L.), Norway maple (*Acer platanoides* L.), Scots elm (*Ulmus laevis* Pall.), silver and pubescent birch (*Betula pendula* Roth., *B. pubescens* Ehrh.), black alder (*Alnus glutinosa* L.), small-leaved lime (*Tilia cordata* Mill.) and black poplar (*Populus nigra* L.).

Coniferous broad-leaf or mixed forests are located in the outwash plains and adjacent terraced complexes. These include both coniferous and broad-leaved trees. In the sands of the outwash plains, the most common are pine forests, often with some characteristics of a taiga. Broad-leaved forests are prevalent mainly in interfluvial spaces of secondary morainic and erosion-denudation plains with grey forest soils as well as in floodplain complexes.

Mordovia is located in the south-western part of the Volga River basin. 47% of the area is located in the basin of Sura and

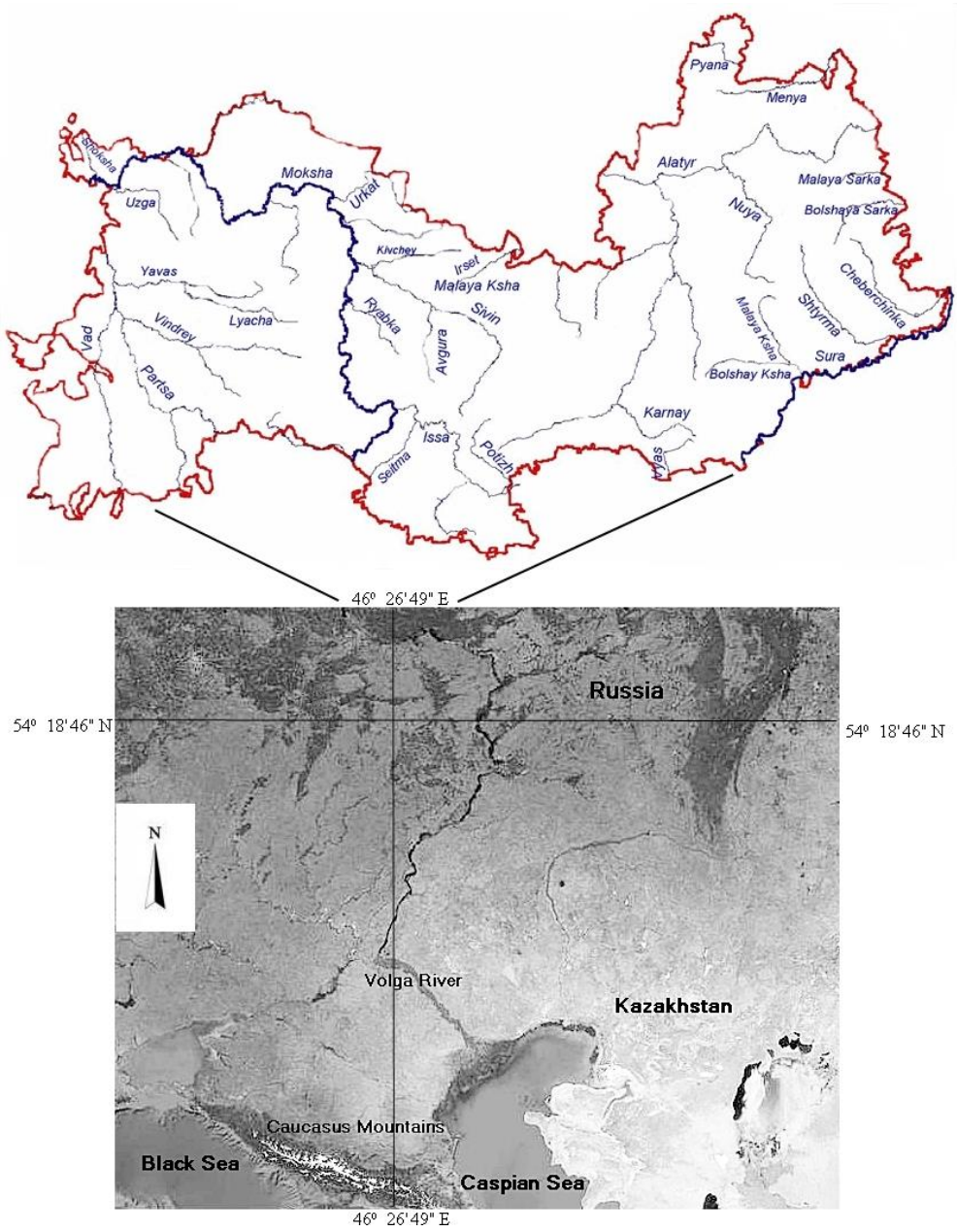

Figure 1. Geographical position of the Republic of Mordovia in Eastern Europe.

53% in the basin of Moksha. Moksha is the main river in western Mordovia that flows in the meridional direction to the confluence of the Urkat River, where its direction changes to the sublatitudinal. The Moksha is the right tributary of the Oka River and empties into it. The channel is 60–90 m wide and 5–8 m deep. The absolute water level is 89–126 m. The Moksha's largest tributaries in the territory of Mordovia are the Vad, the Satis, the Urkat, the Sivin, and the Issa.

The Sura River flows along the southeastern border of Mordovia. The width of the channel varies from 100 to 150 m and its depth is 10 m. It flows 0.3–1.0 m/s and its absolute water level is 90–115 m. The largest tributaries of the Sura include the Bolshaya Ksha, the Bolshaya Sarka, the Piana, the Menya, and the Alatyr.

The density of the river network in the entire area is 0.23 km of river per km^2. By the nature of intra-flow distribution, the republic's rivers are of Eastern European type. The water regime of the rivers is characterised by the presence of summer and winter seasons, spring floods and autumn floods. The most high-water month is April. 3–15% of annual runoff occurs during the low-flow period.

The river's length is used in the study as a criterion for classifying rivers. We validate this method because most reference books on surface water resources are based on that classification (Sokolov, 1964; Sokolovsky, 1968; Yevstigneyev, 1990; Chalov, 1994). According to this classification, large rivers are rivers, the length of which varies from 301 to 1,000 km. Medium rivers are rivers with the length of 101 to 300 km. Small rivers are rivers, the length of which ranges from 26 to 100 km. The smallest rivers are usually the rivers with the length of up to 25 km. In the territory of Mordovia, there are about 1,520 watercourses with the total length of 9,250 km. The major share (96%) of the river network of the republic falls on the smallest rivers. These constitute 65% of the total length of all rivers. Small rivers make up 4% of the total and 22% of the length of all rivers. The share of medium-sized rivers (the Issa, the Sivin, the Insar, the Partsa, the Vad, the Visha, and the Alatyr) in the total length is negligible (0.5%). Two rivers – the Moksha and the Sura – are more than 500 km long (Water resources…, 1999). Small rivers and streams are distributed unevenly in the basins of large rivers. In the river Sura, there are 24 small rivers and 286 very small rivers and streams. 30 small rivers and 385 very small rivers and streams flow into the Moksha River.

It is typical for small rivers to have a 5 to 10 m wide channel, with extensions up to 35 m; for average rivers, from 25 to 50 m with extensions up to 70 m. Large rivers are 100 to 150 m wide and in the mouths, 300 m. Rivers are shallow and the prevailing depths for small rivers is 0.4 to 1.2 m, for average ones 1.5 to 2.0, and for large ones 2.5 to 3.5 m. In rundowns, the depth throughout is less than 0.5 m. The flow rate varies from 0.2 m/s to 1.2 m/s in rundowns.

The studies were conducted on the rivers of Mordovia during the period of 2008–2016. The research was carried out in autumn, spring and summer due to a large amount of work. The rivers were surveyed by using the method described by Dyakov (Dyakov Yu, 1975). The number of settlements in the rivers' areas was recorded. The site of the river was selected and the number of settlements in the channel was determined. The density of individuals in the settlement was estimated by feeding activity and other traces of life activity (huts, dams, burrows). A great help in the work was provided by hunters' survey data.

Initially, enumeration was launched in 2008 in the Chermeley River in the Sura river basin (Andreychev *et al*., 2009). The counting station included 21 km from the mouth on the riverbed. Each settlement was indicated on the map by using GPS and the programme OziExplorer. This pro-

gramme made it possible to calculate the distance between settlements, dams, and lodges, as well as calculate the area and length of the coastline.

The volume of counting work covered 468 km of large rivers, 558 km of medium-sized rivers, and 1,269 km of small and very small rivers. Statistical analysis was performed in MS Excel and PAST (Hammer *et al*., 2001).

Results

The population density of the Eurasian beaver in large rivers in the region ranges from 0.45 to 0.62 colonies per km (average 0.52) (Figure 2). The population density in medium rivers varies from 0.36 to 0.48 colonies per km (average 0.4). In small rivers, population density ranges from 0.2 to 0.94 colonies per km (average 0.46) (Sosnina *et al*., 2014). Thus, the average density of the beaver in large and small rivers is higher than in average rivers. However, the density of the Eurasian beaver population in small rivers is ambiguous. They can be divided into three groups: those with a low population density (less than 0.3 colonies/km), average density (from 0.3 to 0.5 colonies/km), and high density (more than 0.5 colonies/km).

The estimation of the number of beavers in different classes of rivers in the region showed that most settlements fall on small and smallest rivers. 250 beaver settlements were registered in large rivers and 220 settlements were registered in average rivers. By extrapolation, it can be assumed that the number of settlements in medium rivers can be up to 300. Small rivers accounted for 570 settlements. In small and smallest rivers, with a total length of 8,032 km, the number of settlements can be up to 3,700. Thus, the ratio of settlements in large, medium and small rivers is as follows: 6%, 7%, and 87%, respectively. The total number of settlements in the rivers of the region is 4,250. Taking into account that, on average, there are 3–4 individuals per settlement, it is easy to determine the total number of beavers as 17,000 individuals only in rivers. Moreover, it is necessary to take into account that beavers live practically in every lake in the basin of the Sura and the Moksha, as well as in artificial ponds (ponds). Therefore, the number of beavers in all reservoirs in Mordovia will be even higher.

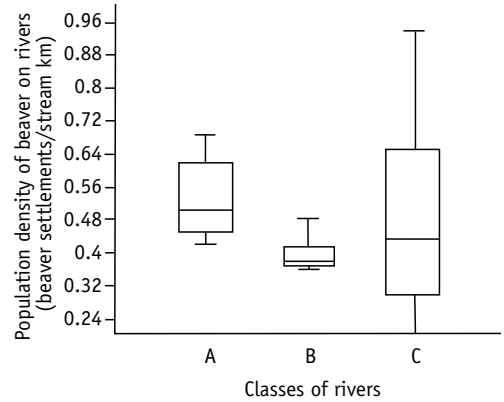

Figure 2. The variation range of Eurasian beaver population density on the region rivers. A – big river (n = 3), B – average river (n = 5), C – small river (n = 33). Box plots indicate median (solid line), 25–75% range (box) and the minimum and maximum values (whiskers).

Discussion

Literature includes a lot of guidance on the restoration size and density of the Eurasian beaver and the American beaver (*C. canadensis*). There are reports that beavers were reduced in number at the site where they were cut off by moving to neighbouring areas (Bhat *et al*., 1993; DeStefano *et al*., 2006). This is evidenced by the number of beavers in different countries. A similar pattern was observed in the western rivers of Mordovia, in particular in the Vad, the Partsa, and the Vyndrey.

Somewhat lower numbers of beaver population density compared to the rivers

of other countries were found particularly in the European rivers of Mordovia. It should lead to comparisons of the situation in some other regions. The density of beaver population in Newfoundland is 0.24 beaver colony sites/km (Bergerud & Miller, 1977).

Our data on the density of beaver settlements are consistent with the results of scientists from Norway, Sweden, and Finland (from 2.4 to 3.8 individuals in the settlement) (Parker *et al*., 2002; Rosell *et al*., 2006). The density of the American beaver population in Tierra del Fuego (TDF) (Argentina) is 0.2–5.8 beaver colony sites/km (Lizarralde, 1993). Between 1999 and 2001, the mean density of the beaver population in the Chilean part of TDF and the adjacent southern island Navarino (NAV) was 1.03 (range: 0.15–1.91) and 1.1 per km (Skewes *et al*., 2006).

Comparable results of counting can be led by counting areas of the American beavers in Allegany State Park and their vicinity in New York from 1984 to 1996, thus the density of the breeders was 45 to 64 pairs × 2 / 250 (study area) = 0.36 to 0.51 beavers/ km^2 (Sun *et al*., 2000)

In southwestern Sweden, according to an estimate calculated as the sum of all found colonies divided by the sum of all surveyed areas, the beaver population density of the whole province increased from 0.10 colonies/km^2 in 1976 to 0.19 colonies/ km^2 in 1987, and then levelled at 0.21 colonies/km^2 in 1999 (Hartman, 2003).

Our research has shown that in small rivers of the region, the conditions for beaver habitation are better in comparison with medium and large rivers. In the conditions of the continuing protection of the beaver population in Mordovia, it is possible to restore their abundance in the rivers where they were exterminated due to movements from neighbouring small rivers. The species from the Red Book cannot be excluded. In the future, it is necessary to conduct constant research on changes in the number of beavers in different river sections. The obtained data should be taken into account in the future with subsequent releases of beavers in different landscapes of Mordovia. They are important for environmental organisations in the region (Andreychev, 2012), as the restoration of water dwellers depends on the success of their activities. It is known that by restoring beaver populations, conditions for biodiversity are created and improved.

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