Features of population and distribution dynamics of the Eurasian beaver (*Castor fiber L*) in the Kursk Region

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Abstract. The population of the Eurasian beaver (*Castor fiber L*) significantly decreased in the Kursk region (Russia) in 70-90 of the twentieth century. The opposite picture is observed from the beginning of the 21st century. There is a significant increase in the population of beavers leading to enormous environmental problems. In this regard, the task for controlling the size of beaver population to minimize the environmental damage to their habitat falls on man. The first stage to complete this task is to measure the exact number of the Eurasian beaver population, and the second one is to optimize its number in accordance with the land capacity. Measurements in all districts of the Kursk region from 2013 to 2018 has been carried out using the method of linear accounting of the population and visual inspection. The result of the work is to identify the trends and dynamics of the beaver population, and to regulate the beaver population in accordance with the specificity of their habitat lands in future.

1. Introduction

One of the interesting directions in the study of the vital activity of beavers is the study of the influence of external factors on the change in the optimal activity patterns of these animals. The results have showed that beavers can change their activity patterns in response to external signals [1,2]. We have also been interested in the construction of beaver dams when, on the one hand, there is a benefit from aquatic and terrestrial biota, on the other hand, the connectivity between various drainage networks is changing dramatically. At the same time, the authors note the modification of river forests and wetlands, with the expected subsequent flooding, and observe extensive extinction of trees in the flood zone [3-7]. Since one of the aspects of our work is the study of populations’ growth, we have also paid attention to the publications that deal with the study of the density of beaver populations in water basins, their reproduction and migration. Particular attention is paid to the all-round effects of animals on herbaceous and woody vegetation. [8-11]. Works on the effect of beaver ponds on the quality of the water itself [12] and the content of certain chemical elements have also attracted our attention [13].

The Eurasian beaver (*Castor fiber L*) is the largest rodent which is adapted to semi-aquatic lifestyle. Its body length is up to 100 cm. The tail length is up to 36 cm, the tail width is 10-13 cm. It weighs up to 35 kg [1]. Females and males of the same age have approximately the same weight. The beaver is very unpretentious. If you do not disturb them, they can live either in close proximity to settlements or even in them. It should be taken into account that anthropogenic factors may influence on the distribution of the population. Availability of suitable reservoirs and food is the necessary
condition for the beaver habitat. Other researchers have noted that when they settle in the certain areas of the riverbank land, beavers begin to influence the processes occurring in water bodies and riverbank biogeocoenosis from their first days [14-16].

All at once beavers interfere in the stable water life and aquatic phytocoenosis by eating woody shrubs and herbaceous plants. Then the beavers begin to arrange their settlements. This process results in disruption of the riverbank integrity when digging the holes and throwing the soil out of them.

The relationship of the beaver family main members also draws the attention of researchers. Beaver couples are contractual, and there are cases when beaver couples live together throughout the entire period of reproduction life. Sometimes, unexpected events occur in beaver families, the reasons of which are difficult to define, because they are not sufficiently studied. Sometimes the reason of “explosive” disappearance of beaver family or the decrease of its size is the death of one animal. In such families, there are baby beavers of the same sex with the remaining beaver. They can not provide reproduction and gradually or at one time leave their settlement.

At this stage of our research, both the number dynamics and the habitat-forming role of beavers are of particular importance, because these make it possible to carry out bioecological monitoring of beaver settlements, to regulate the balance of forest biogeocoenosis in accordance with their habitat conditions. We have conducted our work in two directions: statistical studies (data collection) and field research. The second direction (field research) has been carried out due to the necessity to obtain specific information about the current state of the beaver population in the Kursk region. Of course, the research has required us to know the location of beaver populations in the selected area. The aim of our work is to study the abundance, its dynamics and distribution of the beaver population in the territory of the Kursk region.

2. Experimental part
The object of the study is the Eurasian beaver (*Castor fiber* L) on the territory of the Kursk region. The distribution and abundance dynamics of beaver in the Kursk region are the focus of this research.

The measurement of beaver settlements and abundance was carried out by the method of linear route census – the study of water passages and river areas [2, 3]. The measurement was carried out in accordance with the guidelines for measuring the number of hunting animals in the Forest Fund of the Russian Federation, approved by the order of the Federal Forestry Service of Russia [1]. This account is made to determine and calculate the number of beaver settlements by biting marks. The most intense bites are observed in the center of the settlement of the beaver family. Biting marks are less noticeable along the periphery. On this basis, the boundaries of the family settlement are determined.

We outline linear routes on the map. Focusing on it, we find traces of vital activity of the Eurasian beavers (bites and biowaste) in nature, that is, we mark the settlement and continue river checking. The next settlement is noted only if the distance between the two detected bites exceeds 400-500 m. The boundaries of the settlement, in which beavers use several neighboring water bodies, can also be established by biting marks and biowaste. When working on a river water passage, both banks of the river can be inspected at once. This, in its turn, greatly facilitates the calculations. If the river banks are gently sloping, you can walk along the water's edge along the bank. High banks interfere with the inspection of the river area. If the length of the water body reaches more than 500-600 m, then it is usually assumed in this percentage ratio of more than 3, 4 beaver settlements, which in its turn has a percentage of 78% of the occupied area of the hunting grounds of the Kursk region on 1 hectare of settlement. Therefore, it suffices to find at least one settlement on a given water body, note this settlement on the route and, move on to the next one, by noting all settlements on this route.

The processing of the collected materials is quite simple. The total number of the species or population is obtained by summing the number of settlements multiplied by the conversion factor (average number of beavers in one settlement). All constructions and traces of vital activity of beavers, their arrangement and parameters were registered in each settlement. The form of the constructions and composition of each settlement were also noted.
3. Results and discussion
Beavers are monogamic rodents. The number of beavers in the family varies from one to ten animal individuals. Most of beavers reach their sexual maturity towards the third year of life. However, the observations in natural surroundings in the Kursk region have shown that a certain percentage of two-year females participate in reproduction in different populations. Mating often occurs in water. Gestation period lasts for 102-108 days (106 days on average), for the North American beavers – 106-111 days (107 days on average).

In April-May a female gives birth to 1-6 beaver kittens. This number depends on the age of the female: the old ones give birth to 3-4 kittens, the young – to 1-2 kittens on average. The weight of a newborn kitten is no more than 400 grams. Lactation period lasts for 1.5 months, but may last up to 3 months. Young animals begin to swim in a week after their birth.

Table 1. Dynamics of the Eurasian beaver population in the Kursk region for the last six years

| Name of district | The number of beaver individuals of all age groups |
|------------------|--------------------------------------------------|
| Belovsky         | 57 90 113 201 280 364                            |
| Bolshevoldatsky  | 100 119 123 130 134 144                           |
| Glushkovsky      | 117 144 154 165 181 200                           |
| Gorshechensky    | 176 184 191 200 216 224                           |
| Dmitrievsky      | 188 197 201 216 225 232                           |
| Zheleznogorsky   | 50 56 60 65 73 85                                |
| Zolotuhinsky     | 20 26 130 133 145 160                            |
| Kustorensky      | 260 270 279 290 310 316                           |
| Konysevsky       | 613 624 637 640 655 685                           |
| Korenevsky       | 785 792 802 840 870 900                           |
| Kursky           | 62 97 115 120 128 133                            |
| Kurchatovsky     | 146 151 158 165 176 188                           |
| Lvovskyy         | 349 354 368 375 385 410                           |
| Manturovskyy     | 229 238 246 251 269 295                           |
| Medvensky        | 340 349 358 365 378 395                           |
| Oboyansky        | 50 54 65 71 80 84                                |
| Octyabrsky       | 195 200 219 226 239 244                           |
| Ponyrovskyy      | 70 74 89 95 100 116                              |
| Pristensky       | 135 139 148 155 160 180                           |
| Rylysky          | 420 427 430 439 450 500                           |
| Soviet           | 115 120 125 130 135 140                           |
| Sujan            | 230 233 243 258 268 304                           |
| Timsky           | 150 152 160 170 175 185                           |
| Fatezhsky        | 120 138 150 165 171 184                           |
| Khomutovsky      | 120 150 178 185 200 210                           |
| Chereismsinovsky | 167 187 196 105 120 128                           |
| Shchigrovsky     | 187 202 225 234 267 300                           |
| Total in the region | 5651 5967 6263 6489 6890 7406 |
| Maximum          | 785 792 802 840 870 900                           |
| Minimum          | 50 54 65 71 80 84                                |

So, the main beaver community is their family or so-called beaver settlement. Beavers may live alone, which is a temporary phenomenon in most cases. Most often (in common conditions) beavers live in their families. In summer, when the beaver families “disperse”, adult males may be thought to
be alone when they leave their families. A common composition of beaver settlements in the Kursk region is a couple of adults and young beavers of two generations.

It is a well-known that settlement size of beaver family depends on the season. The minimum size is watched in winter, the maximum size – in summer [17]. During the summer period the distance between beaver settlements (in the Kursk region) decreases up to 310 m on average with fluctuations of no more than 100 m. It leads to a dense expansion of beaver population. The features of habitat conditions have a significant impact on all stages of beaver settlement existence, and on their size in every particular population. Young beavers disperse in spring at the end of the second year of life before their parents have other kittens. In rare circumstances, the dispersal may occur a year earlier or later: in such cases there are families with several generations of young beavers. The average size of a beaver family in the naturally restored population is close to 4-6 animal individuals in this region.

Six-year observations show that the activity of the Eurasian beaver in the Kursk region is threatening one. It leads to the transformation of river systems (complex) and the system of forest and swamp hunting areas. In general, we should not forget that beavers like other fauna representatives are an integral part of forest ecosystems. The influence of beavers on forest stands in the Kursk region is ambiguous one. On the one hand, beavers harm forestry of the region due to the great number of individuals, destroying not only tree species, but also damaging the undergrowth and young forest stands. Thus, the efforts of forest managers to afforest the Kursk region come to nothing. On the other hand, indirect activity of beavers transforms some territories of the Kursk region. So, banking up the rivers and streams by beavers in dry forests leads to water saturation of soil. It significantly improves the growth of trees.

The total area of the Kursk region is 29997 square km; the forest occupies 8% of this area. Beavers’ habitats occupy 75% of the State Forest Fund, where hydrological conditions are of great importance for the natural dispersal of beavers. We have analyzed the naturally restored populations of the Eurasian beaver (table 1) based on our data collection and field studies.

We have noted that the number of beavers in the Kursk region has been consistently increasing from 5651 animal individuals (2013) to 7406 animal individuals (2018) over the past six years. The largest populations are in Korenevsky, Rylsky and Konyshevsky districts, the smallest populations – in Oboyansky district. In all the districts, except Cheremisinovsky one, beaver population is increasing (Figure 1).

Figure 1. The number of the Eurasian beavers in the districts of the Kursk region for the last six-year period (from the maximum to the minimum population) and the ratio by years.
In our region, this rodent prefers forest water bodies, especially rivers of small and medium sizes, but it may settle in large, slowly flowing rivers (the Seym River and the Svapa River), as well as in lakes, river-formed lakes, ponds, channels, and swamps. Outside forests beavers prefer waters with shrubs and hardwood and cattail on the banks. The important features of the state for forest stands are the age structure of tree species, the nature and rate of decay, the stock of stands, especially the composition of canopy, modified composition and placement of the recovery. In addition to the above-mentioned criteria, the assessment of damage to the forest stand caused by biting activity of beavers in the Kursk region is necessary to be taken into consideration. This is due to the presence and degree of degradation processes of stands under the influence of Eurasian beaver vital activity.

Their activity in transforming the landscape often comes in conflict with the cultivation of forest stands. Of course, we should note that the majority of destroyed forest stands in this area are of low value. The damage to the forestry caused by beavers is considered negative only if the area (specifically the floodplain) becomes woodless and coniferous tree species are replaced by deciduous species – aspen and birch. If a beaver settlement is located in acceptable place, there is no conflict with other branches of forest use. Beavers visit the forests located near their settlements throughout the year looking for food. They damage both forest stands and self-grown plants (biting the trees).

Thus, we conclude that growing number of the Eurasian beaver is threatening in the Kursk region. The damage size depends, first and foremost, on the needs of animal to feed in winter. The intensity of damage may also be influenced by snow depth, etc. Bark, tree shoots (aspen, willow and birch) and herbaceous aquatic plants (water lily, cow lily and cattail) are the main food for beavers in the Kursk region.

There are 4 agro-climatic zones in the Kursk region, which determine the habitat of the river beaver: Northern, Southern, Western and Eastern ones. Each zone is characterized by different climatic and natural conditions, which affects the dispersal of beavers and determines the specificity of the population dynamics of these animals in each zone. The positive factor is that the main forest stands of these zones are located in floodplains and, consequently, there is sufficient biotopic capacity for beavers.

Harmonious exploitation of biological resources, management and regulation of populations is possible only if there are clear picture of spatial and ecological structure of the population. The variety of landscape, soil, climatic, anthropogenic conditions of the Kursk region determines the features of beaver expansion and their influence on the species composition of plants and animals and hydrological behavior of the territories. The extent of beaver impact on ecosystems depends on their number and the intensity of their dispersal.

We have analyzed spatial and temporal dynamics of the Eurasian beaver populations in agro-climatic zones in the Kursk region. The assessment is based on the personal field researches and on the data of the Kursk Region Forestry Committee (table 2). We can see uneven dispersal of beaver population in the agro-climatic zones which requires further study.

| Table 2. The dispersal of beaver in the zones of the Kursk region |
|----------------------------------|------------------|
| Agro-climatic zones of Kursk region | Population (%) |
| Northern                        | 28               |
| Southern                        | 15               |
| Western                         | 32               |
| Eastern                         | 25               |

One of the objectives of our research is consideration of types, location, shape, and parameters of constructions of beavers.

Many animals can build shelters. Perhaps, no animal has such highly developed and varied “building” instincts. This animal keeps the level of water supply near its habitats by building beaver dams, tunnels, channels, trails. It allows beavers to get food and to ensure security.
The main construction material is twigs, branches and parts of tree stems (20-25 cm in diameter) and bushes. They may be fresh and old, but beavers have not harvested them. Animals use small and short branches without cutting them into pieces. Branches and tree stems with a diameter of 6-10 cm or more are gnawed into pieces. It can be noted that the thicker the tree stems are, the shorter parts they are cut into. The sizes of branches and parts of stems may be significant. Their mass is up to 10-14 kg. The bonding material of constructions is sludge extracted from the bottom of water bodies, channels, etc. Animals bring fresh and dead parts of herbaceous plants, fallen leaves and other material together with sludge or top layer of other soil.

The classification principles of beaver lodges are well known. But we would like to emphasize the specificity of beaver lodges in the Kursk region. Beavers build shelters in late August. All beaver shelters that we observed may be divided into three types: lodge, semi-lodge, and a hole.

Beaver lodges are conic-shaped isles protruding from under the water. The height of such lodge is 3-4 meters with a diameter of 10-12 meters. The entrance to the shelter is always under the water. Lodges are built from brushwood bonded by sludge, soil and clay. Beavers carefully coated the walls of their shelters with sludge and clay. So, beaver lodge is a solid construction, and the air passes through the passage that is on the upper part of the shelter. There are also passages into the water and the platform that is above the water level. When it gets freezing, beavers additionally coat their lodge with a new layer of clay using the forelegs. In winter, the temperature in lodges is above zero, the water in the passages does not freeze and beavers easily go under the ice of the water body. In winter, there is steam in lodges inhabited by beavers, so air passes into their shelter.

Semi-lodge. A beaver builds it if the passage is collapsed, and there is no space to build a new one or if they do not want to leave the familiar place. Semi-lodge is neither lodge nor a hole. Thus, two types of lodges may be found in a beaver settlement. The entrance to the lodge is under the river bank, and there is a shed made of branches and grass which is bonded with sludge. Beavers dig holes in places with steep slopes.

Hole is a chamber which is about one meter in width. The floor is often covered with dry grass or chips of twigs, which makes a lodge more comfortable.

4. Conclusion
We have observed that the vital activity of beavers changes the hydrological regime and entails syngenetic processes in the biotopes of settled rivers in the moderate continental climate.

Environmental activity of the Eurasian beaver changes the biological productivity of aquatic and semi-aquatic ecosystems, and thus leads to structural changes of each biotope inhabited by beavers, and on the whole, to the change of hunting areas. Since the beaver uses aquatic plants for food and construction, and its ponds act as sanitation facilities and storage of fertile sludge, it is difficult to overestimate its edificatory role in nature.

Beavers strongly affect ecosystems of small and medium sized rivers that are the main water passages in the Kursk region. In this regard, the study of the reacclimatization impact has become the most relevant in recent years.

We have drawn a number of conclusions analyzing the population and dispersal dynamics of beaver in the Kursk region:
- Construction and foraging activity of beavers is very huge; it changes river and near-river biogeocoenosis and the main forest-forming species;
- Selective felling of trees leading to the change of species is different in various growing conditions and often has negative impact;
- The problem of control of the Eurasian beaver population and their compliance with the ecological capacity of the area becomes very urgent task and requires additional research;
- The actual population of beavers in the Kursk region in 2013-2018 is 38.666 individual animals. The percentage of the population of the Eurasian beaver in publicly accessible hunting grounds is 69% of the total number in comparison with the territories owned by hunters.
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