Impact of Reservoirs on the Fauna

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Abstract—The main forms of the impact of man-made lakes on terrestrial fauna populations and communities are considered. Peculiarities of the effect of man-made lakes on zoocomplexes in the upper and lower pools of hydraulic structures are analyzed. Approaches to developing measures aimed at decreasing environmental damage caused by reservoir construction are substantiated.

SCALE OF THE IMPACT OF RESERVOIRS ON THE FAUNA

Reservoirs construction and operation have a considerable effect on the fauna. Such impact is caused by: replacement of land areas by water bodies, which entails natural complexes succession; changes in the hydrological regime of the water body in the upper and lower pools of a hydraulic structure; waterlogging of coastal areas; micro- and mesoclimatic changes; formation of new borders and barriers that were not found in the previously existing natural complexes; intensification of economic activity in the vicinity of the hydraulic structure. The above factors can have direct, indirect, or consequential effect on individual organisms, populations and communities of animals in the zone of reservoir impact.

The total area of land inundated by reservoirs makes about 400,000 km². The area affected by reservoirs is comparable to their water surface area and in some cases exceeds the latter. Construction of reservoirs and changes occurring in the lower pools of hydraulic structures have modified the natural conditions on the area of 700,000 km². Economy infrastructure reorganization and population resettlement from the zones affected by reservoirs occur on the area of 1.5 mln. km². Fauna living conditions on this area have also changed. It goes without saying that the further development of water economy will increase the areas, where water management measures will affect the fauna.

FORMS OF ARTIFICIAL WATER BODIES IMPACT ON THE FAUNA

The indirect impact of reservoirs on the fauna manifests itself in the succession of abiotic (microclimatic, hydrological, and hydrochemical conditions, topography) and biotic (soil, vegetation, zoocomplexes) components of natural complexes. Examples of multifaceted consequential effect of hydraulic structures on the fauna are well known. Thus, reservoir construction modifies the wind regime. Vast water or ice surface areas have a smaller roughness coefficient, than valley forests. That is why the average wind velocity above the reservoir is 1.5–2.0 times higher than in the river valley. Due to strong winds, in winter, there is little or no snow on the ice surface of certain reservoirs (the Kolymskoye, Zeiskoye, etc.). Most of wild ungulates become absolutely helpless on smooth and slippery surface [31]. That is why the ousting of ungulates and other game on the ice becomes the main hunting technique of wolves. As a result, on some of the reservoir coasts, the press of wolves hunting wild ungulates increases (Table 1).

Different types of reservoirs impact on the fauna can manifest themselves either immediately, in the process of construction (e.g. destruction or disturbance of animal migration routes [6, 33]), or during the initial reservoir filling (general destabilization of zoocomplexes, decrease in the number of animals, complete cessation of seasonal migrations [10]), or much later, after natural conditions have changed (e.g. succession of species, dominant in the communities, and secondary destabilization of zoocomplexes [27]).

When the water level rises, the number of the greater part of mammal [13] and bird [21] species, inhabiting flat-country reservoir shores, temporarily increases, which is explained by the formation of biotope mosaics in vast transition zones (ecotones) [9]. On the contrary, when reservoirs are constructed in the mountain areas, the biotope diversity of the respective area decreases. On the coastal slopes of such reservoirs, the biodiversity and production of zoocomplexes largely decrease [10, 26]. The character of such impact on the fauna is also determined by the geographical position of the reservoir and operation regime of the respective hydraulic conditions on this area have also changed. It goes without saying that the further development of water economy will increase the areas, where water management measures will affect the fauna.

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structure. From the viewpoint of synecology, any reservoir inevitably violates natural communities. In some cases, during certain time periods, intensified use of bioresources of the reservoir and its shore areas becomes possible. Temporary peak increases in fish productivity in newly-constructed reservoirs are widely known. For certain types of animals, including rare and specially protected ones, reservoirs and their shores can become zones, where their number rapidly grows. The highest in the world density of osprey (up to 50 nestling pairs per 1000 km$^2$) is found in the Darwin Reserve near the Rybinskoye Reservoir. The nestling density of other viable populations of this species, recorded in The Red Book of the International Nature Conservation Union, is much lower (3 to 5 nestling pairs per 1000 km$^2$) [19].

Let us now consider the most pronounced forms of the impact of water management measures on the fauna, manifesting themselves during the construction of reservoirs and river runoff regulation thereby [2, 5, 12, 36, 39, 43, 44, etc.].

The impact of man-made lakes on the fauna is different in the upper and lower pools of hydraulic structures. This is due to the different character of changes in the abiotic environment and vegetation cover.

**PROCESSES OCCURRING IN THE UPPER POOLS OF HYDRAULIC STRUCTURES**

Upstream of dams and dikes, three main zones of reservoir impact, exercising different effect on the fauna, can be singled out:

**zone of permanent flooding**, where terrestrial animals either die or are ousted to the newly-formed coastal communities, and new habitat is formed—a water body with decelerated water circulation, suitable for the community of limnetic hydrobionts;

**transition zone**, including the areas subject to the direct effect of the water mass in the near-dam area (zone of temporary flooding, zone of the reservoir level drawdown, zone of waterlogging, zone of shore reformation, zone of perceptible climatic changes). Here zoocomplexes are intensely restructured due to both changes in animal living conditions in the transition zone itself (vegetation, climate, local topography, etc.), and impact of the adjacent areas. As was mentioned above, zones of the winter reservoir water level drawdown on steep slopes can become zones, where ungulates perish most frequently. Increased amount of mouse-type rodents and other mammals can be typical of near-mouth zones of the valleys of rivers flowing into mountain reservoirs. Such zones compensate to some of the animals for their lost habitat in the river valley:

**zone of remote impact**, which includes areas that are not directly adjacent to the reservoir, but are subject to indirect and consequential effect thereof. In most cases, while estimating the effect of man-made lakes on the ecosystems, the remote effect of hydraulic structures is neglected. Animals are the most mobile component of the ecosystem. The remote effect of man-made lakes on their populations and communities is most pronounced, and the effect of hydraulic structures on certain animal species can cause chain response in other ones. For instance, a decrease in the population of roe deer, whose migration routes were blocked by the Zeiskoye Reservoir, entailed spatial redistribution of lynx population. Lynx migrated from valleys and canyons to ridges and water divides, and its food base also changed. As a result, the press of lynx hunting musk deer increased [27]. The zone of reservoir impact on the fauna (understood in a most broad sense) can coincide with the contours of areas of migrating populations, whose migration routes became subject to the effect of hydraulic structures.

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**Table 1. Modification of the behaviour of wolves hunting Manchurian wapitis, caused by the reservoir construction (the first number is the amount of individuals crushed to death, the second number is the per cent of the total amount of individuals crushed to death)**

<table>
<thead>
<tr>
<th>Place where ungulates was found</th>
<th>The Sikhote-Alin’ Ridge [14]</th>
<th>The Eastern part of the Tukuringra Ridge prior to the reservoir construction</th>
<th>after the reservoir construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice cover of large (rivers and reservoirs) and small (springs and icings in their valleys) water bodies</td>
<td>4 (28.8)</td>
<td>4 (44.5)</td>
<td>26 (72.2)</td>
</tr>
<tr>
<td>Outside the ice cover</td>
<td>6 (42.8)</td>
<td>3 (33.3)</td>
<td>4 (11.1)</td>
</tr>
<tr>
<td>Total</td>
<td>14 (100)</td>
<td>9 (100)</td>
<td>36 (100)</td>
</tr>
</tbody>
</table>