ANALYSIS OF ANTHROPOGENICALLY INDUCED CHANGES IN ECOSYSTEM COMPONENTS IN THE KATUN RECREATIONAL AREA OF THE ALTAI REPUBLIC, RUSSIAN FEDERATION

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Abstract: The aim of the research is a comprehensive evaluation of the character of the impact of recreational activity and tourism on the biological communities of the Republic of Altai. The article discusses the main tendencies of changes in biological communities in the Altai Mountains proper to places of high recreational load. It is shown that as a rule, changes are manifested in the impoverishment of biological diversity, local extinction or decrease of the number of stenotopic bank types and the extension of the spatial distribution anthropopersistent species. The general regularities and specificity of the reaction of the researched groups of organisms are demonstrated.

Key words: sustainable tourism, ecosystems, mountain areas, biological diversity

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INTRODUCTION

Tourism and recreational activities are usually seen as a viable alternative to other more destructive forms of environmental management, such as mining, timber harvesting and agriculture. Tourism normally helps to increase the employment of the local population, which favourably affects the social environment.

In addition, the development of tourism can serve as an important mechanism for the economic provision for specially protected natural areas, especially national parks (Travkina, 2002). On the other hand, negative manifestations caused by a direct impact of recreation and tourism are well known; their scale and severity require solutions at international level (Bratanovsky et al., 2014). These attributes define tourism as a dual phenomenon that is a “double-edged sword for social and ecological development” (Van der Duim & Caalders, 2002). On the cusp of the 20th and 21st centuries, there is an active search for ways of sustainable development all over the world when an important concept of “sustainable tourism” was formulated as a kind of tourism that ensures its viability over an infinitely long period of time (Butler, 1999).

The goal of sustainable tourism is to find a balance between environmental protection, preservation of cultural integrity of ethnic groups, social justice and economic benefits, as well as to meet the needs of the population in terms of living standards, both in the short and long-time perspective. At the moment, a need for comprehensive development of sustainable tourism is expressed at the level of the UN General Assembly resolution that encourages “intensified efforts on regular evaluation of the role of sustainable tourism, including ecotourism, in appropriate cases, so that more informed decisions can be made at the local and national levels, widely reproduce and apply the experience gained, especially in the context of other economic activities, and use innovative technologies to relieve social, cultural and environmental impacts of tourism” (Zhuravleva et al., 2018). The development of promising forms of sustainable tourism also involves monitoring of the state condition of the environmental biological component. This is largely due to the fact that recreational areas are usually unique natural objects characterized by an increased concentration of biological diversity, often combined with the presence of rare and endemic components. Therefore, the preservation of this diversity is both a prerequisite of the stability of recreational areas and a significant factor of their increased attractiveness for holidaymakers (Sukhova et al., 2018).

The patterns of changes in biological communities under the influence of tourism and recreational activities in the framework of this study are discussed using the example of the Altai Republic as one of the important centers of tourism and recreational industry in Russia. The number of tourists arriving at the territory of the republic increases every year and in 2017, according to data of the AR Government, it reached 2.05 million people. Maximum tourist flows are seen in the valley of the Katun River in the Mayminsky and Chemsalsky districts, where more than half of the tourist enterprises of the Altai Republic are concentrated. In 2017, 64.8% of tourists who visited the Altai Republic visited these districts. Based on the natural and climatic characteristics, the Katun Nature Reserve was created in this part of the Altai (Sukhova et al., 2014).

METHODOLOGY

Katun recreational area is within Mayminsky and Chemsalsky administrative districts of the Republic of Altai (Figure 1). The territory belongs to North-Altai physical-geographical region of Gorno-Altai Autonomous Oblast which is a part of Altai-Sayan mountain country. Orographic base is the spurs of two major submeridional ridges – Seminsky and Iolgo. A characteristic feature of the orography of North Altai, which

determines the main features of its microclimate and natural landscapes, is a combination of narrow and wide dividing ridges and valleys with a high degree of erosion dismemberment, especially in the sides of the valleys of large rivers (Novikov, 2004).

Figure 1. Geographical location of the Katun recreational area

The area is characterised by the general decrease of the height of the area in the Northern direction, namely, from the middle mountains in its Southern and central part to the low mountains in the extreme Northern part. The following main genetic types of terrain are singled out in the geomorphological structure: low-mountain and medium-mountain erosion-denudation, low-mountain erosion-accumulative with elements of tectonic-accumulative terrain (Shchukina, 1960). The valley of the Katun River is a "wind tunnel" of Altai. An air flow under the impact of the baric gradient passes through the ridges, falling on the valley bottom, adiabatically heats and takes the properties of fohns. Fohns are most typical of the cold season (90-100 cases during the year).

In January, average temperature is $-12 - (-16) ^\circ \text{C}$. However, the average wind speed in the valley is 4 or 5 m/sec, so average monthly conventional temperature is $-18 - (-20) ^\circ \text{C}$, at 1 pm is $-13 - (-16) ^\circ \text{C}$. The presence of fohns affects the structure of the weather types. In winter months, the prevailing weather is moderately severe, it is 30-50%; mild weather is 20-25%, 10-15% is the weather with positive temperatures.

The frequency of severe weather in the coldest months does not exceed 20%; very severe weather is not observed. In July, average temperature is $17-19 ^\circ \text{C}$, equivalent effective temperature (EET) is $12-15 ^\circ \text{C}$, at 1 pm is $20-21 ^\circ \text{C}$. In May and September, cold weather of V-VI types makes up about 25%, repeatability of comfortable weather is 15 or 20% and about 15% repeatability of hot weather. In summer months (July - August)

comfortable weather is 30-40% or more, cold weather is 5-10%. The daily course of weather types is expressed very clearly. In the daytime, warm and hot weather, at night this weather disappears, the greatest repeatability is typical cool weather.

The favourable bioclimatic conditions indicator in winter months is 0.70-0.80, in summer is 0.70-0.72, in spring and autumn is 0.30-0.50. During the year, the number of days with favourable weather for the human body is 220-230. According to the degree of comfort of bioclimatic conditions, the area is comfortable. The functional voltage of the thermoregulation systems is mainly minimal and weak, and to a lesser extent, average.

The main watercourse of the area is the Katun River presented by its lower course. It is flown into by more than 40 medium and small rivers and streams, the main of which are the Rivers of Maima, Sema and Chermal. The width of the Katun River valley in the area territory varies from 0.5 to 3 km. The river's depth is to 4-5 m, in low water period is to 1.5-2 m. The average flow velocity is 0.3 m/s during low water period and increases to 1.7 m/s during flood. The rivers of the district are characterised by spring and summer floods. Nutrition is mixed from melting snow (40 %), ground (40 %) and rain (20 %) waters. During rain freshets, discharge of rivers can be higher than during the flood.

The comfort of bioclimatic conditions, exceptional attractiveness of landscapes and transport accessibility make the area very promising for establishing health resorts and the organising various types of tourism. However, tourism should be of ecological character to preserve the biodiversity of the area.

The range of the studied model groups of organisms:

- vegetation cover and flora are the main producing component of any terrestrial ecosystem and the basic level of nutrition chains;
- earthworms (*Lumbricidae*) are one of the most convenient groups of organisms for studying the features of structural changes in mesobiota pedofauna;
- orthopteroid insects (*Orthoptera*) – despite relatively small number of species, orthopteroid insects, in particular locusts which are mainly phytophagous organisms, that is, primary consumers, play an extremely important role in the functioning of biogeocenoses, especially steppe and meadow ones, including those which experience a large anthropogenic load;
- day butterflies (*Hesperioideae*, *Papilionideae*) are a multi-species group, diverse in phenology, abundance and biocenotic significance, a traditional object of monitoring research;
- vertebrate animals (*Vertebrata*) are a multi-species group, diverse in its nutritional adaptation, phenology, abundance and biocenotic significance, a traditional object of monitoring research (amphibians, reptiles; birds, small mammals).

In determining the above-ground phytomass of grass cover, the method of accounting sites laid by the method of random sampling was used (Rysin & Zolotova, 1968). The air-dry mass was determined with following recalculation per 1 hectare. The traditional sweep-net method (entomological net was used) was applied to determine the abundance of orthopteroid insects. It is common knowledge that the results of catching for fifty waves, reflect the density of orthopteroid insects per 1 m² of grassy surface (Kashkarov, 1933; Sergeev, 2009). Butterflies were accounted by the route method on transects. The transect method, unlike methods of accounting sites and labeling imposes less strict requirements for the type of distribution of a species inside station (Hall, 1985).

At every of the investigated sites they walked 2 or 3 km. The specified route length is representational for the evaluation of the abundance of individual species if they repeatedly come across during the route (Thomas, 1983) as well as for the evaluation of the total abundance since a set of single species is a small part of the total

population density. The transect width was determined for every species individually by doubled average detection range (Malkov, 1994, 2005). The accounting of birds is carried out on permanent, but not strictly fixed routes without limiting the width of the transect in accordance with the methodological requirements set out in special research papers (Ravkin et al., 1999; Ravkin & Livanov, 2006). Small mammals were accounted with the help of Gero traps equipped with standard lures (bread moistened with unrefined vegetable oil) by the method of traps and lines, there was one hundred traps in every landscape, on every site and in each time season. The state of the communities was evaluated based on the analysis of the number of discovered species, total abundance and Shannon and Simpson Diversity Indices. The diversity indices take into account two components, namely, species richness and uniformity (equitability) the contribution of species to total abundance, the more species and higher the uniformity, the more diverse and structurally complex community is considered to be. The first of the indices is more sensitive to changes of the number of species, especially at low species richness, the value of the second one is affected most by abundant species (Pesenko, 1982).

The evaluation of the statistical reliability of differences of the diversity indices was performed with the help of resampling and a permutation test (Shitikov, 2012) with 9999 randomisations. All calculations were performed using Microsoft Excel and Paleontological Statistics (Hammer et al., 2001). The bulk information that served as an empirical base for generalization was collected during complex expeditions to the control and recreation-exposed areas of the main landscapes of the Katun Nature Reserve. As a result of quantitative counts, data were obtained on the abundance (density) of species of clavaceous lepidoptera (diurnal butterflies) and orthopterans, amphibians, reptiles, birds, small mammals, resources of superterraneous biomass of herbage cover and earthworms (lumbricide). Materials were partially published (Vozniychuk, 2016; Laptev et al., 2016; Malkov, 2016; Khudyakova et al., 2016). The proposed publication is an attempt of a comprehensive analysis of changes occurring in biological communities as a result of the impact of tourism and recreational environmental management.

RESULTS AND DISCUSSION

Analysis of density and diversity of biological species in the territory of the Altai Republic

Herbage cover and earthworms. The data obtained during the expeditions suggest that the superterraneous biomass of herbage cover and earthworms in the areas with increased recreational burden is normally decreased compared to those not subjected to the influence of the recreational factor. At the same time, statistically significant differences were observed in the herbage cover only; as for lumbricidea, they manifest themselves only as a trend (Laptev et al., 2016). Less pronounced differences in the lyumbricide biomass between the sites with and without recreational impact, in our opinion, are due to the greater stability of the soil environment compared to the ground-air one. A high content of organic matter of the soil, as well as a relatively low level of daily and seasonal fluctuations in temperature and chemical composition, apparently compensate for the negative impact of the recreational factor.

Excessive recreational load causes a change of species composition, especially noticeable in meadow communities. As a rule, this is manifested in the emergence of semi-ruderal plants such as *Rhinanthus minor*, *Verbascum densiflorum*, various species of eyebrights *Euphrasia*, rosette forms of dandelions *Taraxacum*, plantains *Plantago* and meadow weeds *Echium vulgare*, *Nepeta sibirica*, *Prunella vulgaris*, *Lamium album*. From other species on degraded meadows one can note a mass

development of *Achillea millefolium*, *Alchemilla vulgaris*, *Geranium pratense*, *Potentilla anserina*, *Polygonum aviculare*, *Trifolium repens*, *Capsella bursa-pastoris*. In the areas of meadow communities which are not affected or weakly affected by anthropogenic activity the flora does not contain these species or they are single. From the permanent types of such communities one should note *Phleum pratense*, *Alopecurus pratensis*, *Poa pratensis*, *Bistorta officinalis*, *Geum rivale*, *Sanguisorba officinalis*, *Trifolium pratense*, *Origanum vulgare*, *Tragopogon pratensis*, various species of bloodroots *Potentilla*, meadow rues *Thalictrum*, forget-me-nots *Myosotis* and others.

Orthopterans. Orthopteran communities of the Katun Nature Reserve react to the tourism and recreational impact by qualitative and quantitative reorganizations of the species composition and structure. Comparison of intra-landscape differences between the control and recreational areas shows that the latter, as a rule, are covered by a large number of species. In particular, in forest biotopes, anthropogenic changes in the herbage cover structure allows a high density of the northern steppe and meadow species – *Conocephalus dorsalis*, *Glyptothorax biguttulus* and *Chorthippus apricarius*. In the meadows of the Katun valley exposed to recreational activities, a relatively high density of polyzonal *Chorthippus albomarginatus* and *Locusta migratoria* (Figure 2), as well as two non-moral species, *Stethophyma grossum* and *Mecostethus alliaceus*, is observed. The density of their populations in similar biotopes, but mildly disturbed recreation sites, is noticeably lower, or they are not found there at all. In some situations, a high level of recreational exposure can lead to more complex adjustments. On dry meadows, *Euthystira brachyptera*, *Stenobothrus lineatus*, *Megaulacothorax aethalinus* and *Conocephalus dorsalis* drop out of the community but the density of *Metrioptera brachyptera*, *Psophus stridulus* and *Chorthippus apricarius* increases.

Figure 2. *Locusta migratoria* Linnaeus, 1758 (photo by N.E. Khudyakov)

Therefore, depending on the landscape type, the recreational factor can both increase the distribution range and the number of certain species of orthoptera and have a negative limiting effect. Local disappearances or reductions in the number of stenotopic

species of orthoptera in recreational areas are, as a rule, compensated by the population of new, more anthropotolerant elements (Khudyakova et al., 2016).

Diurnal butterflies. A clear trend towards a reduction in the butterfly species richness under the influence of recreational activities was observed. To a large extent, this refers to the Katun Nature Reserve meadow biotopes, which are normally characterized by *Melitaea athalia*, *M. latonigena* metalmarks, *Clossiana dia* pearl butterfly (Figure 3), *Cl. euphrasyne*, *Coenonympha glycerion* chestnut heath, *Maculinea teleius* and *Plebejus argus* blues. An increased recreational burden results in a sharp decrease in their abundance, in some places local extinction. The species composition of the population of clavaceous lepidoptera in forest biotopes is generally more resistant to the recreational burden. In addition, due to the reduction in the density of tree-shrub undergrowth, an increase in mosaic elements, mainly paths, unpaved roads and small grass fields, some meadow species penetrate forest recreational areas. However, even in this case, species of butterflies that were absent in the recreational areas were found, compared to usual and even numerous in the control areas. These include, in particular, *Argynnis sagana* pearl butterflies (Figure 4), as well as *Carterocephalus silvicolus*, *Polygonia c-album*, *Erebia ligea* and *Celastrina argiolus* (Malkov, 2016).

Figure 3. *Clossiana dia* (Linnaeus, 1767)

Figure 4. *Argynnis sagana* Doubleday, 1847

Amphibians and reptiles. An ambiguous reaction of the amphibian and reptile communities to anthropogenic pressure was observed. At the same time, the nature of changes in the communities depends on the intensity of recreational use of natural resources and on the degree of moistening of habitats. Under moderate and low moistening, recreation adversely affects the amphibian and reptile communities and on wetlands, on the contrary, increases the range of distribution and number of most species (Vozniyuchuk, 2016). *Birds.* The nature of changes in ornitocomplexes of the Katun Nature Reserve also depends to a large extent on the type of habitat. In forest biotopes, the species diversity of birds decreases under the influence of the recreational factor. The following species demonstrate a decrease in abundance under tourism burden – *Buteo buteo* buzzard, *Bonasa bonasia* grouse, *Streptopelia orientalis* eastern turtledove, *Dryocopus martius* black woodpecker, *Dendrocopos major* spotted woodpecker, *Anthus trivialis* tree pipit, *Lanius collurio* red-backed shrike (Figure 5), *Luscinia* common nightingale, *Luscinia calliope* red-necked nightingale, *Turdus pilaris* fieldfare (Figure 6), *Phylloscopus trochiloides* green hemlock, *Periparus ater* coal tit. Among meadow biotopes, such an

obvious reduction in the abundance of birds is not observed, but there the number of the optional synanthropus, the common magpie *Pica pica*, increases significantly.

Figure 5. *Lanius colluro* Linnaeus, 1758

Figure 6. *Turdus pilaris* (Linnaeus, 1758)

Small mammals. The analysis of distribution of small mammal species across natural landscapes and their deviates in some cases demonstrates an ambiguous situation when a particular species in one type of habitat was found only in the areas exposed to anthropogenic pressure, and in another biotope, only in the control areas. This mainly refers to shrews. As for the rodents, the Asian Chipmunk *Tamias sibiricus* (Figure 7), the common hamster *Cricetus cricetus*, the small forest mouse *Apodemus uralensis*, the gray red-backed vole *Myodes rufocanus* and the root vole *Microtus oeconomus* show a steady tendency to avoid places with an increased concentration of tourists and recreational impact.

Features of tourism impact on biological diversity

The analysis shows a number of changes occurring in the communities of various groups of organisms resulting from the intensive impact of tourism and recreation in the Katun Nature Reserve of the Altai Republic. The nature of rearrangements in the studied groups is not expected to coincide in detail, since they differ significantly in evolutionary and ecological terms, but the overall focus normally remains the same, i.e. a reduction in the abundance of the species most sensitive to anthropogenic impact. In the orthopteran and clavaceous lepidoptera communities, as well as among part of birds, these changes are partly compensated by the appearance or increase in the abundance of more anthropotolerant elements, however, such rearrangements are not evidence of stability, but, on the contrary, can have serious negative consequences.

The above changes are not the only emerging environmental problems in the Katun Nature Reserve. The ARI “Ecology” employees, in a series of studies during 2012–2015, based on the quantitative data on the ground cover digression and recreational burden in places of unorganized recreation (Report on the research project..., 2012; Pavlova, 2015; Pavlova et al., 2013), believed that if the existing trends persisted by 2018, self-regeneration of the ground cover at some sites of the Katun Nature Reserve would be impossible. Without engaging in a discussion regarding self-regeneration, we would note that the situation has worsened since that time, as predicted by them. The same authors noted an increase in the number of dry and severely weakened trees in the areas of mass recreation, as well as the accumulation of siderophile (Ti, V, Mn), chalcophile (Ni, Cu, Zn) and biogenic (P, B) elements in the foliage (Pavlova et al., 2012).

Figure 7. *Tamias sibiricus* (Laxmann, 1769)

Negative aspects of the impact of tourism development in the Altai Republic on ungulate populations are discussed in the work of Yu.N. Kalinkin (2012). The main focus of this publication is poaching, commercial hunting and, only partly, a disturbance factor, which is completely true for the eastern and southern part of the Altai Republic. In the conditions of the Katun Nature Reserve, a disturbance factor, in our opinion, is of paramount importance, since there is significantly higher concentration of tourists. Some of them have offroad vehicles, including ATVs and snowmobiles, which greatly expands the possibilities of movement. It is important that the territory of the Katun Nature Reserve is one of the main ways of seasonal migrations of the Siberian roe deer *Capreolus pygargus* from the foothill part of Altai to the hinterlands (autumn) and back (spring) (Sobansky, 2008). Therefore, the tourism and recreational sector has become a significant factor of a negative impact on the environment of certain territories of the Altai Republic. Irrational operation leads to the destruction of their potential.

At the same time, a unique recreational resource of the Altai Republic is one of the very few among those involved in its economy and competitive on the Russian and world markets. The actual task, in our opinion, is to create economic (tax) and informational conditions for spending part of the funds of tourist companies to support the ecological conditions of the territory, which is not actually reflected even as a recommendation. This situation is due to the fact that the bulk of tax deductions goes to the budget of the

regions where travel agencies are officially registered (Altai Krai, Novosibirsk and Kemerovo region, Moscow), and the republic receives funds only from the lease of land plots, occupied by the objects of tourism and recreational infrastructure. Improvement of the situation can occur with the full support of sustainable tourism, carried out mainly by the residents of the Altai Republic, especially since the interest in “green” tourism, in particular, living in rural houses, is increasing, as well as with the proper redistribution of tourist flows to the Central and Southeast Altai.

CONCLUSION

This article analyses the biological diversity of the Altai Republic. The impact of tourism and recreational activities on the natural ecosystems of the Altai is discussed. It is established that the number of amphibians depends not only on the degree of the territory's moisture, but also on the intensity of recreational load. This study was aimed at the development of a framework for a comprehensive assessment of the potential of the territory, including the assessment of natural conditions and resources, anthropogenic and recreational development, ecological conditions of the area and the impact of tourism on these components. Recreation and tourism are the main strategically important areas of regional development. A special economic zone of tourism and recreational type is created in the territory of the Republic. The basis for its creation was a unique recreational potential and natural importance. This will ensure the development of the economic potential of the Altai Republic but, at the same time, the need to preserve the historical and natural heritage of the republic, social development and sustainable use of natural resources deserve attention.

The following species were studied during complex expeditions: earthworms, orthopteran insects, diurnal butterflies, amphibians and reptiles, small mammals. It was established that the number of amphibians depended both on the intensity of the recreational burden and a degree of moistening of the territory. The development of tourism may also lead to the reduction in some insect species (*Euthystira brachyptera*, *Stenobothrus lineatus*, *Megaulacobothrus aethalinus*, *Conocephalus dorsalis*, *Meltiaea athalia*, *M. latonigena*, *Argynnis sagana*, *Clossiana dia*, *Cl. Euprhosyne*, *Coenonympha glycerion*, *Maculinea teleius*) and increase in the distribution of others (*Metriopectera brachyptera*, *Psophus stridulus* and *Chorthippus apricarius*). The study analyses the changes that occur in the communities of various biological species. The negative impact of tourism on the environment is due to the irrational exploitation of recreational areas. At the same time, negative changes prevail, causing significant and increasing damage to it. The resolution of this problem requires a systematic approach, which would include a variety of interrelated measures while using natural resources for tourism purposes. Such interventions imply the use of additional technical, organizational, sociological, resource management and environmental knowledge.

Aknowlegments

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