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Initial Study of the Ground Beetles (Coleoptera: Carabidae) and Other Invertebrates from "Leshnitsa" Nature Reserve (Central Stara Planina Mountains, Bulgaria)

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Abstract. The invertebrate fauna of the "Leshnitsa" nature reserve was studied, with particular consideration to the ground beetles. During the study altogether 394 specimens of carabid beetles belonging to 32 species and subspecies were captured, as well as 23 other invertebrate species, some of which are with a conservation significance (protected, Bulgarian and Balkan endemics). Ground beetles were characterized and classified according to their zoogeographical belonging, degree of endemism and the life forms they refer to. Threats for the invertebrate fauna and negative factors of anthropogenic origin were determined and measures for diminishing of their effect were proposed. So far the invertebrate fauna in this part of the mountain has been insufficiently studied. The real state of the diversity of this group in the area will be revealed only after future investigations and discovery of additional new species for the region.

Keywords: ground beetles, Carabidae, Invertebrata, "Leshnitsa" reserve, Stara Planina Mts., conservation.

Introduction

The investigation of the biota of the protected natural areas is an important component of their functioning and allows the assessment of the value of the given territory and its representativeness as a repository for the gene pool of the particular ecosystems. The strict nature reserve "Leshnitsa" keeps typical ecosystems in the lower upland belt of the Shipka mountain massif in Central Stara Planina Mts., near the village of Yasenovo, Municipality of town of Kazanlak (42°42'47"N, 25°13'5"E). Its area is 388.95 ha. The habitats are relatively preserved due to their toilsome accessibility. The territory of the reserve includes century-old beech forests, which are mostly unaffected by anthropogenic activities. They relate to Natura 2000 Habitats with code 9110 and 9130 and in general are characterized by good self-sustaining capability and a specific set of coexisting animal species (SSYMANK *et al.*, 1998; LESHNITSA, 2015).

However, intensive wood felling was observed adjacent to the boundaries of the reserve. This fact greatly reduces the buffer role of these border areas. The area has not been subjected to detailed faunistic investigations. Previous studies on the insect fauna of the reserve are partial and insufficient, and particularly in terms of the carabid fauna the data are missing. The lack of faunistic studies in "Leshnitsa" impedes

the overall assessment of the species abundance, size of the populations, nature of their spatial distribution, biodiversity and extent of anthropogenic influence.

For the middle parts of the Stara Planina mountain chain where the natural reserve "Leshnitsa" is located, but not exactly for the territory of the reserve, about 230 species of ground beetles are known (Coleoptera: Carabidae), and among them there are great percentage of rare and endemic forms, as especially peculiar is the cave carabid fauna. For example, only in the area of the Mount of Shipka there are three endemic species – the local Bulgarian endemites *Duvalius balcanicus* (J. Frivaldszky, 1879) and *Laemostenus plasoni* (Reitter, 1885), as well as the Balkan endemic *Amara municipalis bischoffi* Jedlicka, 1946 (GUÉORGUIEV & GUÉORGUIEV, 1995; GUÉORGUIEV *et al*., 1997).

Up to this point purposive investigations on the species composition of the invertebrate fauna as a whole in the territory of the "Leshnitsa" reserve have not been conducted, which premises the aim of this study. The main objective of the present study is to determine the species composition of Carabidae, existing in the research area. The study will be a preliminary step in order to detect the Coleoptera fauna of Central Stara Planina Mts., where the group is poorly studied.

Material and Methods

Field work was carried out in the periods: 8 – 12 May, 9 – 14 June and 1 – 5 September 2014. It included: 1) transect method with observations *in situ* or collection of material; 2) stationary method with „pitfall" traps (DAHL, 1896; HERTZ, 1927; BARBER, 1931) made of plastic bottles, buried at the level of the ground surface, with a 4% solution of formaldehyde as a fixation fluid; this method is suitable for ecological research on adult beetles, and mainly reflects their activity (LÖVEI & SUNDERLAND, 1996); there are no reasonable alternatives to this type of traps in the study of epigeic arthropod communities (SPENCE & NIEMELA, 1994); it is considered that the application of this method allows approximately 95% of the species active in radius of 50 m around the traps to be caught (BAARS & VAN DIJK, 1984); 3) handpicking and shaking of branches, capturing with a standard entomological sack.

Sampling areas were three: (I) Humid forest and ecotone with White Butterbur; (II) Mesophilous beech forest and ecotone with a brook; (III) Humid beech forest and ecotone with the river of Leshnitsa. Captured animals were determined with the help of several main literary sources: LINDROTH (1974); TRAUTNER & GEIGENMÜLLER (1987); HŮRKA (1996); HARDE (2000); REITTER (2006); ARNDT *et al*. (2011); KRYZHANOVSKIJ (pers. com.), and are deposited in the collection of the Institute of Biodiversity and Ecosystem Research (BAS, Sofia).

The systematic list of Carabidae follows KRYZHANOVSKIJ *et al*. (1995). According to their zoogeographical belonging ground beetles were separated in zoogeographical categories and faunal types according to VIGNA TAGLIANTI *et al*. (1999) with some changes (KODZHABASHEV & PENEV, 2006).

Categorization of the species in respect of their life forms follows the classification of SHAROVA (1981). The following codes were used: Life form class 1. Zoophagous. Life form subclass: 1.2 – Epigeobios; 1.3 – Stratobios;. Life form groups: 1.2.2 – large walking epigeobionts; 1.2.2(1) – large walking dendroepigeobionts; 1.3(1) – series crevice-dwelling stratobionts; 1.3(1).1 – surface and litter-dwelling; 1.3(1).2 – litter-dwelling; 1.3(1).3 – litter and crevice-dwelling; 1.3(1).4 – endogeobionts; 1.3(2) – series digging stratobionts; 1.3(2).1 – litter and soil-dwelling. Life form class 2. Mixophytophagous. Life form subclass: 2.1 – Stratobios; 2.3 – Geohortobios. Life form groups: 2.1.1 – crevice-dwelling stratobionts; 2.3.1 – harpaloid geohortobionts.

Results

During the study 55 invertebrate species under 3 classes, 9 orders and 18 families were established. Altogether 394 specimens of ground beetles were captured. They belong to 32 species and subspecies under 17 genera and 10 tribes (Table 1).

In Table 2 is given the list of the other 23 invertebrate species, established during the field studies: three gastropod species; one lumbricid worm; 19 insects, mostly coleopteran species.

Table 1. Systematic checklist of the carabid beetles, found in "Leshnitsa" natural reserve (codes for the life forms and sampling sites are given in the Material and Methods section).

№	Species	Range type	Life form	Material
	Tribe Nebriini			
1.	*Leistus (Pogonophorus) magnicollis* Motschulsky, 1866	Balkan endemic	1.3(1).2	2♀, 1♂ (II)
2.	*Leistus (Pogonophorus) rufomarginatus* (Duftschmid, 1812)	European	1.3(1).2	1♂ (II)
3.	*Nebria (Nebria) brevicollis* (Fabricius, 1792)	European-Neareastern	1.3(1).2	1♂ (I)
	Tribe Carabini			
4.	*Calosoma (Calosoma) sycophanta* (Linnaeus, 1758)	Palearctic	1.2.2(1)	1♂ (hand)
5.	*Calosoma (Acalosoma) inquisitor* (Linnaeus, 1758)	Palearctic	1.2.2(1)	1♂ (III)
6.	*Carabus (Morphocarabus) versicolor versicolor* E. Frivaldszky, 1835	Bulgarian endemic	1.2.2	1♀, 2♂ (I)
7.	*Carabus (Chaetocarabus) intricatus intricatus* Linnaeus, 1761	European	1.2.2	1♂ (hand); 2♀, 1♂ (II)
8.	*Carabus (Megodontus) violaceus azuresens* Dejean, 1826	Balkan endemic	1.2.2	2♀, 1♂ (II)
9.	*Carabus (Procerus) gigas gigas* (Creutzer, 1799)	Central and Eastern European	1.2.2	1♂ (I)
	Tribe Cychrini			
10.	*Cychrus semigranosus balcanicus* Hopffgarten, 1881	Balkan endemic	1.2.2	1♂ (II)
	Tribe Trechini			
11.	*Trechus cardioderus balcanicus* Jeannel, 1927	Balkan endemic	1.3(1).2	5♀, 2♂ (I); 1♂ (III)
	Tribe Bembidiini			
12.	*Bembidion (Metallina) lampros* (Herbst, 1784)	Holarctic	1.3(1).1	2♂ (I)
13.	*Bembidion (Peryphus) andreae bualei* Duval, 1852	European	1.3(1).1	1♀, 1♂ (III)
	Tribe Pterostchini			
14.	*Myas chalybaeus* (Palliardi, 1825)	Balkan-Carpathian	1.3(1).4	17♀, 28♂ (II); 1♀, 2♂ (III)
15.	*Pterostichus (Cryobius) vecors* (Tschitschérine, 1897)	Bulgarian endemic	1.3(2).1	1♀, 7♂ (I); 1♀, 4♂ (II)
16.	*Pterostichus (Platysma) niger* (Schaller, 1783)	Euroasiatic	1.3(2).1	3♀, 1♂ (II)
17.	*Pterostichus (Melanius) nigrita* (Paykull, 1790)	Palearctic	1.3(2).1	1♂ (hand)
18.	*Pterostichus (Phonias) ovoideus* (Sturm, 1824)	Eurosiberian	1.3(2).1	1♀ (II)
19.	*Pterostichus (Pterostichus) brucki* Schaum, 1859	Northmediterranean	1.3(2).1	1♀ (II)
20.	*Abax parallelus* Duftschmid, 1812	European	1.3(2).1	22♀, 16♂ (II); 4♀, 2♂ (III)
21.	*Abax carinatus* (Duftschmid, 1812)	Central and Eastern European	1.3(2).1	1♂ (I); 2♂ (III)
22.	*Molops alpestris kalofericus* Mlynar, 1977	Bulgarian endemic	1.3(2).1	1♂ (hand); 4♀, 3♂ (I); 11♀, 14♂ (II); 9♀, 14♂ (III)
23.	*Molops dilatatus angulicollis* G. Müller, 1936	Bulgarian endemic	1.3(2).1	1♀, 3♂ (I); 9♀, 6♂ (II); 24♀, 21♂ (III)
24.	*Molops rufipes klisuranus* Apfelbeck, 1902	Balkan endemic	1.3(2).1	2♀, 1♂ (II); 6♀, 9♂ (III)
25.	*Molops piceus bulgaricus* Maran, 1938	Balkan endemic	1.3(2).1	18♀, 22♂ (II); 3♀, 16♂ (III)
26.	*Tapinopterus (Tapinopterus) cognatus kalofirensis* Mařan, 1933	Bulgarian endemic	1.3(2).1	1♀, 6♂ (II); 1♂ (III)
	Tribe Platynini = syn. Agonini			
27.	*Limodromus assimilis* (Paykull, 1790)	Palearctic	1.3(1).1	1♀ (I); 6♀, 2♂ (II); 7♀, 3♂ (III)
28.	*Agonum (Platynus) proximum* (Frivaldszky, 1879)	Bulgarian endemic	1.3(1).1	3♀, 2♂ (II); 1♂ (hand)
	Tribe Amarini = syn. Zabrini			
29.	*Amara (Amara) aenea* (De Geer, 1774)	Holarctic	2.3.1	1♀, 1♂ (II); 1♂ (III)
	Tribe Harpalini			

30.	*Harpalus (Pseudoophonus) rufipes* (De Geer, 1774)	Palearctic	2.1.1	1♂ (III)
31.	*Harpalus (Harpalus) rubripes* (Duftschmid, 1812)	Euroasiatic	2.3.1	1♀ (III)
	Tribe Brachinini			
32.	*Aptinus (Aptinus) bombarda* (Illiger, 1800)	European	1.3(1).3	7♀, 6♂ (II); 1♀ (III)

Table 2. Species of invertebrates, other than Carabidae, found at the territory of the "Leshnitsa" nature reserve.

Species	Family	Order
Phylum Mollusca		
Class Gastropoda		
Helix pomatia Linnaeus, 1758	Helicidae	Sigmurethra
Fruticicola fruticum (O. F. Müller, 1774)	Bradybaenidae	Sigmurethra
Aegopinella nitidula (Draparnaud, 1805)	Oxychilidae	Sigmurethra
Phylum Annelida		
Class Clitellata		
Lumbricus terrestris Linnaeus, 1758	Lumbricidae	Haplotaxida
Phylum Arthropoda		
Class Insecta		
Calopteryx splendens Harris, 1780	Calopterygidae	Odonata
Perla sp.	Perlidae	Plecoptera
Saga pedo (Pallas, 1771)	Tettigoniidae	Orthoptera
Panorpa communis (Linnaeus, 1758)	Panorpidae	Mecoptera
Anthelephila caeruleipennis LaFerté-Senéctère, 1847	Anthicidae	Coleoptera
Morimus funereus Mulsant, 1862	Cerambycidae	Coleoptera
Prionus (Prionus) coriarius (Linnaeus, 1758)	Cerambycidae	Coleoptera
Rosalia alpina Linnaeus, 1758	Cerambycidae	Coleoptera
Anoplotrupes stercorosus (Hartmann, 1791)	Geotrupidae	Coleoptera
Geotrupes vernalis (Linnaeus, 1758)	Geotrupidae	Coleoptera
Dorcus parallelipipedus (Linnaeus, 1758)	Lucanidae	Coleoptera
Lucanus cervus (Linnaeus, 1758)	Lucanidae	Coleoptera
Potosia aeruginosa (Drury, 1770)	Scarabaeidae	Coleoptera
Nicrophorus vespillo Linnaeus, 1758	Silphidae	Coleoptera
Oiceoptoma thoracicum (Linnaeus, 1758)	Silphidae	Coleoptera
Silpha obscura Linnaeus, 1758	Silphidae	Coleoptera
Tipula sp.	Tipulidae	Diptera
Formica rufa Linnaeus, 1761	Formicidae	Hymenoptera
Vespa crabro Linnaeus, 1758	Vespidae	Hymenoptera

Zoogeographical peculiarities of the ground beetles

Endemic complex prevails, consisting of 12 (38%) taxa (5 Bulgarian and 7 Balkan endemics). European faunal type (mostly forest dwelling species connected to the middle and southern part of Europe) consists of 9 (28%) taxa. Representatives of the Northern Holarctic and European-Siberian faunal complex (distributed mainly in the northern regions of the Holarctic, mostly in Europe and Siberia) are 8 species (25%) and the European-Asiatic type (species ranges lie between the Eurosiberian and Mediterranean zones) includes only 2 species (6%) (Table 3).

Life forms of the ground beetles

The 32 ground beetle species and subspecies, established for the area of "Leshnitsa" reserve, relate to two classes of life forms proposed by SHAROVA (1981), with clear predominance of class Zoophaga, presented by 29 species. Mixophyito-phagous were only 3 species. The most numerous are the digging litter and soil-dwelling stratobionts from class Zoophaga, typical forest dwellers from the genera *Pterostichus*, *Abax*, *Molops* and *Tapinopterus* (Fig. 1).

Species with conservation and biogeographical significance

Twenty five species with conservation and biogeographical significance were found, including endemic, protected, rare or species with limited distribution (Table 4). Eleven species are included in the IUCN Red List (IUCN, 2015) with the categories: LC – Least Concern (5 species), NT – Near

Threatened (3 sp.) and VU – Vulnerable (3 sp.); five species are protected by the Biological Diversity Act (2002): Annex II – Species for which conservation are declared protected areas for protection of their habitats, Annex III – Species protected on the territory of the whole country and

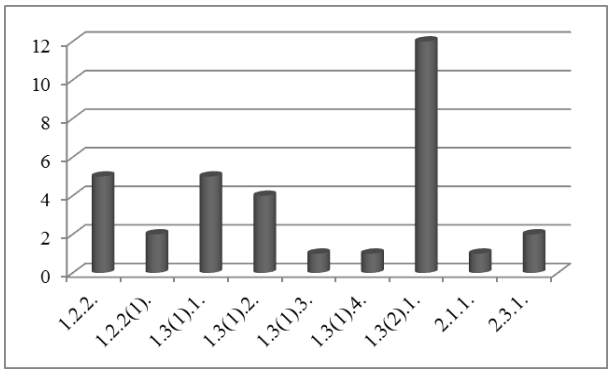

Fig. 1. Life forms of the ground beetles from "Leshnitsa" nature reserve (descriptions of the life form codes are given in the Material and Methods section).

Annex IV – Species under regime of protection and regulated use from the nature; five Natura 2000 species were found; four species are protected under the Directive 92/43 (DIRECTIVE 92/43/EEC, 1992): Annex II – Animal and plant species of community interest whose conservation requires the designation of Special Areas of Conservation. Annex V – Animal and plant species of community interest, whose taking from the wild can be restricted by European Law; three species are included in the check list of the threatened invertebrates of the CORINE biotopes project (COUNCIL OF THE EUROPEAN COMMUNITIES, 1991); three are in the Appendices of the Bern Convention (CETS, 1979): two in Appendix II – Strictly protected fauna species and one in Appendix III – Protected fauna species; *Calosoma sycophanta* is included in the ESC Red List of threatened animals and plants in Europe of the Economic and Social Council (ESC) of the United Nations. Five Bulgarian and seven Balkan endemics are recorded as well as one Balkan subendemic and one Tertiary relict. This study represents the first exact note about the distribution of *Leistus magnicollis* in the mountain, which was cited so far simply as "Stara Planina" (GUÉORGUIEV & GUÉORGUIEV, 1995; GUÉORGUIEV *et al.*, 1997).

Table 3. Zoogeographical categories of the ground beetles (Coleoptera: Carabidae) in "Leshnitsa" natural reserve.

Faunal type	Zoogeographical element	Number of taxa
Northern Holarctic and European-Siberian	Holarctic	2
	Palearctic	5
	European-Siberian	1
European	European-Neareastern	1
	European	5
	Central and Eastern European	2
Euroasiatic	Balkan-Carpathian	1
	Euroasiatic steppe complex	2
Mediterranean	Northmediterranean	1
Endemic	Balkan endemic	5
	Bulgarian endemic	7

Table 4. Species with conservation significance, found at the territory of the "Leshnitsa" nature reserve.

№	Trivial name	Latin name	Conservation status
1.	Roman snail	*Helix pomatia*	IUCN –LC; Directive 92/43(V); LBD (IV); CORINE
2.	Banded demoiselle	*Calopteryx splendens*	IUCN – LC
3.	Predatory bush cricket	*Saga pedo*	IUCN – VU; Natura 2000; Bern (II)
4.	Common scorpionfly	*Panorpa communis*	IUCN – LC
5.	Blue ground beetle	*Carabus intricatus*	IUCN – NT; Natura 2000
6.	Forest caterpillar hunter	*Calosoma sycophanta*	ESC Red List; CORINE
7.		*Carabus versicolor versicolor*	Bulgarian endemic; rare
8.		*Molops alpestris kalofericus*	Bulgarian endemic
9.		*Molops dilatatus angulicollis*	Bulgarian endemic
10.		*Tapinopterus cognatus kalofirensis*	Bulgarian endemic
11.		*Agonum proximum*	Bulgarian endemic
12.		*Leistus magnicollis*	Balkan endemic
13.	Violet ground beetle	*Carabus violaceus azuresens*	Balkan endemic
14.		*Cychrus semigranosus balcanicus*	Balkan endemic
15.		*Trechus cardioderus balcanicus*	Balkan endemic
16.		*Pterostichus vecors*	Balkan endemic
17.		*Molops rufipes klisuranus*	Balkan endemic
18.		*Molops piceus bulgaricus*	East-Balkan endemic
19.		*Myas chalybaeus*	Balkan subendemic; Tertiary relict
20.	Beech longhorn beetle	*Morimus funereus*	IUCN – VU; Natura 2000; Directive 92/43 (II); CORINE; LBD (II)
21.	Rosalia longicorn	*Rosalia alpina*	IUCN – VU; Natura 2000; Directive 92/43 (II); Bern (II); LBD (II, III)
22.	Tanner beetle	*Prionus coriarius*	IUCN – LC
23.	Stag beetle	*Lucanus cervus*	IUCN – NT; Natura 2000; Directive 92/43 (II); Bern (III); LBD (II, III)
24.	Red wood ant	*Formica rufa*	IUCN – NT; LBD (III)
25.	European hornet	*Vespa crabro*	IUCN – LC

Discussion

Forest environment is definitely the most ancient on the Balkans (POPOV & DELTSHEV, 1997), which is the reason the predominant arboreal morphoecotype to be formed by cryptobionts with lower mobility: geobionts, stratobionts, and subterranean species. Trophic structure of carabid beetles in woodland habitats is usually characterized by predominance of zoophagous beetles (SHAROVA, 1981; AYDAMIROVA, 2009; LÖVEI, 2008; etc.). Same predominance was established during the study. It evidences for the relative evolutionary completion of the researched area, as far as the typical predators are characteristic for the final stages of the successional development (e.g. LÖVEI, 2008).

Degradation of the forest communities in large parts throughout Europe is the reason for the displacement of the typical European nemoral complex by more adaptable European-Asian species in many otherwise forest or mountain areas (DESENDER & TURIN, 1989; KODZHABASHEV & PENEV, 2006; ALEKSANDROWICZ, 2011). The old nemoral carabid complex (Carabini, Pterostichini, Platynini) is shifted to plots with preserved forest biotopes, such as the studied nature reserve. The remnants of preserved woodlands treasure those forest elements in the denuded and

anthropogenized territories and their conservation is essential for maintaining a diverse fauna of mostly European and European-Siberian forest species (VARVARA, 2005; KODZHABASHEV & PENEV, 2006).

Some of the species (e.g. *Carabus intricatus* and *Leistus rufomarginatus*) have become rare under the influence of anthropogenic pressures and changes in their primary habitats. *Calosoma inquisitor*, *Calosoma sycophanta* and some of the *Carabus* species are usually highly sensitive to chemical agents, which affects their range and numbers (HUUSELA-VEISTOLA, 2000). Most of the species are stenotopic forest inhabitants, attached to mesophilous vegetation. Only three eurybionts are established (*Bembidion lampros*, *Harpalus rufipes*, *Harpalus rubripes*), represented with single specimens. A large part of the priority species are directly linked to the presence of dead wood. Such are *Rosalia alpina*, *Morimus funereus, Lucanus cervus*, etc., whose larvae develop in dead deciduous wood.

Threats and negative factors for the invertebrate fauna in "Leshnitsa" natural reserve

The primary threat to the biodiversity of the invertebrate fauna in the forests is the systematic removal of the fallen dead wood, which affects the invertebrates of all trophic levels taking part in the circle of the wood, and it was observed in the border areas mainly in the northern parts of the reserve. The primary purpose of protected areas is the maintenance of model biodiversity, which is unthinkable in such anthropogenic interventions. Felling, destruction of old trees and trees with hollow holes, removal of deadwood may lead to deterioration, narrowing or destruction of the forest habitats, and as a result – to the distortion of the structure of the communities and banishing or destruction of the populations of different species. Most of the insect species included in the international conservational regulations and agreements develop in the deadwood. Nearly one-third of all forest species are dependent on the presence of dead wood and old trees (DUDLEY & VALLAURI, 2004).

In the immediate vicinity of the borders of the reserve was observed intensive wood felling. This fact greatly reduces the buffer role of these border areas. Given the fact that the main threatening factors for the beech forests are: intensive forestry, too short cultivation of logging, uprooting, depositing of harmful substances in the air, damage from wild game (SSYMANK *et al.*, 1998), and that the forestry practices are the major threat for the red-listed species (RASSI *et al.*, 2000), serious attention to this problem should be paid.

Afforestation with conifer species (found in the southern part of the reserve) also has a strong negative impact on the populations of a number of species. The disappearance of old beech forests limits the food base for the development of the beetles.

Collection by collectors can greatly influence the abundance of some of the rare or priority species (e.g. the large and attractive longhorn or ground beetles, butterflies, dragonflies, etc.).

Conclusions

The fauna of the ground beetles in the reserve has not been studied so far. As a result of the present study 32 taxa were captured. Twelve endemics were found. Twenty three other invertebrates were established.

Twenty five invertebrate species with conservation and biogeographical significance were found. Monitoring of the populations of all protected, endemic, relict and rare species, which have been identified so far, is to be carried out and the preservation of their natural habitats undisturbed or not altered by human activity is recommended. The real state of the diversity of this group in the area could be revealed only after future investigations and discovery of additional new species for the region.

It is necessary the abiding of all restrictions and prohibitions currently in force within the territory of the reserve to be ensured, and the conservation of the natural

habitats in unaltered state, which would provide a possibility for fulfilment of the natural successional changes.

Habitat fragmentation and deterioration are one of the most important causes of species declines and extinctions across the world. Therefore it is necessary to provide for the limitation of the intensive economic (forestry) activities, observed during the study in the buffer zones of the reserve.

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