EARTHWORMS BIODIVERSITY IN TATARSTAN REPUBLIC

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During 25 years period we investigated diversity of Lumbricidae in Tatarstan Republic. Studies took place at the territory in the middle flow of the Volga river at its confluence with the Kama river. It is south taiga, broadleaved forests and forest-steppe subzones. Lumbricidae fauna included 16 species and subspecies among 20, recorded in Middle Volga Region. Those were European and Asian cosmopolitians (species of Eisenia genus) and Ural endemics *E. intermedia* and *P. tuberosa*. The most abundant in Republic were plow worm *A. caliginosa*, pink Eisenia *A. rosea, gigrofilious calcofilic O. lacteum* and sibirican *E. nordenskioldi*. The earthworms are sensitive to soil moisture, acidity and anthropogenic impact. They habitat broadleaved forests, flood meadows and forests (alders, willows, elms). Among mentioned above there were rare species: synanthropic A. longa (we have recorded it in Kazan city), amphibiotic E. tetraedra tetraedra and South Ural endemic *E. intermedia*, which we did not record. *E. fedida* was abundant at cattle farms and treatment facilities. Among different soil types earthworms prefer gray forest and podzol ones. Lumbricidae fauna and population differed in relation to zones. The highest biodiversity and abundance was recorded in broad-leaved forests zone (14 species), then – in subtaiga (12) and the smallest number of species was found in the forest-steppe zone (9).

Key words: fauna, earthworms abundance, south taiga, broad-leaved forest subzone, forest – steppe subzone.

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INTRODUCTION

Earthworms are related to the most known, economically important and well-studied representatives of soil fauna (Тиунов 2007). Back in XIX century classic studies of V. Hensen, Ch. Darwin, Muller and G. Visotskiy showed their major contribution into soil structure formation and soil profile development (Чеснова & Стриганова 1999). Ch. Darwin estimated earthworms activity. He was the first, who declared that humus is the product of earthworms. He argued that they accelerate litter decomposition, recycling it mechanically

and chemically as well, passing it through the intestines. Ch. Darwin determined coprogenic character of the meadow and forest soils. G. Visotskiy, geobotanist and soil scientist, worked in forestation in steppe zone. He established that precisely earthworms activity determined chernozems grainy structure.

Earthworms are the typical "ecosystem engineers", they modify the other soil biota components habitats (Jones et al. 1994, Жуков 2004, Lavelle et al. 2006, Тиунов 2007). Some authors consider that they do not contribute greatly into the soil community metabolism (respiration) (Тиунов 2007), the other have the opposite opinion (Гордиенко и др. 2009, Гордиенко & Вавилов 2014). Earthworms directly recycle litter and stimulate microorganisms activity as well. They influence chemical characters of soil, increasing calcium, magnesium, ammonia, nitrates, phosphoric acid content, increase soil breathability and water permeability. Lumricidae is the abundant group in soil macrofauna community. They can reach 100% of macrofauna abundance (Хабибуллина 2012). Earthworms are sensitive to environment pollution and recreation (Воробейчик 1994, Paoletti, 1999, Rousseau 2010, Соколова 2011). Then they are bioindicators of ecosystem status.

Biodiversity conservation is the foreground direction in ecology all over the world (Turbe 2010). At Tatarstan territory Lumricidae fauna was studied by several researchers (Michaelsen 1910, Светлов 1937, Изосимов 1954, Алейникова 1969, 1972). By the middle of the century 17 species and subspecies were recorded in republic among 20, recorded in Middle Volga region (Алейникова 1969). At present 16 species and subspecies of Lumbricidae inhabit territory of Republic (Жеребцов и др. 2008, Александрова и др. 2011, Кадастр сообществ почвообитающих беспозвоночных (мезофауна) естественных экосистем Республики Татарстан 2014).

The aim of our study was to estimate fauna and population of earthworms along the 20-year period of soil macrofauna study in Tatarstan Republic.

MATERIAL AND METHODS

We carried out our investigations in natural

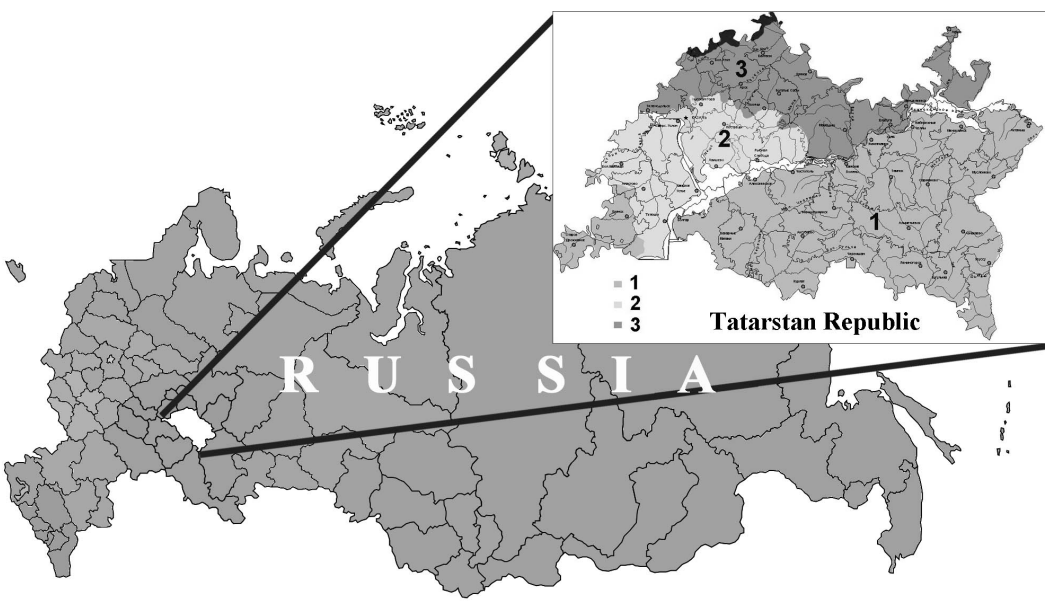

Fig. 1. Location of investigations: 1 – forest-steppe subzone, 2 – broad-leaved (deciduous) forest subzone, 3 – subtaiga subzone.

and anthropogenically disturbed ecosystems in Tatarstan Republic (TR) in 1997 – 2018. We used standard soil-zoological method to record earthworms (Количественные …1987): we took samples 0.25x0.25m^2 in size and 0-20 cm in depth. In each plot we took 8-16 samples. We have analyzed data from 150 plots, over 5000 individuals were identified. Investigations took place in three landscape subzones (Ермолаев с соавторами 2007) in Tatarstan Republic of Russian Federation (RF). Republic is situates in the middle flow if the Volga river in its influence with the Kama river: in subtaiga, broad-leaved (deciduous) forest and typical south forest-steppe subzones (Fig. 1). We identified earthworms according to cadastre-definition keys T. S. Vsevolodova-Perel (1997).

Results were processed in Excel and Statistica 6.0 (Боровиков 2003). We used descriptive statistics and multidimensional method – discriminant analysis. Predictor in the latter was landscape zoning characters.

RESULTS AND DISCUSSION

Our own 21-year investigations and published papers analysis revealed, that 16 species and subspecies of Lumbricidae inhabit Tatarstan Republic (Алейникова и др. 1979, Корчагина 2002, Зелеев и др. 2003, Жеребцов и др. 2008, Gordienko & Kibardina 2010, Кадастр почвообитающих … 2014, Гордиенко и др. 2016, Гордиенко & Вавилов 2017) among 20, recorded in the Middle Volga Region: *Lumbricus terrestris* Linnaeus 1758, *Lumbricus castaneus* Savigny 1826, *Lumbricus rubellus* Hoffmeister 1843, *Aporrectodea longa* Ude 1826, *Aporrectodea rosea* Savigny 1826, *Aporrectodea caliginosa caliginosa* Savigny 1826, *Aporrectodea caliginosa trapezoids* Dugesi 1828, *Octolasion lacteum* Orley 1885, *Dendrobaena octaedra* Savigny 1826, *Dendrodrilus rubidus tenuis* Eisen, 1874, *Eisenia nordenskioldi nordenskioldi* Eisen 1873, *Eisenia uralensis* Malevic 1950, *Eisenia fetida* Savigny 1896, *Eiseniella tetraedra tetraedra* Savigny 1826, *Perelia tuberosa* Svetlov 1924. We did not record the South Ural endemic *Eisenia intermedia* Michaelsen, 1901, which was mentioned in Kadastre… (2014). Among recorded species there were wide spread European species of Aporrectodea, Octolasion, Dendrobaena, Lumbricus, Eiseniella genera and Asian species of Eisenia and Dendrodrilus genera. South Ural and Near-Ural endemic *P. tuberosa* was recorded at the north – east of Republic. Synanthropic *E. fetida* was abundant in the rotted manure at the cattle farms and sewage treatment plants. That is common to this species. The highest biodiversity of Lumbricidae was in broad-leaved forests subzone (14 species), then – in subtaiga (12 species) and forest-steppe zone (9). The mean number varied – 119.5 ind. per sq.m, 81.2 ind. per sq.m and 31.6 ind. per sq.m, respectively (Fig. 2).

Dangy worm *E. fetida*, plowed worm *A.c. caliginosa*, pink Eisenia *A. rosea* and calcofilic gigrophilic *O. lacteum* dominated in broad-leaved forest zone (Fig. 3). *E. fetida* was recocded at the cattle farms and sewage treatment plants only. In subtaiga zone the same *A.c. caliginosa, A. rosea* and *O. lacteum* were abundant and Siberian *E. uralensis* as well. The most similar in species diversity were forest-steppe and subtaiga subzones (Jaccard's coefficient of community 0.75) and subtaiga and broad-leaved forests subzones as well (0.73). Less similar were forest-steppe and broad-leaved forests subzones (0.64). In total *A. caliginosa, A. rosea, O. lacteum* and *E. nordenskioldi* were most abundant at the territory of Republic.

Though the number of species recorded in forest-

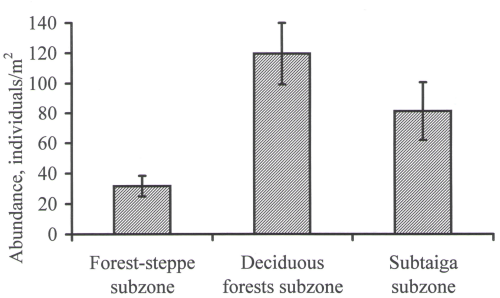

Fig. 2. Mean number of earthworms.

Table 1. Indexes of Lumbricidae communities

Indexes	Forest-steppe subzone	Deciduous forests subzone	Subtaiga subzone
Taxa, S	9	14	12
Individuals	7	41	25
Dominance, D	0.61	0.29	0.35
Shannon, H	1.93	1.78	1.78
Simpson, 1-D	0.39	0.71	0.65
Evenness, e^H/S	0.77	0.42	0.49
Menhinick	3.40	2.19	2.40
Margalef	4.11	3.50	3.42
Equitability, J	0.88	0.67	0.72
Berger-Parker	0.57	0.34	0.48

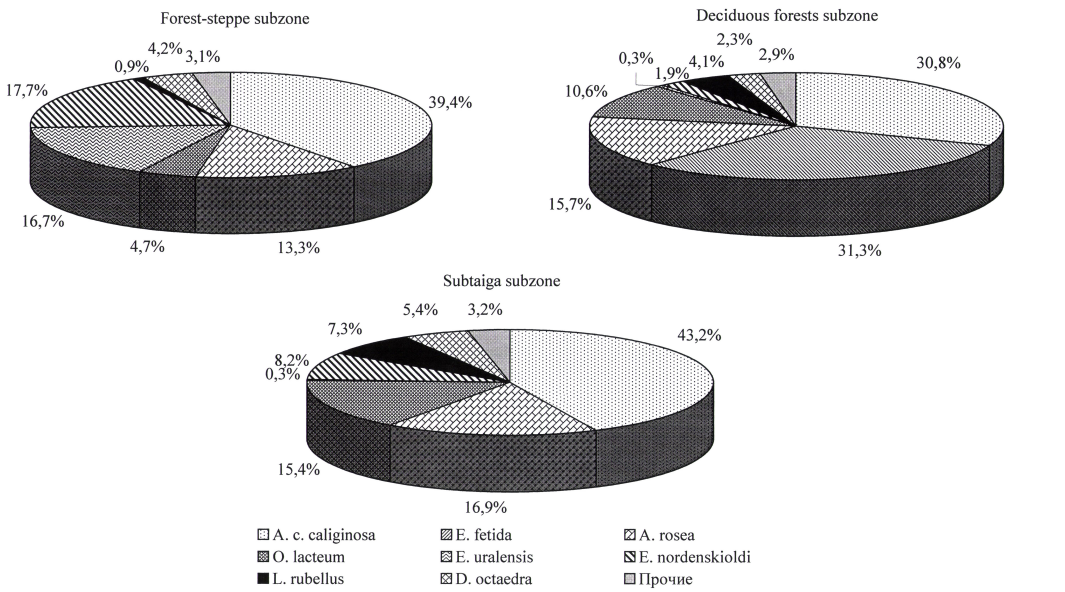

Fig. 3. Dominating earthworms species diagram.

steppe zone was the lowest, the Shennons index of biodiversity there was higher; other indexes of communities studied are presented in Table 1. In relation to nutrition type and soil dwelling the earthworms are divided into morpho-ecological groups (Перель 1979, https://www.earthwormsoc.org.uk/earthworm-ecology): feeding on soil surface with dead organics and real-soil (endogeic), consuming soil humus. These groups include four ecotypes – anecic *L. terrestris* and *A. longa*, epigeic *D. octaedra* and other red earthworms, endogeic species from Aporrectodea, Octolasion genera and compost earthworms *E. fetida*. In our study the earthworms communities included 4 ecotypes: endogeic ones dominated in all zones (Fig. 4), compost

Table 2. Squared Mahalanobis distances between centroids of communities studied

	Forest-steppe subzone	Deciduous forests subzone	Subtaiga subzone
Forest-steppe subzone	0	**2.30*** **	**1.54** **
Deciduous forests subzone	**2.30*** **	0	**1.41***
Subtaiga subzone	**1.54** **	**1.41***	0

Note: in bold statistically significant values, ***- p<0.001, ** - p<0.01, * - p<0.05

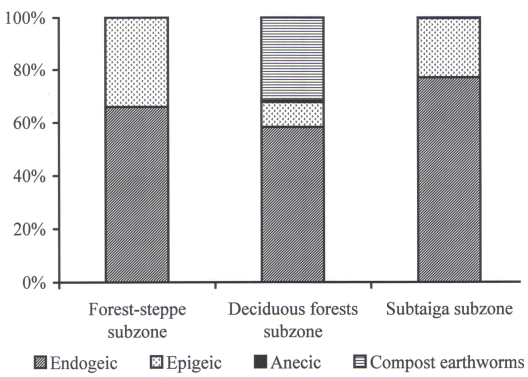

Fig. 4. Ecotypes of earthworms in studied areas.

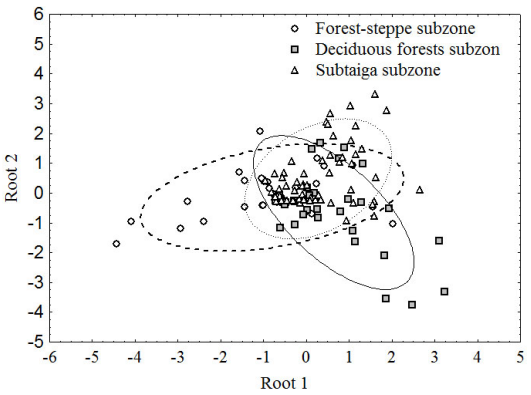

Fig. 5. Disriminant analysis results in ordination of Lumbricidae communities.

earthworm was abundant in broad-leaved zone, epigeic ones were less in number and anecic ones were very rare.

Discriminant analysis resulted in significant differences in communities structure in different zones (Wilks' Lambda: 0.61276 approx. F (28.258)=2.5568 p< 0.0001) (Fig. 5). Plowed worm *A.c. caliginosa*, infrequent *E. uralensis*, *L. castaneus* and rare *A. longa* had the greatest loading in discrimination function. Squared Mahalanobis distances were not large, but significant (Table 2).

According to our observing and published data the earthworms are very sensitive to soil humidity, acidity and anthropogenic impact. They prefer broad-leaved forests (till 289 ind. per sq. km in number), flood – plain meadows (till 247 ind. per sq. m) and flood-plain forests (till 336 ind. per sq. m in elm, alder and willow forests). The lowest number of Lumricidae occurred in pine forests and rural habibtats.

There are rare and low number species in Tatarstan. Among them sinanthropic *A. longa,* recorded in Kazan city (2 ind.), amphibiotic *E. tetraedra tetraedra* (also in Kazan, the single one). Endemic *P. tuberosa* is common at the east of Tatarstan. Dung earthworm *E. fetida* is abundant in cattle farms and sewage treatment plants (till 632 ind. per sq. m). Among different types of soil Lumricidae prefer gray forest and podzole soils (Александрова и др. 2011).

CONCLUSION

Biodiversity estimation is the first and necessary step, when elucidating functional traits variation in different taxa. Then comprehensive ecological and faunistic studies needed in different zones and all over the area of species. Species composition, distribution and number estimates are the obligatory and to some extent basic step in this direction. The latter determines the foreground researches of present day ecology – elaboration of

scientific base in biodiversity conservation and its rational use as the factor of ecosystems stability.
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