

Physiological and Biochemical Parameters of the Grey Red-backed Vole (*Craseomys rufocanus*) Population in the Northern Priokhotye at Different Population Levels

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In order to clarify the manifestations of stress in the grey red-backed vole population under conditions of a relatively low number, the variability of several physiological and biochemical indicators was studied for 13 years. The study revealed that in most years of observation, with a low and average level of animal numbers, there were no signs of stress. The level of physiological parameters corresponding to the stress state of voles was detected only once, in the year of "peak," i.e. the maximum population size. The identified stress, apparently, was the main reason for the lowest subsequent survival of animals in this period for all years studied.

Key words: Northern Priokhotye, grey red-backed vole, population density, physiological and biochemical indexes (parameters), stress

In a number of previously published works (Lokhmiller, Moshkin, 1991; Boonstra, Boag, 1992, etc.), as well as in the recently released article by the author (Lazutkin, 2019), attention is drawn to the lack of actual observations of the manifestation of stress in the natural populations of mammals. The stress reaction in animals is nonspecific, i.e. It can be caused by many factors, but in the natural populations of small rodents experiencing sharp fluctuations in numbers, the most important of them is the periodically arising overhaul of the population (Lazutkin *et al.*, 2016; Lazutkin, 2019). In the latest work of the author, using the example of the studied population of the gray red-backed vole (*Craseomys Rufocanus*, Sundevall, 1846), inhabiting floodplain larch forests in the upper reaches of the Kolyma River, using several energy and immune indicators at different phases of the population cycle, a comparative assessment of the physiological state of the animals was made.

As a result, it was shown that each individual level of the number of animals' population corresponded to its physiological status. Stress, determined by the set of physiological and biochemical indicators, was detected only when the population reached its highest numbers. It was of interest to explore the population of this type of voles in different conditions of existence and with a relatively low number of animals. In this work, based on the materials of 13-year observations in the area of floodplain larch forests in northern Priokhotye, which were not previously investigated, using the same methodological approaches, a similar assessment of the physiological state of the grey red-backed vole population was carried out.

MATERIAL AND METHODS

The material of the article was perennial inpatient studies conducted in 2010-2022 in the larch sparse forest of Northern Priokhotye (Olskaya lowland, the surroundings of Lake Chistoye, 59° 30' N, 153° 20' E). According to these results, the population dynamics of forest voles *Clethrionomys* and *Craseomys* was described in details (Lazutkin, 2023). A distinctive feature of the newly studied territory, in comparison with

previously studied high-bonitet floodplain forests of the region, was its simpler ecosystem, with a relatively low abundance of the red-sided vole in most years of observation. Through almost the entire observation period, the population of this species fluctuated between the low and medium levels. And only once (in 2020) reached a "peak", i.e. maximum number. Nevertheless, the red-gray vole here is the second background species after the red vole among the rodents of the taiga zone. In this work, a homogeneous cohort of immature yearlings is selected, which are the most vulnerable to the stress manifestation (Creel, 2001). Their share in the total population of this species amounted to about 70 %.

The average annual number of voles is calculated according to relative accounting data from June to September, conducted by the standard trading method (Karaseva, Telicina, 1996). Voles, caught by livestock, equipped with a signaling of the capture, were anesthetized and scored in 2-4 minutes after the capture.

Physiological and biochemical indicators (lipids and glycogen in the liver, glucose and leukocytes in the blood, bone marrow cellularity, weight indicators of spleen and thymus) were determined by the methods described by us earlier (Chernyavsky *et al.*, 2003; Chernyavsky, Lazutkin, 2004; Lazutkin, 2016).

Males and females of the voles were combined into one group, because there were no reliable differences in their considered physiological indicators. A preliminary comparative analysis of the variability of physiological parameters in voles at low and medium abundance showed that this difference was not significant, and therefore they were also combined.

In total, 322 gray red-backed voles were investigated, including 76 caught alive. The data was analysed using the Statistica 6 package. A 5% level of significance was adopted for statistical assessment.

RESULTS AND DISCUSSION

In our previous study of the red- gray vole population in the upper reaches of the Kolyma River, it was shown that during periods of high numbers of animals, the physiological parameters show exhibit variability which is characteristic of stress exposure (Lazutkin, 2019). It

was of interest to conduct a similar analysis of the same vole species, with less pronounced population dynamics, under different environmental conditions. It was assumed that the density factor in the newly studied population of the red-sided vole may also be one of the main factors in the variability of the discussed physiological and biochemical parameters.

The population size. Fig. 1 illustrates the dynamics of the average annual (summer-autumn) density of the *C. rufocanus* population in the larch sparse forest of Northern Priokhotye, which is described in detail in our previous article (Lazutkin, 2023). During the first 10 (2010-2019) and the last 2 (2021, 2022) years of observation, the population of the red-gray vole fluctuated between the low depressive and average non-high level. And only once for the entire period of observation (2020), exceeding the average annual number of the number several times and reached a "peak", i.e. maximum number. It should be noted that after reaching the population of its peak, i.e. during the next autumn and winter, there was a sharp drop in the number of animals – the mortality rate of animals to the beginning of the next reproductive period was 95%.

Thus, the dynamics of the number in the studied area, despite a certain similarity with such in the optimal habitats of this type of animal (cyclical, demographic parameters, etc.) differs in generally less density of the population and rare peak lifts.

The significance of physiological and biochemical indicators used in the work as stress identifiers, with the involvement of literary sources, was argued and discussed in detail earlier (Lazutkin *et al.*, 2016; Lazutkin, 2019). At the same time, it was stated that under stress, the level of lipids in the liver sharply increases – that phenomenon is normally unusual for mammals and the content of reserve carbohydrate – glycogen – in this body decreases. A decrease in this polysaccharide content causes hypoglycemia in animals, i.e. low amount of glucose in the blood. Also stress is associated with disturbances and resulting tension of the immune system. At the same time, leukocytosis develops in animals, i.e. an increased amount of immature leukocytes in the blood, which causes changes in hemocytogenesis – the formation of

hematopoietic cells in the bone marrow, which increases at the beginning of stress, and falls sharply with prolonged stress. One of the most important immune organs is not left without change – the spleen, the average weight of which in the animals of animals increases, and splenomegaly is detected in some animals. The normal involution of another organ of the immune system – the thymus gland (Timus) - is violated and its weight index remains high.

Physiological indicators in the immature animals of the red-gray vole in the larch sparse forest of Northern Priokhotye at different levels of numbers are given in Figure 2 (A, B, C, D, E, F, G).

Lipids in the liver. Their accumulation in this body in mammals is an unambiguous evidence of the adverse state of the body, as a rule, with stress or starvation (Newsholm, Start, 1977).

During the high number of animals, amount of lipids in the liver of the voles studied was significantly higher than in the years of low and average numbers (Fig. 2 a).

Glycogen of the liver. Remaining an important reserve carbohydrate to replenish glucose in the blood, the content of glycogen in the voles' liver is usually not large (Chernyavsky, Lazutkin, 2004). Nevertheless, it varies depending on the trophic conditions of the animals' life.

A comparison of this energy indicator in the animals studied during the years of different numbers showed, that at a high density of the voles its values was minimal (Fig. 2 b).

Glucose in the blood. Despite the stability of this vital indicator of homeostasis in animals, its low blood content (hypoglycemia) can be observed during stress conditions or other dysfunctional situations (Dubuc *et al.*, 1983).

A comparison of the amount of glucose in the blood of the voles with high, low and medium density showed that in the first case it turned out to be significantly lower (Fig. 2 c).

Leukocytes in the blood. Increased in comparison with the normal amount of leukocytes is usually associated with an accelerated emissions and intake of immature cells in the bloodstream due to the violation of

the centers of their formation – bone marrow, spleen, thymic gland (Horizontov *et al.*, 1983; Neiman *et al.*, 1991; Gabriel *et al.*, 1992). One of the main causes of such a malfunction in the immune system are stress conditions.

Our new data on the content of general leukocytes in the blood of red-gray voles showed that in the population studied the average level throughout all years of observation was lower than the norm we set-3500-4000 cells/ml (Mosin, Lazutkin, 1985; Lazutkin, 1997). Nevertheless, at a high density, it was significantly higher than at a low and medium density of animals (Fig. 2 d).

Bone marrow cellularity. The data on this immune physiological indicator in the natural populations of animals are extremely fragmentary (Chernyavsky, Lazutkin, 2004; Tarakhtiy *et al.*, 2007; Lazutkin *et al.*,

2016). Nevertheless, it is known that, depending on the tension and duration of stress exposure, the hematopoietic function of the bone marrow sequentially passes the stages from mobilization and resistance to exhaustion and pathology (Horizontov, *et al.*, 1983; Homeostasis, 1983).

A comparison of the number of cells in the bone marrow in the voles studied at different density conditions showed a reliably low content at high as compared with low and medium density (Fig. 2 e).

Weight indices of the spleen and the thymus gland (Timus). Violation of the bone marrow can cause a negative impact on the functioning of these organs of the immune system. The assessment of the weight index of the spleen and thymus in yearlings of the studied population of the red-gray vole revealed its significantly high levels at high density (Fig. 2 f, g).

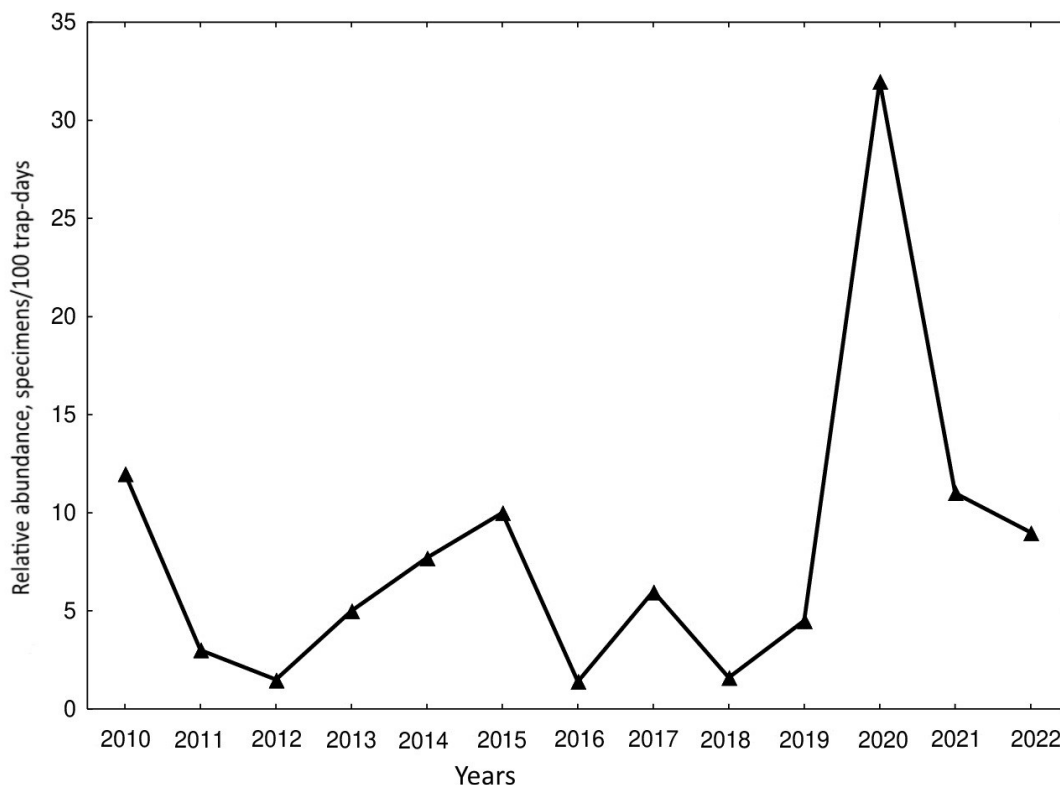


Figure 1. The dynamics of the average annual number of the population of the grey red-backed vole in the larch editorial of the Northern Priokhotye (the surroundings of Lake Chistoye) in 2010-2022.

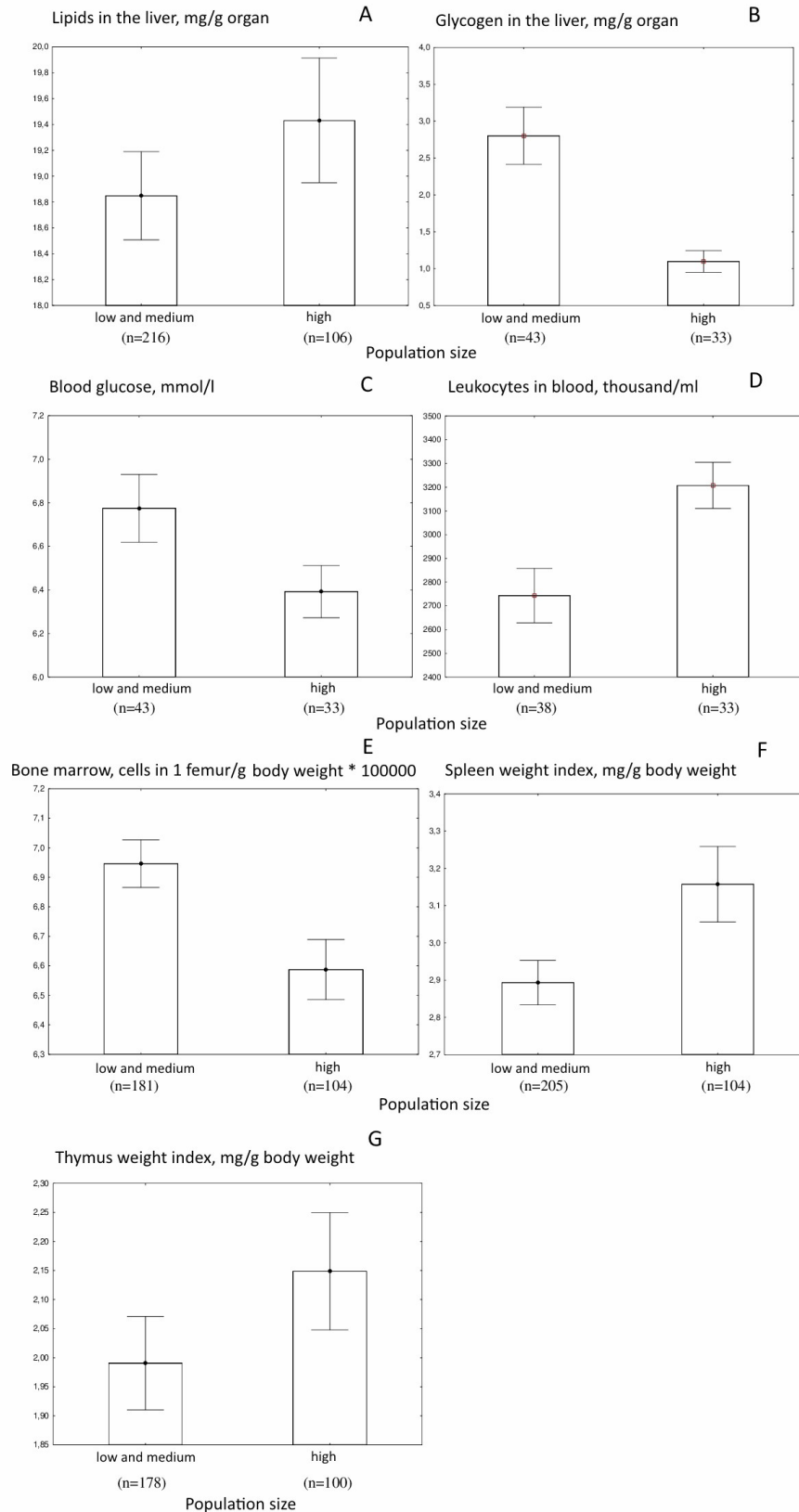


Figure 2. Physiological and biochemical indicators of the population of the grey red-backed vole with different numbers in the larch sparse forest of Northern Priokhotye (the surroundings of Lake Chistoe).

n is the number of animals

CONCLUSION

A long-term study of the dynamics of the population of the grey red-backed vole, which inhabits the vast territory of the larch sparse forest of Northern Priokhotye, showed that the density of animals does not reach the values of the biotopes of floodplain river valleys obtained earlier. In most years of observation, the population was at the stages of low and medium density and only once reached its "peak", i.e. maximum number. A comparative analysis of a complex of physiological and biochemical indicators, reflecting the energy and immune state in the studied animals was carried out. It shows that in the phase of the maximum number, reliable shifts in the entire aggregate of the investigated parameters were identified, which are characteristic to stress according to existing ideas. In this period, such a stressful state, apparently of a long-term nature, caused the subsequent highest mortality of animals. Thus, even in such a rarefied population of rodents we examined, stress is an important factor of regulation of their number.

CONFLICTS OF INTEREST

The author declares that he has no potential conflicts of interest.

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