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MORPHOLOGICAL INDICATORS OF THE NARROW-CRUSTED VOLE OF THE ANTHROPOGENIC TERRITORY OF NORTH-EASTERN KAZAKHSTAN

This study delves into the intricate relationships between ecological factors, adaptation, and the effects of anthropogenic activities on small mammals in the Northeastern region of Kazakhstan. External traits, including body mass, length, tail length, ear height, and hind foot length, provide valuable insights into adaptive adjustments in response to various climatic and ecological conditions. Industrial areas reveal a reduction in average body mass, attributed to patchy vegetation and proximity to factories and roads.

Size variations are closely tied to food availability, with a reduction in body size and growth rates observed in technogenic zones. Tail sizes differ by age and sex, while foot sizes tend to even out as animals mature. Notably, anthropogenic pollution has minimal impact on ear length.

The heart index reflects an individual's mobility and thermoregulation, while the liver index is influenced by food availability and energy resources. Notably, the analysis extends beyond average differences, considering the range of variability to identify increased diversity, even in ecologically challenging areas.

Small mammals exhibit a high metabolic rate and limited physiological stress adaptability, yet the population demonstrates remarkable adaptation. Enlarged heart indices suggest increased locomotor activity associated with overcoming anthropogenic barriers, such as railways and highways.

In addition to heart indices, liver mass calculations reflect the accumulation of energy reserves and materials for growth. The study highlights that the liver mass index of field mice in industrial zones exceeds that of the control group, indicating the impact of anthropogenic activities on these organisms.

This research provides valuable insights into the intricate relationships between ecological factors, adaptation, and human influence on small mammal populations in the Northeastern region of Kazakhstan.

Keywords: small mammals, narrow-crusted vole, morphophysiological indicators method, exterior signs, interior signs.

Introduction

Research into biodiversity and the ecology of organisms in regions impacted by human activities encompasses various scientific fields. Experimental studies confirm that organism populations generally strive for stability, which includes genetic adaptations aimed at preserving their numbers and the equilibrium of micro-populations. There is evidence that environmental changes can lead to alterations in the genetic structure of populations, but when the habitat reverts to its original conditions, the population's genotype returns to its initial state [1]. These phenomena not only result in changes in population size but also bring about qualitative transformations. This process exemplifies a homeostatic response to environmental fluctuations. The primary objective of population homeostasis is to ensure adaptability and survival [1]. Such phenomena can arise in response to shifts in the planet's climatic conditions and can also be induced by localized human interventions that disrupt population equilibrium, triggering homeostatic processes and micro-population adjustments.

Animals living in areas affected by human activities can respond to adverse environmental effects not only at the population level but also at the individual organism level. The transformation of organisms likely contributes to shifts in the balance of micro-groups within populations, which are distinguished by age, gender, and other characteristics. We propose that changes in the external and internal attributes of organisms do not always manifest at the level of individual organs or organ systems but can impact population traits. Therefore, to comprehend ecological processes, it is crucial to compare the morphological and physiological characteristics of small mammals inhabiting regions influenced by industrial facilities.

Materials and methods

The method of morphophysiological indicators, developed at the Institute of Plant and Animal Ecology under the guidance of Academician S. S. Schwarz [2], is a research method that allows establishing a link between physiological mechanisms in the organisms of animals and the size and weight of their internal organs. This method is widely used in ecological and biological research to assess the impact of biotic and abiotic environmental factors on organisms.

Description of the method includes the following key steps and parameters [3, 4]:

1 Use of rapidly euthanized animals: This is done to avoid distorting the results through prolonged fasting, which can lead to uneven organ weight loss;

2 Measurement of morphological parameters: Various parameters are measured, such as overall length, body length, body size, ear height, hind limb length, and tail length. These parameters are used to determine the size of the animals;

3 Dissection and laboratory examination: Animals undergo anatomical dissection, and internal organs are examined to assess their condition, structure, and weight;

4 Calculation of the relative organ weight: A formula is used to determine the relative weight (index) of an organ, expressed as a percentage of the animal's body weight. This allows an assessment of the importance and activity of specific organs relative to body size [5];

5 Study of the heart and liver mass index: These organs are selected because they are actively functioning and can be important in interactions with pollutants through the bloodstream.

The method of morphophysiological indicators helps researchers understand how changes in the environment affect organisms and their physiological processes. This can be useful for studying ecological issues, including the impact of pollution on animals and assessing their health.

Results and discussion

The level of energy exchange intensity serves as an indicator of the habitat conditions in which the animals reside. The extent of adaptation becomes evident through the size and weight of various organs, with particular emphasis on the heart and liver. The heart index is associated with an individual's mobility and chemical thermoregulation, while the liver index is influenced by the availability of food resources and energy [6].

In addition to comparing average differences, the analysis of relative organ indices also involves the determination of the range of variability. This approach helps identify increased variability, as there is data suggesting that diversity

indicators can expand in ecologically unfavorable areas, even when average values are similar [6].

The liver functions as a reservoir for energy and proteins, and its mass can change rapidly over a short period, often within hours. The natural conditions of animal habitats are subject to constant changes, including shifts in food availability and temperature, among other factors. Therefore, the assessment of the liver index should be considered in conjunction with other organs. Increased heart mass typically results from long-term environmental changes [5].

External characteristics are employed as indicators when examining adaptive adjustments in organisms residing in diverse climatic, ecological, and geographical conditions [7, 8].

External traits encompass body mass (M) and length (L), tail length (C), ear height (A), and hind foot length (PI). Internal data includes indices related to the heart, liver.

Although there is some sexual dimorphism in external traits, it is not highly pronounced. Males and females exhibit differences in the dynamics of body mass growth. Generally, during the spring-summer period, the body mass of male animals surpasses that of females, but in the winter, according to Ivanter E.V.'s findings [9], the mass of males becomes significantly greater than that of females.

The study revealed a decrease in the average body mass of both male and female narrow-skulled voles in areas affected by industrial activity in comparison to the control group. This reduction in body mass may be linked to the patchy vegetation in impact zones and the proximity (1–2 km) of factories, roads, and agricultural facilities. Thus, anthropogenic influence indirectly affects body mass through food resources and their restricted access.

The size of animals is closely tied to their body mass, and under conditions of limited food resources, the growth of mammalian organisms tends to slow down. Consequently, in the study of body length, a reduction in the size of animals in technogenic zones was observed compared to the control group.

Tail sizes typically vary depending on the sex and age of the animal. Young females generally have smaller tails than young males, but in adults, the difference is hardly noticeable. Our research did not uncover any differences in tail sizes between organisms in technogenic zones and the control group.

As animals age, the growth rate of their feet in small mammals slightly decelerates, unlike tail sizes. Young females typically have smaller feet [10], but as they mature, the difference levels out.

Ear size, similar to tail and foot sizes, experiences slower growth during the cold season. This adaptation allows the organism to minimize energy expenditure

on heating protruding body parts [11]. The study did not detect any significant impact of anthropogenic pollution on the ear length of rodents.

It is assumed that organs with smaller surface areas do not significantly drain energy, which may explain the absence of significant deviations in tail, foot, and ear sizes.

Small mammals typically possess a high metabolic rate and limited physiological adaptability to stress. However, at the population level, these animals demonstrate a notable degree of adaptation [12]. Hence, the assessment of anatomical features, such as the relative organ mass (e.g., heart, kidneys), in narrow-skulled field mice living in the same region, offers valuable insights into the environmental influence on this mammalian species.

The heart, as the foremost organ signaling an animal's physical activity and energy expenditure during movement, plays a crucial role [9]. Enlarged heart indices suggest substantial physical exertion and active stress on the heart muscles. An increase in body size signifies alterations in the animals' habitat, which, in turn, lead to elevated metabolism. Higher metabolism can, in some cases, result in reduced body size [13].

When comparing the indices of representatives from the same family residing in industrial areas with those from control groups, we observe an increase in these indicators. This upturn in locomotor activity is associated with the need to surmount anthropogenic barriers such as railways and highways that these animals are compelled to cross.

In addition to heart mass indices, morphophysiological approaches also encompass the calculation of liver mass indices. The liver serves as a reservoir for energy in the form of carbohydrates and fats, as well as materials for growth, primarily proteins, for the organism [5]. An increase in liver mass signifies the accumulation of carbohydrates, to a lesser extent, proteins, and fats. In situations of stress, glycogen is predominantly consumed, followed by the utilization of lipid and protein reserves [5]. Therefore, the liver index stands as a reliable indicator of the environment's impact on the organism. In the Northeast of Kazakhstan, the liver mass index of the narrow-skulled field mice population in industrial zones exceeded that of animals in control territories.

Conclusions

The analysis of the study results using the morphophysiological method leads us to a conclusion regarding the profound influence of ecological factors on living organisms and entire populations. There exists a direct correlation among various elements, including dietary habits, competition within and between species, and the effects of the non-living environment, as demonstrated by the examination of external and internal characteristics. In turn, anthropogenic factors can alter

the quality of dietary patterns, the conditions of habitats, and even the survival of individual species. Hence, human activities and their impact on the environment can significantly impact parameters such as body size and the mass of internal organs in small mammals inhabiting anthropogenic areas in the Northeastern region of Kazakhstan.

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СОЛТҮСТІК-ШЫҒЫС ҚАЗАҚСТАННЫҢ БҮКІЛ АНТРОПОГЕНДІК АУМАҒЫНДАҒЫ ТАР ӨЗІМШІЛ ӨСІМДІКТЕРДІҢ МОРФОЛОГИЯЛЫҚ КӨРСЕТКІШТЕРІ

Мақалада экологиялық факторлар, антропогендік әрекеттің Қазақстанның солтүстік-шығыс аймағындағы ұсақ сүтқоректілерге бейімделуі мен әсері арасындағы өзара байланыс сипатталған. Дене салмағын, ұзындығын, құйрығын, құлағының биіктігін және артқы аяқтарының ұзындығын қоса алғанда, сыртқы белгілер әртүрлі климаттық және экологиялық жағдайларға жауап ретінде бейімделу туралы құнды ақпарат береді. Өнеркәсіптік аудандарда орташа дене салмағының төмендеуі байқалады, бұл гетерогенді өсімдіктермен және өсімдіктер мен жолдарға жақын орналасуымен түсіндіріледі.

Мөлшердегі айырмашылықтар тағамның қол жетімділігімен тығыз байланысты, ал техногендік аймақтарда дене мөлшері мен өсу қарқынының төмендеуі байқалады. Құйрықтың өлшемдері жасына және жынысына байланысты өзгереді, ал аяқтың өлшемдері Жануарлар жетілген сайын теңестіріледі. Бір қызығы, антропогендік ластану құлақтың ұзындығына аз әсер етеді.

Жүрек индексі адамның қозғалғыштығын және терморегуляциясын көрсетеді, ал бауыр индексіне тамақ пен энергия ресурстарының болуы әсер етеді. Кішкентай сүтқоректілер метаболизмнің жоғары жылдамдығын және физиологиялық стресстерге шектеулі бейімделуді көрсетеді, дегенмен популяция бейімделуді көрсетеді. Жүрек индексінің жоғарылауы темір жолдар мен автомобиль жолдары сияқты антропогендік кедергілерді жеңуге байланысты қозғалыс белсенділігінің жоғарылауын көрсетеді.

Жүрек индексінен басқа, бауыр массасының есептеулері өсу үшін энергия қорлары мен материалдардың жиналуын көрсетеді. Зерттеу өнеркәсіптік аймақтардағы тар бас сүйекті тышқанның бауыр

массасының индексі бақылау тобынан асып түсетінін көрсетеді, бұл антропогендік әрекеттердің осы организмдерге әсерін көрсетеді.

Мақалада экологиялық факторлар, бейімделу және адамның Қазақстанның солтүстік-шығыс аймағындағы тар бас сүйегінің популяциясына әсері арасындағы өзара байланыс туралы ақпарат көрсетілген.

Кілтті сөздер: ұсақ сүтқоректілер, тар бас сүйек тышқаны, морфофизиологиялық индикаторлар әдісі, сыртқы белгілері, ішкі белгілері.

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МОРФОЛОГИЧЕСКИЕ ПОКАЗАТЕЛИ УЗКОЧЕРЕПНОЙ ПОЛЕВКИ АНТРОПОГЕННОЙ ТЕРРИТОРИИ СЕВЕРО-ВОСТОЧНОГО КАЗАХСТАНА

В статье описываются взаимосвязи между экологическими факторами, адаптацией и воздействием антропогенной деятельности на мелких млекопитающих в Северо-Восточном регионе Казахстана. Внешние признаки, включая массу тела, длину, хвост, высоту ушей и длину задних лап, дают ценную информацию об адаптивных приспособлениях в ответ на различные климатические и экологические условия. В промышленных районах отмечается снижение средней массы тела, что объясняется неоднородной растительностью и близостью к заводам и дорогам.

Различия в размерах тесно связаны с доступностью пищи, причем в техногенных зонах наблюдается уменьшение размеров тела и темпов роста. Размеры хвоста различаются в зависимости от возраста и пола, в то время как размеры ног, как правило, выравниваются по мере взросления животных. Примечательно, что антропогенное загрязнение оказывает минимальное влияние на длину ушей.

Сердечный индекс отражает подвижность и терморегуляцию человека, в то время как на индекс печени влияет доступность пищи и энергетических ресурсов. Мелкие млекопитающие демонстрируют

высокую скорость метаболизма и ограниченную приспособляемость к физиологическим стрессам, однако популяция демонстрирует адаптацию. Увеличенный индекс сердца свидетельствуют о повышенной двигательной активности, связанной с преодолением антропогенных барьеров, таких как железные и шоссейные дороги.

В дополнение к индексу сердца, расчеты массы печени отражают накопление энергетических запасов и материалов для роста. В исследовании подчеркивается, что индекс массы печени узкочерепной полевки в промышленных зонах превышает показатель контрольной группы, что указывает на воздействие антропогенной деятельности на эти организмы.

В статье отражена информация о взаимосвязях между экологическими факторами, адаптацией и влиянием человека на популяции узкочерепной полевки в Северо-Восточном регионе Казахстана.

Ключевые слова: мелкие млекопитающие, узкошерстная полевка, метод морфофизиологических показателей, внешние признаки, внутренние признаки.

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