

## **PHENOTYPE CRANIOLOGICAL VARIATION OF THE TWO SEXES OF THE ZOO-MONITOR SPECIES *A. FLAVICOLLIS* IN AGRICULTURAL ECOSYSTEMS IN BULGARIA**

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**Key words:** *Apodemus flavicollis*, Zoo-monitor, Craniometrical variation

**Abstract:** Craniological analysis of specimens of the Yellow-necked mouse (*Apodemus flavicollis*) from agricultural region in North-Eastern Bulgaria was carried out. The degree of sexual dimorphism of the studied craniometrical measurements was revealed through: (i) variation flow and (ii) assessment of the degree of comparative variation. The obtained results extend the knowledge about population characteristics of the zoo-monitor *A. flavicollis* regarding the assessment of phenotype population variation of the two sexes under agricultural conditions. The established characteristics constitute substantial morphological basis for further eco-physiological studies of this zoo-monitor species in agricultural ecosystems in Bulgaria.

## **ФЕНОТИПНА КРАНИОЛОГИЧНА ИЗМЕНЧИВОСТ НА ДВАТА ПОЛА НА ЗООМОНИТОРНИЯ ВИД *A. FLAVICOLLIS* В АГРОЕКОСИСТЕМИТЕ В СЕВЕРОИЗТОЧНА БЪЛГАРИЯ**

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**Ключови думи:** Зоомонитор; краниометрична изменчивост; *Apodemus flavicollis*;

**Резюме:** Проведен е краниологичен анализ на представители на жълто гърлата горска мишка (*Apodemus flavicollis*), обитаващи агрорегион в Североизточна България. Чрез анализът на: (i) потока на изменчивост и (ii) оценка на степента на сравнителна изменчивост е разкрита степента на проява на полов диморфизъм при изследваните краниометрични показатели. Получените резултати разширяват знанията за популационните характеристики на зоомонитора *A. flavicollis*, с оглед оценката на популационната изменчивостта на краниологичния фенотип на двата му пола, при условията на развитие на биоиндикатора в характерен по вид на прилагана агротехника и ландшафт агагрорегион в Североизточна България. Установените характеристики предоставят солидна морфологична база за последващи детайлни еколого-физиологични изследвания на този зоомонитор в агроекосистемите в България.

### **Introduction**

Because of the complex character of pollution in agricultural ecosystems, the application of bio-indication and bio-monitoring of the environment there requires criteria and methods reflecting adequately the anthropogenic influence on different levels of organization of biological matter: macromolecules, cells, organisms, populations and biocoenoses.

The anthropogenically modified combination of physical, chemical and biological parameters of the environment plays an important role in formation of morphological parameters, their deformations and alterations in the living organisms. The idea that morphological changes in mammals inhabiting polluted environments could be used as indicators of human impact is based on the hypothesis that ecological conditions in each one ecosystem have a very strong influence on the formation of morphological characteristics of the populations inhabiting there and regulates them reliably as an undividable entity [1]. This hypothesis is the starting base in application of investigations

of structure, composition, statics and dynamics of populations, through the morphological approaches of population morphology, in the system of biological monitoring of the environment. The use of morphological deformations of mammals, inhabiting polluted environments, as indicators of anthropogenic impact, is very effective, especially when the combination of anthropogenic factors is difficult to be measured directly; this is most often the case of diffuse pollution of agricultural ecosystems as a result of agrotechnological procedures. The knowledge about the range of natural variation of organisms under conditions of change and breach of biotic processes in ecosystems due to anthropogenic influence represents a necessary condition for correct analysis of the data obtained from biomonitoring of the environment using zoomonitor biological species.

The application of morphobiological zoomonitoring in agricultural regions of the country is based on the knowledge gained in the field of population morphology; in order to analyze the variation of morphological characters in eco-physiological investigations of population dynamics it applies the following methods: (i) "variation flow" – provides information about the relative functional importance of the studied characters on the grounds of practically deduced assumption that functionally important characters have relatively lower variation; (ii) "analysis of comparative variation" – based on the experimentally established postulate that each morphological character strives for retaining its place in different compared operational units, independently of the differences in absolute values of the coefficient of variation; (iii) "morphological profiles" – the same morphological characters of populations are compared not by absolute values, but by relative values representing the ratio of their absolute variation to a chosen operational unit defined as "standard" [4]. Different modifications of these methods have been used successfully in the biological monitoring applied in ecological monitoring. Craniologically characterized populations of zoomonitors represent a good starting base for all subsequent investigations in particular regions reflecting the vast diversity of possible biological analyses carried out in the process of bioindication. If some of the parameters of the studied morphogenetic structures are beyond of the presumable variation range, a real necessity arises to analyze the observed deviations from ecological point of view.

The aim of the present investigation was to analyze the variation of morphological characters through combined application of the three main morphobiological methods, and to assess the degree of craniometrical variation of the two sexes of the wood mouse (*Apodemus sylvaticus*) inhabiting agricultural ecosystem in Northeastern Bulgaria.

Because of the incorrectly adopted understanding that this species doesn't express any sexual craniometrical dimorphism, during the last decades all classical morphobiological characteristics of the wood mouse have been analyzed using pooled samples of males and females. This necessitated the assessment of phenotype craniological variation of the two sexes of the zoomonitor species *A. flavicollis* in agricultural ecosystems in Northeastern Bulgaria. The absence of possibility to differentiate unambiguously the studied specimens of the morphologically sibling species *A. flavicollis* and *A. sylvaticus* have also made it difficult to obtain correct morphobiological characterization of the species. This difficulty have been bridged over with the craniological complex of characters based on biochemical-genetically determined specimens of the two sibling wood mice in Bulgaria, which is able to classify correctly 100% of the studied specimens as *A. sylvaticus* or *A. flavicollis* [5]. This possibility for massive craniological species determination of the wood mice premised that the biological diversity could be assessed correctly as regards species morphobiological variation and local craniometrical characteristics under specific ecological conditions in the main natural and agricultural ecosystems in the country inhabited by these animals.

## Materials and Methods

The study was carried out in biotopes typical for the wood mice situated in agricultural ecosystems near the town of Shoumen. In the craniometrical analysis were included only adult specimens; their age was determined on the grounds of tooth system condition. Initially, caught wood mice were distinguished as *A. sylvaticus* specimens using the craniological character complex for species determination [5] with 100% ability for differentiation between *A. sylvaticus* and *A. flavicollis*.

Craniometrical characteristics of *A. sylvaticus* was based on craniometrical complex of characters including all known till now metric parameters of the wood mouse skull from Europe, which were established to describe well the craniometrical structure of these species. The used craniometrical complex includes 32 characters: V1 – Condylbasal length; V2 – Basal length; V3 – Basilar length; V4 Condylbasilar length; V5 – Occipital length; V6 – Diastema length; V7 – Length of incisive foramen; V8 – Length of visceral part; V9 – Length of brain part; V10 – Length of nasal bones; V11 – Length of upper molar series (alveolar); V12 - Length of upper molar series (coronar); V13 – Length of bulla ossea; V14 – Interorbital width; V15 – Occipital width; V16 – Width of nasal bones; V17 – Palatal length; V18 – Rostrum width; V19 – Palatinal length; V20 – Zygomatic width; V21 – Rostrum height; V22 – Height of brain case; V23 – Width of brain case; V24 – Thickness of incisive. V27 -

Articular height; V30- Length of the lower molars row (alveoli); V31-Mandible length; V32-Length of the lower molars row (crown)

In the craniometrical characterization of the two sexes were used 36 male and 40 female *A. flavicollis*.

The univariate description of the craniological structure was based on the basic statistical parameters of the studied skull characters – mean values ( $\bar{X}$ ), etc. At population level the degree of sexual dimorphism of the studied craniometrical characters was revealed through: (i) variation flow, (ii) assessment of degree of comparative variation and (iii) morphological profiles. The presence of sexual dimorphism in each one of the studied characters was tested by the Coefficient of sexual dimorphism (Dsex) computed as percentage difference between the mean values of the character in the males and in the females divided by the mean value of the character in males.

## Results and Discussion

Application of “variation flow” method resulted in arrangement of relative variation of similar characters in females (Fig. 1a) and males (Fig. 1b). The specific pattern of arrangement of the characters by the values of relative variation in the two sexes was established. It was within the framework typical for the rodents.

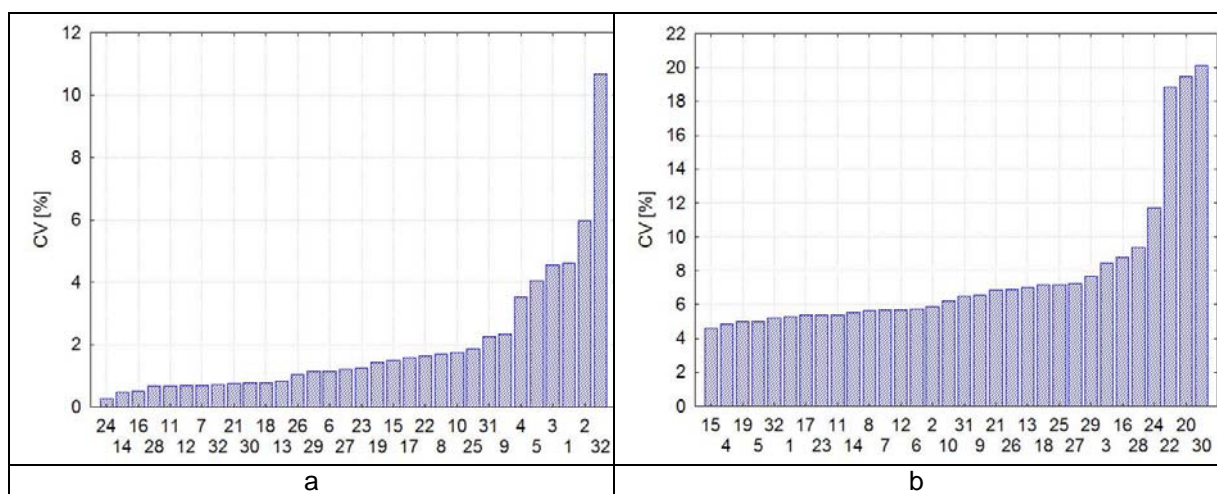


Fig. 1 Variation flow of skull measurements in female (a) and male (b) yellow-necked wood mice (*Apodemus flavicollis*) from agricultural ecosystem in Northeastern Bulgaria. Craniometrical characters on the abscissa are in increased order.

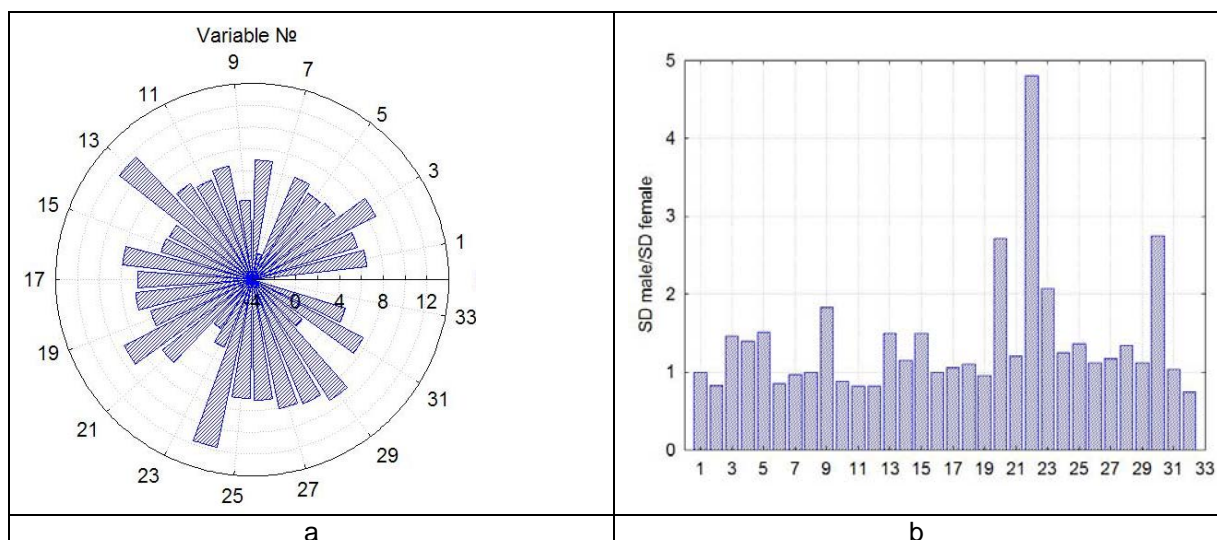


Fig. 2 Values of the coefficient of sexual dimorphism (a) and relative value of the absolute variation (males towards females) of similar craniometrical characters in the two sexes of yellow-necked wood mouse (*Apodemus flavicollis*) from agricultural ecosystem in Northeastern Bulgaria.

The evaluation of the differences in the mean values of the studied craniometrical characters in the two sexes confirmed the presence of craniometrical sexual dimorphism in the adult yellow-necked wood mice in Northeastern Bulgaria (graphically presented in Fig 2a).

The coefficient of sexual dimorphism (Dsex) of all studied characters was from 1.5% to 11%; except for V7 the mean values of craniometrical characters in males were higher than in females.

The comparison of morphological profiles of the two sexes in yellow-necked wood mouse (Fig. 2b) showed that: (i) the established absolute variation was in total lower in the craniometrical characters of females, the higher individual value amounted to 11%; in males, the relative maximum variation of some characters reached 20%; (ii) a trend to higher absolute variation of the studied craniometrical characters in males was revealed; (iii) in view of the established relative values of characters absolute variation in females, it is supposed that the typical limits of absolute craniometrical variation in the two sexes were revealed.

### Conclusion

All the results of the analysis of population craniometrical characteristics of the two sexes of the yellow-necked wood mouse (*A. flavicollis*) from North-Eastern Bulgaria revealed the sexual specificity of its craniometrical characteristics, and unequivocally determined their importance for the analysis of morphological variation in the two sexes in ecological-morphological researches for biological monitoring of agricultural ecosystems in Northeastern Bulgaria.

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