

ETHOLOGICAL PECULIARITIES OF *Apodemus* GENUS SPECIES IN THE ECOSYSTEMS FROM THE REPUBLIC OF MOLDOVA

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Abstract. The species of the genus *Apodemus* are the main species in rodent fauna. The open field behaviour of the genus *Apodemus* representatives is complex, having sex, intra- and inter-specific features. According to the degree of emotional response to the new situation the most fearless (curious) were *A. flavicollis* individuals and the most precocious were *A. sylvaticus* representatives. The females of *A. sylvaticus*, *A. flavicollis* and *A. uralensis* were more curious than the males, while in *A. agrarius* the males were more curious than the females. The sex differences in the dynamics of horizontal activity are connected with greater emotionality of females compared with males, with the presence of species-specific behaviour and sexual dimorphism. The lowest values of vertical activity were detected in *A. agrarius* females and the highest in *A. sylvaticus* males. The grooming parameter had low values in all *Apodemus* genus species; the individuals need more time to fully adapt to new conditions for manifest comfort behaviour. With increasing of time spent in open field chamber and adaption to the situation the duration of freezing periods also increased. The identified interspecific and intraspecific differences in the horizontal and vertical activity showed that the motivation of exploring new environment in the studied species is stronger than the emotional response to the new situation.

Keywords: *Apodemus* genus species, open field, latent period, exploratory behaviour, horizontal activity, vertical activity, grooming, freezing.

Rezumat. Particularitățile etologice ale speciilor genului *Apodemus* în ecosistemele agricole ale Republicii Moldova. Comportamentul speciilor genului *Apodemus* în „câmp deschis” este complex, având particularități de sex, intra și interspecifice. În funcție de gradul răspunsului emoțional la noua situație reprezentanții *A. flavicollis* au fost mai curioși, iar cei mai precauți au fost indivizii *A. sylvaticus*. Femele de *A. sylvaticus*, *A. flavicollis* și *A. uralensis* au fost mai curioase decât masculii, în timp ce la *A. agrarius* masculii au fost mai curioși decât femelele. Diferențele între sexe în dinamica activității orizontale sunt legate de emotivitatea mai mare a femelelor în comparație cu cea a masculilor, cu prezența comportamentului specio-specific și cu dimorfismul sexual. Cele mai scăzute valori ale activității verticale au fost înregistrate la femelele *A. agrarius*, iar cele mai ridicate la masculii de *A. sylvaticus*. Groomingul are valori scăzute la toate speciile studiate, indivizii necesită mai mult timp pentru adaptarea completă la noile condiții și manifestarea comportamentului de confort. Odată cu creșterea timpului petrecut în câmpul deschis și adaptarea la situația nouă, durata perioadelor de freezing, de asemenea, a crescut. Diferențele interspecifice și intraspecifice în activitatea pe orizontală și verticală la speciile studiate, demonstrează că motivația de explorare a noilor condiții de mediu este mai puternică decât răspunsul emoțional față de mediul nou.

Cuvinte cheie: Speciile genului *Apodemus*, câmp deschis, comportament de explorare, perioada de latență, activitate orizontală, activitate verticală, grooming, freezing.

INTRODUCTION

The species of genus *Apodemus* are the main species in rodent fauna, having an important role in the community food chains and a special importance as consumers of tree seeds and of agricultural crops. On the territory of Moldova the genus is represented by four species: *Apodemus uralensis*, *Apodemus sylvaticus*, *Apodemus flavicollis*, *Apodemus agrarius*. In the conditions of anthropogenic landscape each of these species inhabit a certain habitat, which is optimal for their existence. Thus, in *A. flavicollis* such habitats are the forests, in *A. sylvaticus* island forests, forest plantations and shelter belts, as well as, gardens and orchards, *A. uralensis* is confined to fallow grounds grown with shrub and grass vegetation, also often found in forest shelter belts, orchards and gardens, while *A. agrarius* is less frequent, occurring mostly in acacia stands and other tree or shrub biotopes (SAVIN, 2004, 2005; SAVIN et al., 2011).

The open-field test is widely used in ethological studies and allows the quantification of behavioural elements in standardized new environment in a fixed time period. The open-field method is an analytical tool for assessing species-typical behavioural tendencies in a relatively unstructured situation (WILSON et al., 1976). The *Apodemus* genus species are suitable for ethological study; it includes closely related species representing diverse ecological strategies. There are several studies on *Apodemus* genus species open field behaviour in their inhabiting range (DOJDEV 1983; DOJDEV & MOLLE 1983, 1985; DOJDEV et al., 1983; FRYNTA, 1992; ATANASOV, 1983; LODEWIJCKX, 1984; STOPKA & GRACIASOVA, 2001 etc.). Although such studies in R. Moldova have been conducted for many years, only several data were published in literature (MUNTEANU & CEMIRTAN, 2007; MUNTEANU et al., 2009; CEMIRTAN et al., 2012).

This research was conducted in order to collect comparative data on open-field behaviour in wild *Apodemus* species occurring on the territory of the Republic of Moldova. The exploratory behaviour of *Apodemus* genus species in new environment will allow to emphasize some adaptation peculiarities of the species under the influence of external factors and to explain the difference between their adaptability and ethological strategies of the species.

MATERIAL AND METHODS

Studies were performed on adult specimens of both sexes of four species of forest mice: *A. uralensis* – 69 individuals, *A. sylvaticus* – 31 individuals, *A. flavicollis* – 30 individuals and *A. agrarius* – 26 individuals. The individuals were caught with live traps during spring-autumn period in various types of agricultural ecosystems. The open field orientation-exploratory behaviour (HUGHES, 1978) was studied by placing the animals for 15 min in the experimental chamber and registering each 3 minutes and in total for 15 minutes the following parameters: horizontal activity (number of crossed squares), vertical activity (jumps and vertical stands), duration of grooming (comfort behaviour) and freezing (resting periods), latent period – time of entering from the portable cage into open field chamber. Before starting the experiment the animals were weighed.

RESULTS AND DISCUSSIONS

In small rodent communities the most numerous was *A. uralensis*, followed by *A. sylvaticus*, *A. flavicollis* and *A. agrarius*. Sex ratio (males: females) in *A. uralensis* population was 59%: 41%, in *A. sylvaticus* – 62% : 38%, in *A. flavicollis* – 62% : 38% and in *A. Agrarius* – 50% : 50%. The mean body weight was higher in females of three species: at *A. sylvaticus* it constituted 24.38 ± 5.22 g in females and 19.98 ± 2.92 g in males, at *A. agrarius* 23.3 ± 4.76 g in females and 22.4 ± 3.94 g in males, at *A. uralensis* 17.21 ± 2.07 g and 16.89 ± 2.44 g, respectively, and only in *A. flavicollis* the female weight (31.12 ± 4.23 g) was lower than of males (34.87 ± 4.68 g), although the differences between sexes were insignificant.

The latent period parameter indicates the time amount necessary for the animal to overcome the fear of the new open environment. Among rodents of all species there were recorded very suspicious individuals, which were not able to overcome the fear and did not leave the portable cage within 10 minutes and were transferred in open field by the experimenter. More curious and fearless individuals left the portable cage and entered open field by themselves within 10 minutes period.

The ratio of suspicious and curious individuals in the populations varied. Thus, the least suspicious proved to be *A. flavicollis*: 37.5% of males and 30% of females, with a latent period of 104.6 ± 13.12 seconds in males and 171.43 ± 21.14 s in females. In *A. agrarius* 30% of males and 60% females were suspicious, while the latent period of curious individuals was 102.57 ± 10.25 s in males and 74.25 ± 8.39 s in females. In *A. uralensis* 65% of males and 30% of females were suspicious and the latent period of curious animals was 173.36 ± 15.73 s and 178.63 ± 16.36 s respectively. The most suspicious was *A. sylvaticus* (61% males and 45% females), but in curious individuals the lowest latent period was recorded: 15.53 ± 2.38 s and 90.67 ± 8.13 s. When comparing these indicators between males and females, it was found that three species: *A. uralensis* (70% vs. 35%), *A. sylvaticus* (55% vs. 39%) and *A. flavicollis* (70% vs. 62.5%) the females were more curious and fearless than the males (Fig. 1).

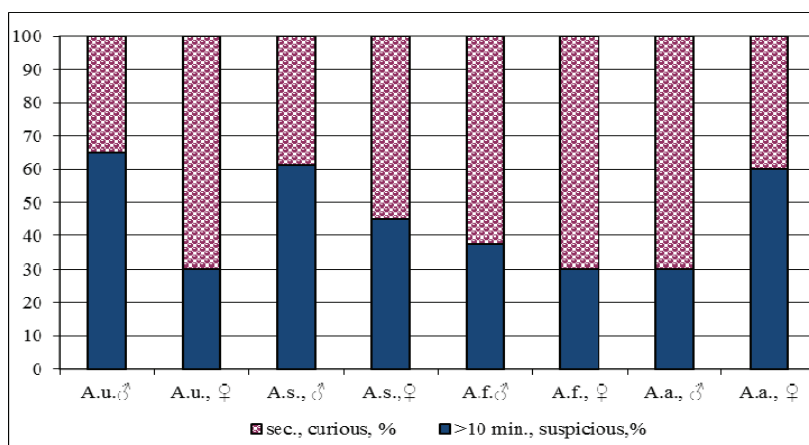


Figure 1. Intra and interspecific ratios of curious and suspicious individuals of *Apodemus* sp. genus species.

Horizontal activity. The number of crossed squares was counted every consecutive 3 minutes and on the whole for 15 minutes. This parameter reflects the locomotor activity of the animal, its capacity to explore the environment and to adapt to new conditions.

The total horizontal activity was the highest in *A. sylvaticus*, followed by *A. uralensis*, *A. flavicollis* and the lowest was registered in *A. agrarius* (Fig. 2). Only in *A. uralensis* the females recorded higher values of horizontal activity, while in other three species the males were more active, but the sex differences in total horizontal activity were insignificant.

The behaviour strategy of males in studied species is similar: the highest index values were in the first 3 minutes in open field, toward the 6th minute a significant decrease in motor activity occurred, and then, in 3 species

gradual decreasing to minimum values at the end of the experiment was observed, and only *A. sylvaticus*, remained at the 6th minute level (Fig. 2). In *A. flavicollis* males the values of horizontal activity are much lower than in females and in other species, starting at values below 50 crossed squares in the first minutes, then insignificantly decreasing below 40 crossed squares in the next 3 minutes and remained practically at the same level till the end of experiment. The highest values of horizontal activity in the first minutes were registered in *A. uralensis* males. In general, the parameter values in the first minutes of open field indicated a high level of emotional reaction to new conditions, while their decline indicated the ability to overcome fear and to adapt to the environment. Thus, all males successfully overcome fear and quickly adapted to the environment, except for *A. sylvaticus* males, which need longer time period for adaptation than other species.

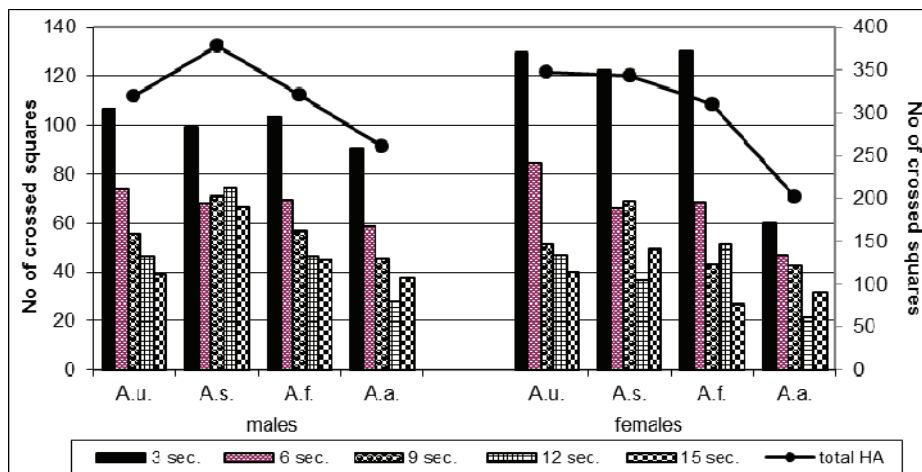


Figure 2. Horizontal activity of males and females in *Apodemus* species during 15 seconds and total horizontal.

In females, at the beginning of the experiment, almost all species had higher values of activity than males (Fig. 2), except for *A. agrarius*, which values were situated around 60 crossed squares in the first minutes. In the rest of the species the maximum values reached over 120 crossed squares in the first minutes. The reduction of horizontal activity, first sharply, then gradually down to minimum values at the end of experiment, occurred in *A. uralensis* and *A. flavicollis* females. At the last species on the 12th minute there was a slight and transient increase of the parameter. *A. agrarius* and *A. sylvaticus* females showed significant reduction in motor activity only in the 12th minute and in the 15th minute – it increased again. In general, in *A. sylvaticus* females, sudden change in motor activity was registered. The observed differences in the dynamics of horizontal activity (Fig. 2) are, probably, connected with greater emotionality of females compared with males, with the presence of species-specific behaviour and sexual dimorphism. Some researchers (DOICHEV, 1983) reported significantly higher number of squares crossed during 15 min. of open-field tests in males than in females of *A. sylvaticus* and no significant differences between the sexes were found in *A. flavicollis* (DOICHEV et al., 1983).

Vertical activity in all *Apodemus* species consisted in two indicators: the vertical jumps and vertical standings. The vertical standings were considered as proper research activity and vertical jumps – as emotional reaction to the new situation. There was also analysed the total vertical stand and jump activity.

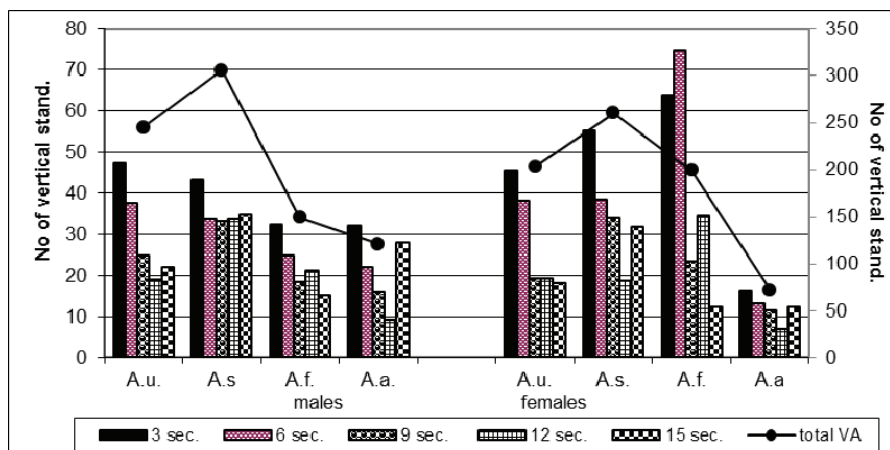


Figure 3. Vertical activity of males and females in *Apodemus* species during 15 seconds and total vertical activity.

In general, the total vertical activity was the highest in *A. sylvaticus* species, followed by *A. uralensis*, then *A. flavicollis*, and the lowest – in *A. agrarius*, the males being more active than the females in all studied species except *A. flavicollis*, where the females registered higher values of vertical activity (Fig. 3).

The lowest values of vertical activity were detected in *A. agrarius* females; this also applies to the number of jumps (lowest number of all species) and to the number of vertical stands (Fig. 3). The males of this species were more emotional and more curious than the females. This was reflected in higher values of jumps and vertical stands. The vertical activity of both males and females increased in the last 3 minutes of the experiment (Fig. 3).

Low levels of jump activity were registered in *A. flavicollis* individuals (Fig. 3), which practically disappeared toward the end of 15th minute. At the same time, they have different values of exploration activity dynamics between both sexes. In males, compared to females, the exploration activity was lower in the first minutes of the experiment, then in males this parameter is gradually declining to the lowest value at 6th minute and remained practically the same by the end, while in females the parameter remained at a high level until the 6th minute, sharply decreased to 9th min., slightly increased at the 12th min. and reached a minimum value at the end of the experiment. In general, the exploring activity of this species males was the lowest of all studied species.

In *A. uralensis* the values of jump activity was higher than in the above-mentioned species, their value remained practically unchanged for the duration of the experiment, being higher in males (Fig. 3). The dynamics and the values of exploring activity of males and females of this species are similar and, in general, higher than that of *A. agrarius* and males of *A. flavicollis*, starting with maximum values at the beginning of experiment, drastically decreased at 6th minutes, then gradually decreased toward the end of the experiment. The vertical activity is the highest in the first minutes then decreases and remains at the same level in the last minutes of the experiment, fact registered in previous studies (MUNTEANU et al., 2009).

A. sylvaticus males occupied the first place after the number of jumps and in females this parameter values were close to those of *A. uralensis* females (Fig. 3). At the same time, their jump activity was the highest of all the species, reaching maximum values in the middle of the experiment. The dynamics of exploring activity in *A. sylvaticus* male and female was also different. It was established that the values and dynamics of the “jump” parameter practically has no effect on the dynamics of the total vertical activity (jumps + stands), i.e., in general, it did not influence upon the dynamics of proper exploring activity. Thus, we can assume that the motivation for exploration in studied rodent species is stronger than the emotional response to a new situation.

Grooming is another element that characterizes animal behaviour. According to its value amount (Fig. 4) this parameter is not very particular for *Apodemus* genus species. Apparently, within 15 minutes of being in the open field chamber the animals did not have enough time to fully adapt to the environment, therefore the elements of comfort manifestations of behaviour, which include grooming, are not so significant in duration and stability. The highest time amount spent in grooming activity was registered in *A. agrarius* females, while the lowest – in *A. uralensis* females. It should be noted that intra-specific dynamics of the parameter, as well as the interspecific ones of males and females are different. Thus, between the males and females of *A. uralensis* and *A. flavicollis* the differences are significant, the males being almost two times longer involved in grooming activity than the females. In *A. sylvaticus* and *A. agrarius* the sex differences are insignificant with slight prevailing of the males in *A. sylvaticus* and of the females in *A. agrarius*. In other studies there was no evidence that the distributions of self-grooming bouts are different between sexes and that the total time spent self-grooming per time unit does not differ between sexes (STOPKA & GRACIASOVA, 2000).

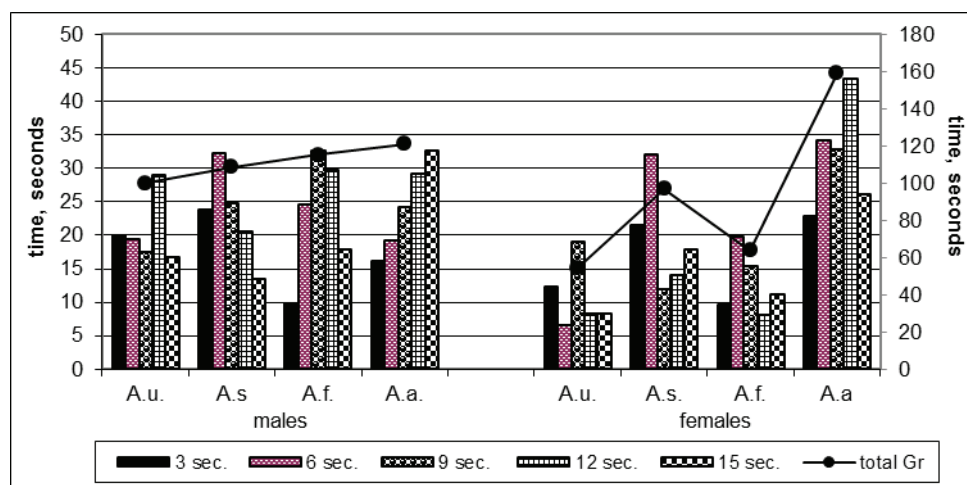


Figure 4. Grooming duration of males and females in *Apodemus* species during 15 seconds and total grooming activity.

Freezing in comparison with grooming lasts longer in time in all the species, being the highest in *A. uralensis* and the lowest in *A. flavicollis* males (Fig. 5). In females and males of *A. agrarius* species were emphasized the following features: with increasing of time spent in the open field chamber and adaption to the situation the duration of

inactivity periods also increased. In *A. flavicollis* and *A. uralensis* males the relatively high values of freezing in the first 3 min of the experiment significantly decreased in the 6th min. and then began to increase, reaching a maximum on the 9th min. without further changings (in *A. uralensis*), or reaching a maximum at the 15th min. (*A. flavicollis*). In *A. sylvaticus* males sharp changes of the parameter values were revealed during the whole period of the experiment.

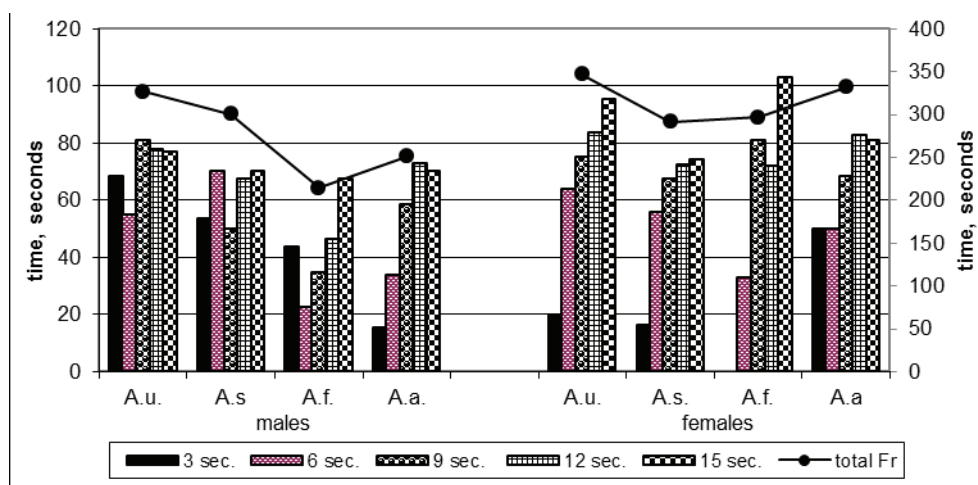


Figure 5. Freezing duration of males and females in *Apodemus* species during 15 seconds and total freezing activity.

In spite of apparently significant interspecific variation, there were not found considerable sex differences in the majority of behavioural elements registered during the open field tests. Similar results were obtained in several studies conducted in *Apodemus sylvaticus* and in *A. flavicollis* from other areas of its range (LODEWIJCX, 1984; FRYNTA, 1999; ATANASSOV, 1983).

As to the interspecific differences, our results showed marked variation. It was emphasized that in *Apodemus agrarius* the majority of behavioural elements for every 3 minutes of the tests and the total values are differ from other species under study. Its horizontal and vertical activities are the lowest, while the grooming activity is the highest. These differences can be explained by its ecological peculiarities: *A. agrarius* inhabit mostly humid biotopes covered with dense herb vegetation, while other *Apodemus* species are less specialized.

CONCLUSIONS

The open field behaviour of the genus *Apodemus* representatives is complex, having sex, intra- and inter-specific features. According to the degree of emotional response to the new situation the most fearless (curious) were *A. flavicollis* individuals and most precocious were *A. sylvaticus* representatives. The females of *A. sylvaticus*, *A. flavicollis* and *A. uralensis* were more curious than the males, while in *A. agrarius* the males were more curious than the females.

The sex differences in the dynamics of horizontal activity are connected with greater emotionality of females compared with males, with the presence of species-specific behaviour and sexual dimorphism. The lowest values of vertical activity were detected in *A. agrarius* females and the highest in *A. sylvaticus* males. The identified interspecific and intraspecific differences in the horizontal and vertical activity showed that the motivation of exploring new environment in the studied species is stronger than the emotional response to the new situation.

The grooming parameter had low values in all *Apodemus* genus species; the individuals need more time to fully adapt to new conditions for manifest comfort behaviour. With increasing of time spent in open field chamber and adaptation to the situation the duration of freezing periods also increased.

The time period of 15 minutes is not enough for complete adaptation of studied rodent species toward new environment and manifestation of comfort behaviour elements.

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