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Some Aspects of the Behavior and Defensive Vocalization of the Romanian Hamster, *Mesocricetus newtoni*

***Daniela Simeonovska-Nikolova*[1], *Orlin Dekov*[2]**

[1] Department of Ecology and Protection of Nature, Faculty of Biology, Sofia University 8, Dragan Tsankov Blvd., 1164 Sofia, Bulgaria; E-mail: mammals@abv.bg
[2] Institute of Soil Science, Agrotechnologies and Plant Protection "Nikola Poushkarov", 2230 Kostinbrod, Bulgaria; E-mail: odekov@abv.bg

Abstract: The Romanian hamster, *Mesocricetus newtoni* is a Balkan endemic included in the Red Lists of Romania and Bulgaria as well as in Appendix II of the Bern Convention, but little is known about its behavior. In this context, a preliminary study on daily activity rhythm, behavior and vocalization of several specimens captured in July 2012 in an agroecosystem in Northern Bulgaria, was conducted. The observations were carried out both directly in the field and in semi-natural conditions in captivity for a period of seven days. The results showed that the animals were active mainly at night, but signs of activity were also registered during the day. There were two peaks of activity: during dawn and dusk. We distinguished the following categories of individual behavior: locomotion, resting, feeding, self-grooming, digging and cleaning. Vocalization of *M. newtoni* was recorded with an Olympus LS-5 linear PCM recorder. The calls emitted by the hamsters in context of defensive behavior were classified into three main groups: 1. Harsh calls with strong noise component and without harmonic structure; 2. Harsh calls with noise component, but with harmonic structure; 3. Weak calls with clear harmonic structure. Functions of daily activity rhythm, behavior and vocalization are discussed.

Key words*:* *Mesocricetus newtoni*, daily activity rhythm, behavioral patterns, vocalization, spectral characteristics

Introduction

One of the biggest challenges for humanity in the twenty-first century is to stop the loss of biodiversity. Although Europe is the second smallest continent in the world, it is one of the most urbanized. It is not surprising that many of the populations of our mammal species are rapidly declining due to habitat loss and degradation, pesticide use, isolation etc. However, the ethology and ecology of small mammals remain less studied, unlike the relatively more abundant amount of information about the state of populations of large mammals. Such is the case of the Romanian hamster (*Mesocricetus newtoni*), also known as Dobrudja hamster.

The Romanian hamster, *Mesocricetus newtoni* (Nehring, 1898), is a Balkan endemic species. It is restricted to lowlands along the right bank of the lower Danube River in Northern Bulgaria and Romania, Dobrudja (Vohralík 1999). *M. newtoni* inhabits uncultivated lands, alfalfa and corn fields, vineyards, orchards and vegetable gardens (Popov *et al.* 2007). According to data from the region of Konstanta, Romania (Hamar, Sutova 1963) it prefers areas occupied by forage crops, uncultivated lands, less often settling in corn crops and the field-protecting belts, practically absent in ploughable lands (Popov *et al.* 2007). It feeds on herbaceous plants, mainly corn and beans, as well as seeds (maize, sunflower, wheat, oats). *M. newtoni* lives in separately dug out holes, similar to those of the European hamster *(Cricetus cricetus*) but shallower: the nesting chamber is at a depth of about 50-60 cm, rarely up to 1.5 m (Ionescu 1968). They reach sexual maturity when 56–70 days old and breed from early April to August (MacDonald *et al.* 1993, Musser, Carleton 2005, Coroiu, Vohralík 2008).

The species is included in the Red Lists of Romania and Bulgaria as well as in Appendix II of the Bern Convention, but little is known about its ecology and behavior (Nechay 2000). The only information about its population number is from the region of North Dobrudja (Romania), where the number of the species in 1995 was estimated to be about 3000 adult individuals (Murariu 1995, Coroiu, Vohralík 2008), and in 2005, about 2000 individuals (Botnariuc, Tatole 2005) with a tendency for a drastic decline (Murariu, 1995, Botnariuc, Tatole 2005, Coroiu, Vohralík 2008, Murariu *et al.* 2010). In Bulgaria there are no specific data about the number of species, but it can be estimated as low. For this reason, conducting behavioral research seems to be hard for realization. Probably this explains the contradictory views about seasonal activity of the Romanian hamster. According to some authors, the hamster is a hibernating species (Hamer, Shutova 1963), but according to others, the species does not hibernate (Markov 1960). Unclear facets about its daily rhythm activity also exist. There are data that the Romanian hamster is active during the night, but there were also reports that it goes out in search for food during the day (Popov *et al.* 2007). Regarding behavior and communications, the only information is that hamsters communicate by squeaking and ultra-sound. Both sexes mark their territory by rubbing their glands against objects (MacDonald, Barret 1993, Popov *et al.* 2007). Although the social organization of the Romanian hamster has not been studied yet, it could be assumed that like other hamster species, the body posture, auditory and chemical communication play an important role in its intra- and interspecies interactions (Bartlett, Earle-Bridges 2003). Having in mind, that efforts to conserve wildlife populations are often hampered by lack of information about animal behavior and communication, the aim of this study was to investigate the daily activity rhythm, behavior and vocalization of *M. newtoni*, which play an important role for its survival.

Material and Methods

Study area and study animals

Five Romanian hamsters, 4 females and 1 male, were captured in July, 2012 from a wild population of the species in the region of Northern Bulgaria, near the town of Pleven (latitude 43°26‘N, longitude 24°55‘E). The climate is continental, with cold winter and warm summer. The average temperatures vary from -2°C to 2°C during winter (December-February) and from 20°C to 23°C during summer (June-August). During the study period the average temperatures were 2-3°C higher than usual for the season.

The hamsters were captured with Sherman live traps set around the hamster burrows in the wheat stubble fields. Traps were baited with oat flakes mixed with peanut butter. The traps were set in the evening (19:00-21:00) and checked at 6:00-8:00. At each capture the following parameters were recorded: trap location, sex, body mass to ±1 g and reproductive status. The age of each animal was determined on the basis of its body mass and reproductive status. All captured hamsters were sexually active adults weighting from 80 g to 130 g.

The captured animals were individually housed in cages 30 x 30 x 40 cm at natural temperatures, 20–35°C, and 15 h of day light during the experiments. The floor of each cage was covered with 15 cm layer of soil and shavings. Alfalfa stems were put over the shavings to serve both as food and shelters. Additionally, the hamsters were fed with a mixed-seed diet and pieces of apples and cucumbers.

The investigation complied with the international requirements for ethical handling of animals (Lehner 1996). Upon completion of the experiments, the animals were released back in their habitat.

The daily activity rhythm, behavior and vocalization of captured individuals were studied both directly in the field and under semi-natural conditions in captivity for a period of seven days as follows:

Defensive behavior and vocalization

The captured hamsters were transferred from the traps to plastic containers. The calls were emitted mainly when the hamsters were placed in the containers, and when they hold upright postures, after being disturbed by the observer, considering him as an enemy. The calls emitted by the animals in captivity were of similar character. Vocalization of

M. newtoni was recorded using an Olympus LS-5 linear PCM recorder with an embedded microphone. The device was placed at a distance of about 20 cm away from the animals. The calls were analysed by the Spectrogram – FFT Spectral Analysis system program, version 12. The transformation of calls into digital form was done by 44.1 kHz sampling frequency, while the frequency range of the sound-recording device was between 100–10000 Hz, and the sampling precision was 16 bits. On average, from two to seven calls per individual were analysed. The call parameters were set at logarithmic amplitude axes and linear frequency axes. Minimum, maximum and dominant frequency (peak frequency at peak amplitude), as well as the duration of each call were measured in spectrograms using a program cursor directed manually in the spectrum display. The significance of differences between the median scores of the sound characteristics was estimated by the Mann–Whitney U-test at $p<0.05$. The software Statistica for Windows, version 10 – StatSoft, was used to perform calculations.

Daily activity rhythm and individual behavior

The daily activity rhythm and behavior of hamsters were registered for a period of five days by regular observations of all animals for five min, four times per hour (scan sampling). Thus, the total time of observation was 20 min per hour. The behavior of hamsters was monitored directly and by video recording with a digital camera Canon Power Shot A1200 HD. A red light was used during the night. The behavioral events demonstrated by *M. newtoni* in the individual cages were categorized as follows: locomotion - walking, rearing (the animals rear up on hind legs), self-grooming, digging (scraping with forepaws, ejecting material with hind legs; pushing bedding material aside), cleaning the burrow and around themselves (the animals throw away feces or scraps with their muzzles), feeding (eating and gnawing of food – seed, seedling, alfalfa), and resting (standing still, sitting, lying, sleeping). The behaviors demonstrated by the hamsters were registered into the protocols. The relative time spent by each hamster in activity and the relative frequency of displayed behavioral categories were calculated. The results were represented by the median and the dispersion by the extremes. The significance of differences between the median scores of the observed behavioral categories was estimated by the Mann-Whitney U test at $p < 0.05$.

Fig.1. *Mesocricetus newtoni* at upright posture (Photo Daniela Simeonovska-Nikolova)

Results

Defensive behavior and vocalization

When disturbed by uncommon events within the animal surroundings, such as a sudden noise, the hamsters stood still listening around or hid under the shavings. When disturbed by the observer, the hamsters held upright postures showing the black spot on their breasts (Fig. 1). As a last resort the hamsters tried to bite. The calls emitted in this context were classified into three main groups: 1. Squeals – harsh calls with strong noise component and without harmonic structure; 2. Creaks – harsh calls with noise component, but with harmonic structure; 3. Squeaks – weak calls with clear harmonic structure. These calls differed in structure and intensity. The acoustic parameters of the calls are presented in Table 1.

1. Squeals – These calls were emitted by the hamsters while holding upright postures. The calls were emitted as a series of sounds, Fig 2. There was a succession of two or three long notes followed by one short. The notes significantly differed in duration (Mann-Whitney U test, $U_L = 162$, $p < 0.001$), the short notes lasted 66.8 ± 5.6 ms, range 40–79 ms, $n = 9$, while the long ones 294.4 ± 37.6 ms, range 144–529 ms, $n = 18$) (Table 1). In addition, the first signals were more intensive, reaching nearly 20000 Hz, while most of the signals were up to 10000 Hz. Squeals were followed by weak short squeaks with clear harmonic structure, resembling a cheep, Fig. 2.

Table 1. Mean values (±SE) of the vocal signals emitted by *M.newtoni* individuals (minimum and maximum values in parentheses, *n* = number of notes measured)

Type vocal signals	Minimum frequency (kHz)	Maximum frequency (kHz)	Dominant frequency (kHz)	Duration (ms)	Interval	Notes per s
Squalls – harsh calls with strong noise component, without harmonic structure n = 27	-	-	-	218 ± 36 (40–529)	170.3 ± 19.4 (88–406)	2–3
Creaks – harsh calls with noise component, with harmonic structure, resembling cackle; n = 12	2196 ± 17 (2150-2240)	2389 ± 30.8 (2365-2480)	2306 ± 31.6 (2230-2400)	372 ± 23.1 (39–572)	169 ± 30 (39–572)	2-3
Squeaks – weak calls with clear harmonic structure, n = 8	556 ± 2.8 (550-570)	713.3 ± 18.7 (660-805)	608 ± 4.2 (600-630)	105.7 ± 22.9 (29-232)	-	0.5-1

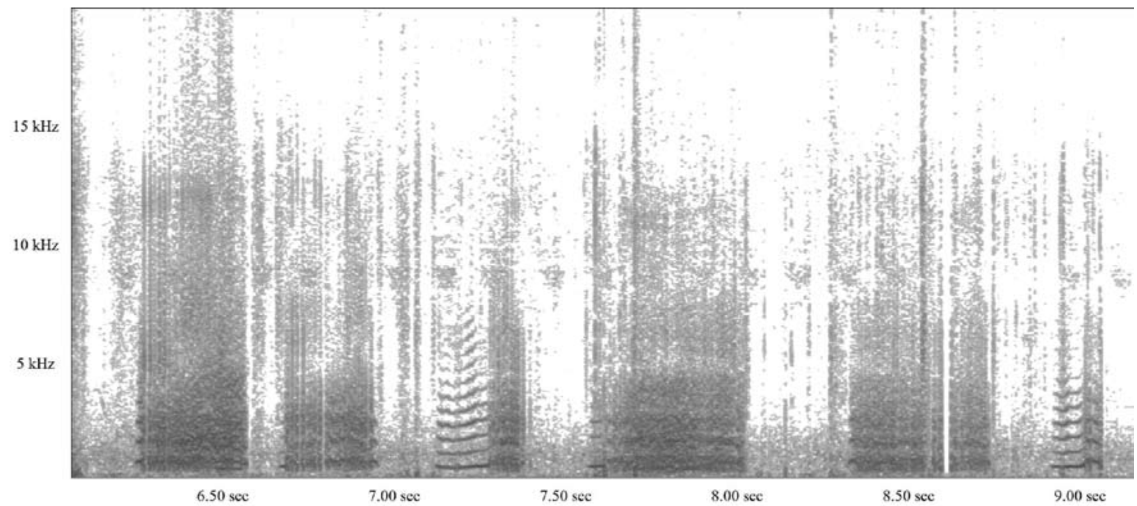

Fig. 2. Harsh calls with strong noise component and without harmonic structure produced by *M.newtoni* at upright postures alternated by weak squeaks with clear harmonic structure (the third and last signals)

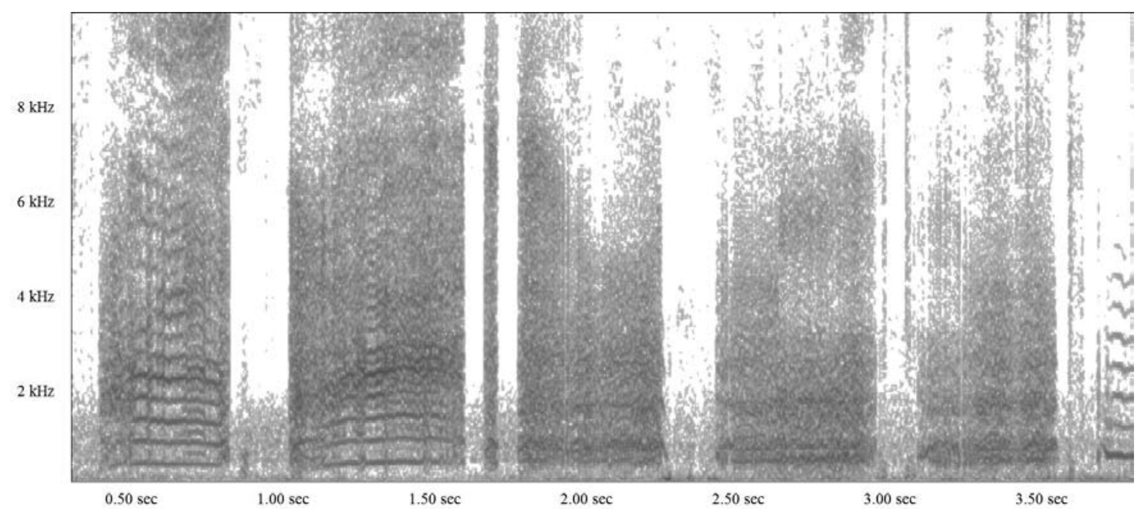

Fig. 3. Examples of the calls resembling cackle

2. Creaks - After the first loud squeals, notes with marked tonality tone followed. They had a harmonic structure and resembled a cackle, Fig. 3. The dominant frequency was 2306 ± 31.6 Hz, and the duration was 372 ± 23.1 ms (Table 1). Most notes had four subharmonics in their spectrum. Some signals contained both a noise and a harmonic component in their spectrum. In one animal the dominant frequency of this type of calls was 6500 Hz.

3. Squeaks – These were weak short calls with clear harmonic structure, Fig. 2. The dominant frequency was 608 ± 4.2 Hz, and the duration was 105.7 ± 22.9 ms, (Table 1). Usually these signals were at the end of the series and when the danger decreased.

Daily activity rhythm and individual behavior

During the dark period, the hamsters showed higher activity than in daylight (Mann-Withney U test, $U_L = 106$, $p < 0.05$; $n_1 = 15$, $n_2 = 9$). Nevertheless, there were two peaks of activity: between 03.00 and 07.00 and between 19.00 and 22.00, Fig. 4. In these intervals, all animals were active. They walked and reared up, exploring the surrounding. Among other activities feeding, self-grooming and digging were often recorded. In addition, the animals were observed to clean the burrow or the area around them by throwing outside the feces and scraps with their muzzles. The median number of locomotion (Lc) was significantly higher than those of feeding (Fd), self-grooming (Sf), digging (Dg) and cleaning (Cl), Fig. 5 – (Mann-Withney U test, $U_L = 410.5_{(Lc \times Fd)}$, $p < 0.05$; $n_1 = 24$, $n_2 = 24$; $U_L = 427_{(Lc \times Sf)}$, $p < 0.01$; $n_1 = 24$, $n_2 = 24$; $U_L = 547_{(Lc \times Dg)}$, $p < 0.001$; $n_1 = 24$, $n_2 = 24$; $U_L = 532_{(Lc \times Cl)}$, $p < 0.001$; $n_1 = 24$, $n_2 = 24$. In addition, the median numbers of feeding and self-grooming were significantly higher than those of digging and cleaning, Fig. 5. The significance of differences between the mentioned behavioral categories revealed by the Mann-Whitney U test is as follows: $U_L = 504_{(Fd \times Dg)}$, $p < 0.001$; $n_1 = 24$, $n_2 = 24$; $U_L = 472.5_{(Fd \times Cl)}$, $p < 0.001$; $n_1 = 24$, $n_2 = 24$; $U_L = 485_{(Sf \times Dg)}$, $p < 0.001$; $n_1 = 24$, $n_2 = 24$; $U_L = 447_{(Sf \times Cl)}$, $p < 0.001$; $n_1 = 24$, $n_2 = 24$. During the day the animals mostly slept, sat or mainly lay down. However, they periodically came out of the burrow for 1-2 minutes or moved around in order to eat alfalfa seeds and went to sleep under the leaves again.

Discussion

The calls emitted by *M. newtoni* differed in their structure and intensity. This is probably because of their different functions and significance for the communication. Squealing vocalization is practically universal during defense among rodents. Vocalization is typically associated with fear or

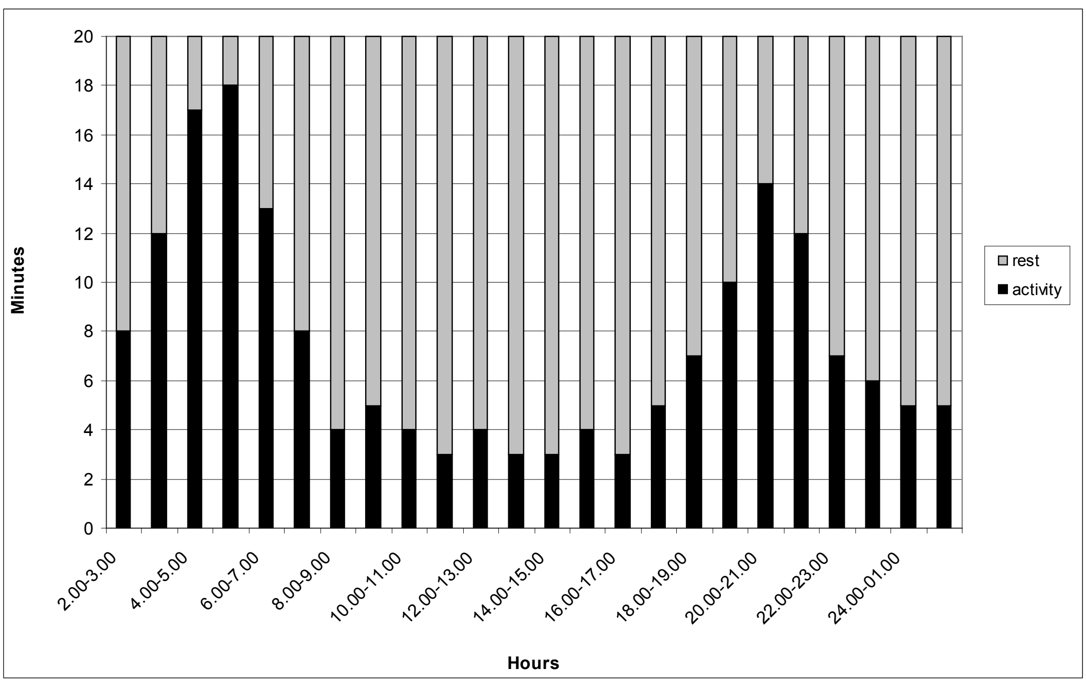

Fig. 4. Periods of activity and rest, displayed by hamsters. The time in minutes is given by the median values for each 20 minutes

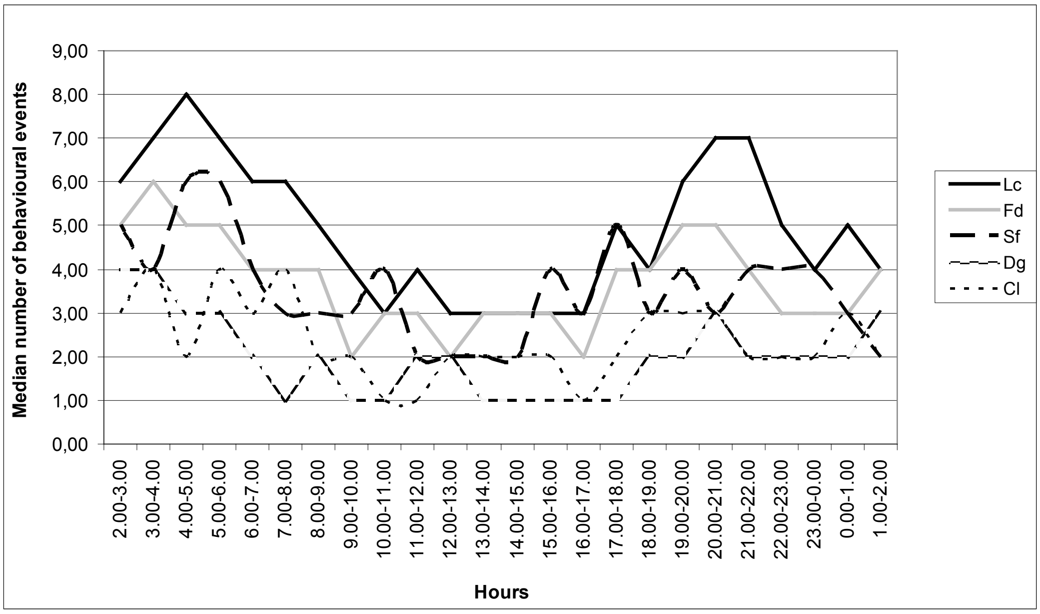

Fig. 5. Median number of behavioral events in categories, displayed by hamsters in the period of activity. The thickness of the curves is proportional to the frequency of occurrence of behavioral categories

feeling of being threatened (Martin, Bateson 1993, Adams 1980). In some species, such as *Rhombomys opimus* and *Dicrostonyx groenlandicus,* squeals are produced when a potential predator is still at some distance from the animal (Brooks, Banks 1973, Naumov 1975, Adams 1980). According to Adams (1980), defense may be elicited in wild rodents by confronting them with an unfamiliar object or unfamiliar place, a phenomenon that has been called "neophobia". Our experiment also confirmed these findings in *M. newtoni*. Most of the calls were emitted by the hamsters after their appearance in an unfamiliar place and after disturbance by the observer. While holding upright postures the hamsters displayed the black spot on their breasts. With this behavior, they probably warned the enemy (in this case the observer who bended over them) to retreat. This behavior is observed in other mammals as well, for example, the red-bellied tamarin (*Saguinus labiatus*), which sits up on its hind legs, displayng its golden-red belly (Sarkar 2003). Therefore *M. newtoni* used both visual and acoustic signals in its defensive behavior.

When the danger decreased, the squeal turned into weaker squeaks. There are indications that different motivation affects the structure of calls, and thus allows evaluation of the animal emotional condition (Movchan, Shibkov 1982). Most likely, hamsters' different levels of distress and quickly changing attack or retreat tendencies are reflected in the varieties of calls. But all of the calls are of low frequency. The hearing sensitivity, reception range and time parameters of signals are distinctly dependent on ecological factors and the acoustics of the animal environments (Gould 1983, Konstantinov, Movchan 1985). The vocalization of many subterranean rodents and moles consists mainly of relatively low frequency components, which is a result of their underground way of life (Rado *et al.* 1991, Müller *et al.* 1992, Credner *et al.* 1997). Based on the data from the present research, it can be assumed that a low frequency range of sounds probably reflects the way of life of *M. newtoni*. Yet, further studies are needed to expand the knowledge about sound signalization and its functions in *M. newtoni*.

During dawn and dusk, the hamsters showed the highest level of locomotion-exploratory activity. The remaining time they spent mostly in resting, feeding, and grooming. According to Mota (1987), high locomotion scores usually indicate reduced fear in the animals and active environment exploration. In the present research grooming was observed in all the hamsters. According to Spruijt *et al*. (1992) and Yu *at al.* (2010), grooming is an innate stereotyped behavior that exists in most animal species, and most small mammals spend a large amount of time self-grooming. However, in our study self-grooming spontaneously occurred after feeding and exploratory behavior. According to Jolles *et al.* (1979) and Kalueff, Tuohimaa (2004), exposure to novelty and stress also triggers grooming. There are many hypotheses that try to explain the functions of self-grooming behavior (Yu *et al.* 2010), for example, it serves to remove ectoparasites and clean the pelage, to lower their body temperature, and to release excess motivational energy (Geyer, Kornet 1982, Witt *et al*., 1990, Mooring *et al*. 2000). Self-grooming may signal a transition from one type of behavior to another (Baker, Aureli 1997). Each of these hypotheses may be true for the Romanian hamster. Moreover, the animals were observed to clean not only their fur, but also the burrow or their surrounding by throwing outside feces and scraps with their muzzles. This suggests that the cleanliness is very important for their existence.

The results showed that the hamsters had the highest levels of activity during dawn and dusk. A number of factors such as temperature, humidity, predation and food availability could influence or mask daily activity rhythm (Mrosovsky 1999, Gattermann *et al.* 2008). The Romanian hamster becomes a prey to different predators - foxes, weasels, polecats, and in particular, owls. It is present in the food of the Eurasian Eagle-Owl *Bubo bubo*, The Long-eared Owl *Asio otus*, the Barn Owl *Tyto alba*, and the Tawny Owl *Strix aluco* (Popov *et al.* 2007). In this context we suggest that the crepuscular activity of *M. newtoni* could reduce the predation pressure in some extent. At the same time, it could also be suggested that *M. newtoni* constrain their activity to avoid high mid-day surface temperatures. Moreover, during the study period the average temperatures were 2-3°C higher than usual for the season, reaching 35°C. Thus, the crepuscular activity could be an effective way of avoiding thermal stress. Nevertheless, our observation showed that even for a short time, the hamsters were active during the day, mainly for eating. Therefore, the short duration of the daily activity suggests that animals balance foraging needs, predator avoidance and potential heat stress. It could be suggested that daily activity rhythm of the Romanian hamster as well as behavioral patterns are quiet complex and depend on the environmental factors. More investigation is needed to reveal its biological rhythm and behavioral ecology.

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References

Adams D.B. 1980. Motivational systems of agonistic behavior in muroid rodents: A comparative review and neural model. – *Aggressive Behavior*, 6: 295-346. (on Internet at http://www.culture-of-peace.info/aggression-intro.html)

Baker K., F. Aureli 1997. Behavioural indicators of anxiety: an empirical test in chimpanzees. – *Behaviour,* **134**: 1031-1050.

Bartlett P. P., M. Earle-Bridges 2003. The hamster handbook. Hauppauge, NY: Barron's

Brooks R. I., E. M. Banks 1973. Behavioral biology of collared lemming (*Dicrostonyx groenlandicus*): An analysis of acoustic communication. – *Animal Behaviour Monographs,* **6**: 1-83.

Botnariuc N., V. Tatole (Eds). 2005. Cartea Rosie a vertebratelor din România. Museul National de Istorie Naturala "Grigore antipa". Bucuresti.

Coroiu I., V. Vohralík. 2008. *Mesocricetus newtoni*. – In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>.

Credner S., H. Burda, F. Ludescher 1997. Acoustic communication underground: Vocalization characteristics in subterranean social mole-rats (*Cryptomys sp.*, Bathyergidae). – *Journal of Comparative Physiology,* **180**: 245-255

Gattermann R, R. Johnston, N. Yigit, P. Fritzsche, S. Larimer, S. Özkurt, K.Neumann, Zh. Song, E. Colak, J. Johnston and M. Elsbeth McPhee 2008. Golden hamsters are nocturnal in captivity but diurnal in nature. – *Biology Letters*, **4:** (3) 253-255.

Geyer L. A., C. A Kornet 1982. Auto-grooming and allo-grooming in pine voles (*Microtus pinetorum*) and meadow voles (*Microtus pennsylvanicus*). – *Physiology & Behavior,* **28**: 409-412.

Gould E. 1983. Mechanisms of mammalian auditory communication. – In: Eisenberg J. F., Kleiman D. G..(Eds.): Advances in the study of mammalian behavior. Special Publication of American Society of Mammalogists, **7**: 265-342.

Hart B.L. 1990. Behavioral adaptations to pathogens and parasites-five strategies. – *Neuroscience & Biobehavioral Reviews*, **14**: 273-294.

Hamar M. M. Sutova 1963. Studiul ecologic al rozatoarelos (Glires) din Baragan si Dobrogea. – *Analele sectieti de protectia plantelor*, **1**: 195-216.

Ionescu V. 1968. Vertebratele din Romania. Bucuresti, 496 p.

Jolles J., J. Rompabarendregt, W. H. Gispen 1979. Acth-induced excessive grooming in the rat-influence of environmental and motivational factors. – *Hormones and Behavior*, **12**: 60–72.

Kalueff A.V., P. Tuohimaa 2004. Grooming analysis algorithmfor neurobehavioural stress research. – *Brain Research Protocols*, **13**: 151-158.

Konstantinov A. I., V. N.Movchan 1985. Zvuki v zhizni zverei. (Sounds in the life of animals). Leningrad: Leningr Univ. (In Russian).

Lehner P. 1996. Handbook of ethological methods. Cambridge (UK), Cambridge University Press.

MacDonald D., P. Barret 1993. Mammals of Britain & Europe. 1.

London: HarperCollins. 238-239. ISBN 0-00-219779-0.

Martin, P. P. Bateson 1993. Measuring behaviour. An introductory guide. 2 ed. Cambridge University Press.

Markov G. 1960. Beitrag zur Untersuchung der Hamster (Cricetinae) in Bulgarien. – *Bull. de l'Inst. Zool. de l'Acad. Sci. Bulg.,* Sofia, 9:293-304. (In Bulgarian, German summary).

Mooring M. S., J. E.Benjamin, C. R Harte, N. B. Herzog 2000. Testing the interspecific body size principle in ungulates: the smaller they come, the harder they groom. – *Animal Behaviour*, **60**: 35-45.

Mota P. G 1987. Behavioural analysis of two rodent species from different ecological habitats. A model for understanding the evolution of social behaviour. – In: Brain P. et al. (Eds.): House Mouse Aggression, Harwood Acad.Publishers, 69-86.

Movchan V. N., A. A. Shibkov 1982. Structural patterns of acoustic signals in shrews (Soricidae). – *Zoologicheskii Zhurnal*, **61**: 1695-1705. (In Russian with English summary)

Mrosovsky N. 1999 Masking: history, definitions, and measurements. – *Chronobiology International,* **16**: 415-429.

Murariu D. 1995. Mammal species from Romania. Categories of conservation. – *Travaux du Museum d'Histoire Naturelle "Grigore Antipa"*, **35**: 549-566.

Murariu D., G. Cheisamera, A. Petrescu, I. Atanasova, I. Raykov. 2010. Terrestrial vertebrates of Dobrogea – Romania and Bulgaria. – *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"*, **53**: 357-375.

Müller M., Laube B., Burda H., Bruns V. 1992. Structure and function of the peripheral auditory system in the African mole rat (*Cryptomys hottentotus*): Evidence for a low frequency acoustic fovea. – *Journal of Comparative Physiology,* **171**:469-476.

Musser G. G., M. D. Carleton. 2005. Superfamily Muroidea. In: Wilson D. E. and D. M. Reeder (Eds.): Mammal Species of the World a Taxonomic and Geographic Reference. Johns Hopkins University Press, Baltimore, 894-1531

Naumov N. P. 1975. The great gerbil. – In: Prakash I., Ghosh P. K. (Eds): "Rodents in Desert Environments." The Hague.

Nechay G. 2000. Status of hamsters: *Cricetus cricetus*, *Cricetus migratorius*, *Mesocricetus newtoni* and other hamster species in Europe. Council of Europe Publishing.

Popov V., N. Spasov, T. Ivanova B. Mihova, K. Georgiev 2007. Mammals – important for protection in Bulgaria. Dutch Mammal Society VZZ, Sofia, 328 p.

Rado R., Z. Wollberg, J. Terkel 1991. The ontogeny of seismic communication during dispersal in the blind mole rat. – *Animal Behaviour,* **42**: 15-21.

Sarkar A. 2003. Social Behaviour In Animals. Discovery Publishing House, p.92

Spruijt B., J. Van Hooff., W. Gispen 1992. Ethology and neurobiology of grooming behavior. – *Physiological Reviews*, **72** (3): 825-852.

Vohralík V. 1999. *Mesocricetus newtoni*. – In: A. J. Mitchell-Jones, G. Amori, W. Bogdanowicz, B. Kryštufek, P. J. H. Reijnders, F. Spitzenberger, M. Stubbe, J. B. M. Thissen, V. Vohralík and J. Zima (Eds.): The Atlas of European Mammals, Academic Press, London, UK.

Witt D. M., C.S.Carter, R. Chayer, K. Adams 1990. Patterns of behavior during postpartum estrus in prairie Voles, *Microtus ochrogaster*. – *Animal Behaviour*, **39**: 528-534.

Yu H., P. Yue, P. Sun, X. Zhao 2010. Self-grooming induced by sexual chemical signals in male root voles (*Microtus oeconomus* Pallas). – *Behavioural Processes,* **83** (3): 292-298.

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