THERYA, 2020, Vol. 11 (2): 161-167 DOI: 10.12933/therya-20-801 ISSN 2007-3364

Activity of the Russian desman *Desmana moschata* (Talpidae, Insectivora) in its burrow

Alexey Andreychev[1]*, Vyacheslav Kuznetsov[1], Alexandr Lapshin[1] and Maksim Alpeev[1]

[1]Department of Zoology, National Research Mordovia State University, Saransk, 430000 Russia. E-mail: andreychev1@rambler.ru (AA), zoomordovia@gmail.com (VK), lapshin1954@rambler.ru (AL), and alpeev2013@gmail.com (MA).
* Corresponding author

A new method of studying for activity of a semi-aquatic mammal Russian desman *Desmana moschata* (Linnaeus, 1758) with use of digital portable voice recorders is developed. To identify the burrows in which the recorders were to be installed, the burrows were probed. A probe is a pole pointed at one end with a T-shaped handle at the other end. The researcher's task was to detect the entrance to the burrow, usually under water. The direction of the underground passage is determined by means of the probe. For this purpose, the ground is pierced to detect the hollows in the burrow with the probe starting from the burrow entrance (the probe falls through unevenly). At a distance of 2 to 3 meters from the burrow, in some cases largely depending on the burrow length, the ground is dug up above the burrow in the form of a small well, 10 to 15 cm in diameter. A digital voice recorder was placed vertically in this well, so that the microphone was directed down towards the burrow. Desman noises can be characterized as short series formed as a sequence of contiguous short peaks of 15 to 25 seconds with five second interruptions formed by regular waves of breathing and its movement noises. As a rule, the noise audibility ranges from 1 to 3 minutes.

Se desarrolla un nuevo método de estudio para la actividad del Desman ruso *Desmana moschata*, mamífero semiacuático, por medio del uso de grabadoras portátiles digitales. Para identificar las madrigueras en las que se iban a instalar las grabadoras, se sondearon las madrigueras. Se utilizó una sonda, adjunta en un extremo a un poste con un mango en forma de T en el otro extremo. La tarea del investigador era detectar la entrada a la madriguera, generalmente bajo el agua. La dirección del tunel subterráneo se determina por medio de la sonda. Para este propósito, se perfora en el suelo huecos en la madriguera con la sonda, comenzando desde la entrada de la madriguera (la sonda cae de manera desigual). A una distancia de dos a tres metros de la madriguera, en algunos casos dependiendo en gran medida de la longitud de la madriguera, el suelo se excava sobre la madriguera en forma de un pequeño pozo, de 10 a 15 cm de diámetro. Se colocó una grabadora de voz digital verticalmente en este pozo, de modo que el micrófono se dirigió hacia la madriguera. Los ruidos de Desman se pueden caracterizar como series cortas formadas como una secuencia de picos cortos contiguos de 15 a 25 segundos con interrupciones de cinco segundos, formadas por ondas regulares de respiración y los ruidos del movimiento. Como regla general, la audibilidad del ruido varía de uno a tres minutos.

Keywords: burrow; daily activity; day-night activity; desman; voice recorder.

Introduction

The study of the Russian desman in the Republic of Mordovia was initiated by well-known mammalogist Borodin (1963, 1970). In his monograph and articles (Borodin 1963, 1970), stated the following habitat areas of the desman within the territory of Mordovia: Zubovo-Polyansky, Temnikovsky, Tengushevsky, Kochkurovsky, Bolshebereznikovsky, and Dubensky Districts. He noted that the desman was found in the Sura, Moksha, Vad, Vysha, Yuzga, Partsa Rivers and their tributaries.

Our research on the desman in Mordovia has been intensified since 2009 until 2018. We aimed at identifying the current distribution of the species within the region and their populations status. In the course of expeditionary work on accounting for desmans in remote areas, we had the idea of checking whether the desman's burrow is residential or non-residential. On the first (transparent) ice, finding out whether a burrow is inhabited or uninhabited is not difficult. However, clear ice is not always; moreover, it is problematic to have time to examine a large number of reservoirs in the short-term period of clear ice. Therefore, we have developed a technique that allows studying the desman's activity in a hole and determining whether a burrow is inhabited or uninhabited in the ice-free period. The method for identifying the activity of underground excavation is taken as the basis (Andreychev and Zhalilov 2017; Andreychev 2018, 2019a). The method could be adapted and improved for other semi-aquatic mammals (*e. g.* muskrat or beaver; Andreychev 2019).

The sudy of the day-night rhythm of the Russian desman in the wild was carried out in the Khopersky Nature Reserve on Lake Kresty using an actograph. Serdyuk (1969) the device was installed in inhabited and fodder burrows from 2:00 pm on October 31 to 2:00 pm on November 2. The device recorded the entry of animals into the burrows. By the number of into or exits of desman from the burrow, their activity was determined. Two peaks of the desmans' day-night activity were identified. They are associated with the periods of sunrise and sunset (Serdyuk 1969). Similar results using a night vision device were obtained in Ryazan region in July 1967 (Khakhin and Ivanov 1990).

In the Seltsov hunting estate, Vladimir region, the number of burrow entries was recorded by an actograph for 51 days from November 1972 to April 1973. Three seasonal periods of desmans' activity associated with changes in external conditions were identified. The first period is associated with the beginning of freeze-up (November–December) and it is characterized by high activity. The second period is associated with strong freeze-up (January–February). The activity of animals decreases during this period. They spend most of their time in burrows. The third period is associated with the end of freeze-up (end of March – beginning of April). It is characterized by increased activity, but less than during the freeze-up period (Khakhin and Ivanov 1990). There are three peaks of day-night activity during freeze-up: morning (5:30 to 7:30), afternoon (12:30 to 14:30), and evening (19:30 to 21:30; Barabash-Nikiforov *et al.* 1964; Sokolov *et al.* 1984; Sukhov 1984); in some cases, the fourth peak is recorded (23.00 to 0:00; Khakhin and Ivanov 1990).

With the use of actographs and a night vision device, only activity at the entry to the burrow was recorded. With regard to identifying the burrow activity of semiaquatic inhabitants, in particular, the Russian desman, both of the above methods are largely unsuitable. Since the animal can use another entrance or be active inside the burrow.

Detailed studies of the daily and seasonal activity of the Russian desman have been conducted by Onufrenya and Onufrenya (2016). They noted that the duration of the continuous stay of the desman in water, regardless of the season of the year, rarely exceeds four to five minutes. The maximum values of this indicator, noted in different individuals for all the time of observation, lie within 18.8 to 65.7 min (Onufrenya and Onufrenya 2016). A detailed discussion of their results is given below in comparison with our data.

The majority of researches on activity of the Russian desmans have been conducted in experimental captive conditions (Barabash-Nikiforov *et al.* 1964; Nazyrova and Karpov 2000; Rutovskaya and Kulikov 2013). In 1994 to 1995 in the vivarium of the Khopersky Reserve, it was revealed that desmans spent more time in artificial burrows, and less time in the water. Sukhov (1984) *in vivo* showed that is, muskrats spend more time in water than on land. The authors of experimental studies in vivarium conditions recognize that the activity of animals' changes depending on the conditions created by them, in particular the feeding conditions. In vivarium conditions distinguish five types of Russian desman activity can be distinguished: activity on the ground, activity in the water, feeding, brushing wool, rest (day and night; Nazyrova and Karpov 2000).

This article describes the method that can be used to study the activity of the Russian desman *Desmana moschata*, with potential implications on other semiaquatic species (*e. g.* beaver, muskrat, and others). The principle of this method is based on recording the noise of animals while they are moving along burrows.

Materials and methods

Study region. The Republic of Mordovia is located in the centre of the European part of Russia. It is extreme points are defined by geographical coordinates 53º 38′ 64″, –55º 11′ 41″ N and 42º 11′ 53″, –46º 45′ 16″ E. Features of the geological structure of Mordovia are determined by its location in the central part of the Russian Platform and the north-western slopes of the Volga Upland. In the western part of the Republic of Mordovia, the Volga Upland reaches the Oka-Don Lowlands.

The climate of the region is moderate with pronounced seasons throughout the year. The influx of direct solar radiation in Mordovia varies from 5.0 in December to 58.6 kJ / cm^2 in June. Total radiation throughout the year is 363.8 kJ / cm^2; the radiation balance is 92.1 kJ / cm^2. The average annual air temperature varies from 3.5 to 4.0 °C. The average temperature of the coldest month (January) is in the range of –11.5 to –12.3 °C. Temperature drops down to –47 °C occur. The average temperature of the warmest month, i.e. July, is in the range of 18.9 to 19.8 °C. Extreme temperatures in the summer reach 37 °C. The average annual precipitation in the territory of Mordovia is 480 mm. Over the course of observation lasting many years, periods of more and less humidification were noted, ranging between the minimum and maximum values of 120 to 180 mm. Distribution of precipitation across the territory is not very diverse. The average long-term value of evaporation is calculated to be in the range of 390 to 460 mm (Yamashkin 1998).

Surveys were carried out on the possible habitats of the Russian desman in areas of the Republic of Mordovia in order to find its holes for subsequent study of activity (Figure 1). In the course of the field work, we used burrows to a greater extent, which are known to us from of expeditionary work of 2009 to 2012 in the Tengushevsky region (Andreychev *et al.* 2012). As a result, we also found desman burrows in the European beaver's burrows and passages, which was consistent with the literature data on the desman and beaver symbiotic relationships (Barabash-Nikiforov 1959). The high population density of European beaver population is favorable for the desman in Mordovia in this respect (Andreychev 2017).

Since there is no information on animal noise in burrows in the literature, some explanations are required. According to G. Tembrock's classification (Tembrock 1963), acoustic signals of mammals are divided into two groups: own voice sounds, and non-voice noises not related to the vocal apparatus itself. The second group includes, in particular, the noise generated by the air stream during inhalation and exhalation, mainly by means of nasal cavities (Ilyichyov *et al.* 1975). In addition, they are overlapped by noises of the animal movements. The method proposed is based on the registration of these noises as a whole.

A description of the method for studying the activity of semiaquatic mammals in burrows should be given, since it has not been previously mentioned in the literature. Habitat areas should be identified at the preparatory stage. Difficulties in identifying the burrowing systems of most species of semi-aquatic mammals are due to the absence of land emissions from the burrows, as is the case with under-

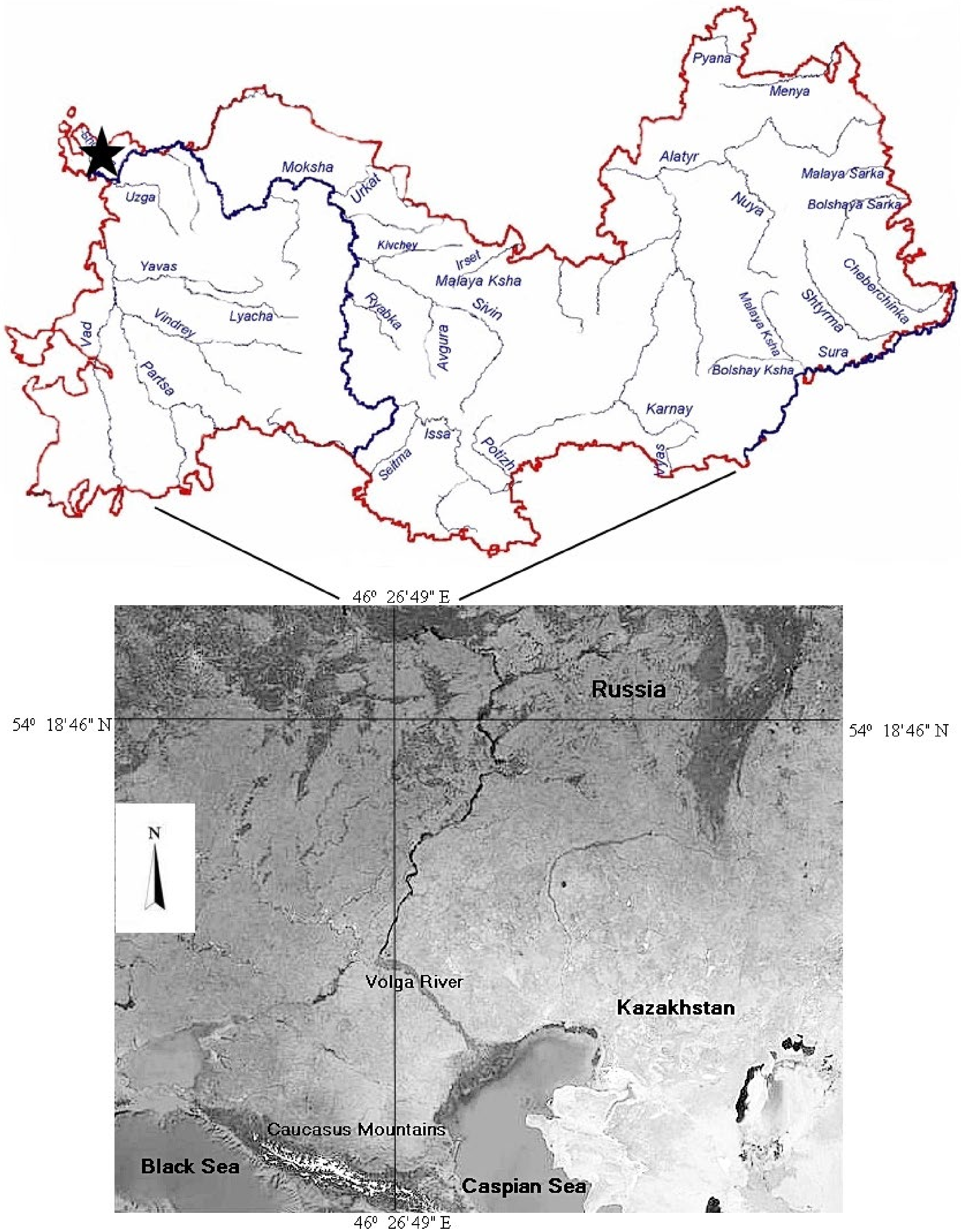

Figure 1. Geographic location of the Russian desman populations studied in Tengushevsky District, Russia.

ground burrowing animals (*e. g.,* mole rats and moles). Therefore, to identify the burrows in which the recorders were to be installed, the burrows were probed (Figure 2). A probe (5) is a pole pointed at one end with a T-shaped handle at the other end. The researcher's task is to detect the entrance to the burrow, usually under water. And then the direction of the underground passage is determined by means of the probe. For this purpose, the ground is pierced to detect the hollows (1) in the burrow with the probe starting from the burrow entrance (the probe falls through unevenly). At a distance range of 2 to 3 meters from the burrow, in some cases largely depending on the burrow length, the ground is dug up above the burrow in the form of a small well (depression), 10 to 15 cm in diameter approximately. A digital voice recorder (4) was placed vertically in this well, so that the microphone was directed down towards the burrow. The recorder was placed in a 0.5 liter water plastic bottle which was used as a container. Pre-cuts were made in the bottle to place the recorder as well as two through cross holes for the spacer bar on which the bottle itself was fastened in the ground. Plastic bottles were used for moisture insulation of voice recorders. The bottles were preliminary cleared of labels and poured with boiled water to eliminate all suspicious odors. After placing the switched-on voice recorders into the wells, they were covered with plates (3) and covered with soil and turf (2).

Olympus VN-416PC, VN-712PC voice recorders were successfully used. Other alternative models that are similar in technical characteristics may also be used. Voice recorders were powered by alkaline or zinc-carbon AAA batteries, or by an external battery unit, which extended the recording time of the voice recorder. On average, one set of batteries was enough for 80 to 100 h of continuous recording. Batteries were replaced at the end of the battery life.

The activity of animals should be monitored using voice recorders in different parts of the reservoir. The choice of installation locations for recording devices was determined using the OziExplorer software. To check the sensitivity of microphones to record the noise of animals, several recorders were placed in one burrow. In this case, one recorder was placed directly at the burrow entrance and the rest were placed a few meters away from the burrow entrance. For convenience of the further processing of audio recordings obtained from voice recorders from one burrow system, the recorders were switched on simultaneously. This made it possible to clearly identify the time intervals in which the animal moved past each recorder. Practice showed that the noises of animals were heard on all voice recorders. However, the recorders that were placed farther from the entrance recorded only the noises of the animals themselves, excluding extraneous noises, such as the wind noise. Therefore, it has been concluded that it is better to place a voice recorder not at the burrow entrance, but directly in the burrow system at some distance from the entrance. For easy re-detection of previously placed voice recorders in the field, a GPS navigator was used. Diurnal time was set between dawn and dusk, and nocturnal time between dusk and dawn.

Office processing of the audio recordings obtained should be carried out using AIMP 1.75 (2007) and AUDACITY 2.1.1 (2015). This software allows for identification and subsequent listening to the noises of moving mammals along the burrow by frequency characteristics in visual mode. Alternative software, in particular, Sony sound forge audio studio 7.0 (2003), can be used to convert audio files from WMA to WAV and divide them into short sections for easy analysis in AUDACITY. During the study period, we listened to more than 2000 hours of recordings.

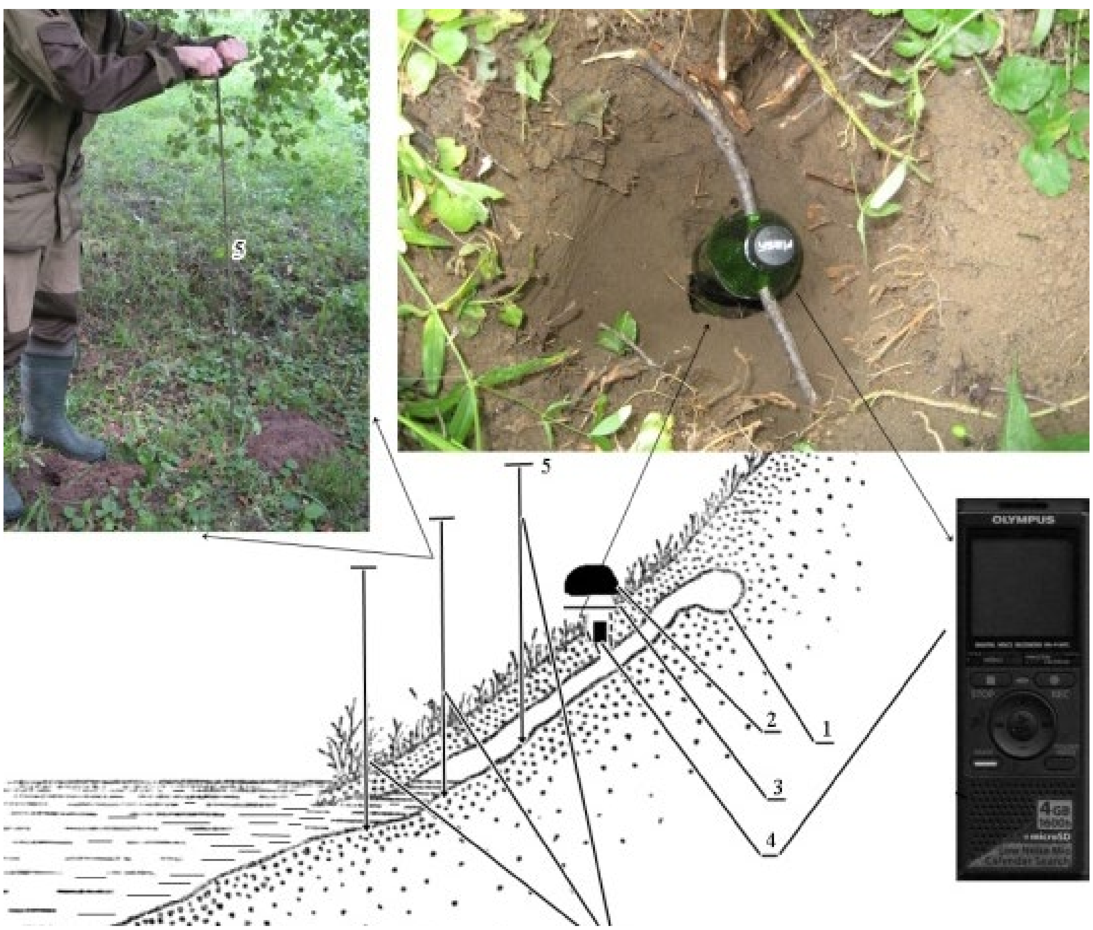

Figure 2. Diagram of installation of a voice recorders of the Russian desman in their burrow:1) hollows, 2) soil, 3) plates, 4) voice recorder, 5) probe.

Results

Desman noises can be characterized as short series formed as a sequence of contiguous short peaks of 15 to 25 seconds with five second interruptions formed by regular waves of breathing and its movement noises. Desman noises differ by mean amplitude and duration on oscillograms. As a rule, the noise audibility ranges from one to three minutes.

According to the results of radiotelemetric observations of Onufrenya and Onufrenya (2016) on average flow Oka is known that the type of daily activity of Russian desman remains unchanged throughout the entire annual cycle (Onufrenya and Onufrenya 2016). Our results using digital voice recorders confirm the results of radiotelemetric observations on the polyphase activity of the animal. The desman's activity in the hole is unevenly distributed in time of day. The greatest activity in the burrow was noted from 13:00 to 15:00 h. Somewhat inferior activity was in the period from 1:00 to 03:00 h and from 19:00 to 22:00 h. Four periods of rest in the hole were noted: from 6:00 to 7:00 h, from 11:00 to 13:00 h, from 15:00 to 16:00 h, from 22:00 to 1:00 h (Figure 3). During these hours there was no desman passage along the course. This indicates that the animal was at this time either in a nest or in water. In this regard, the effectiveness of radio telemetry observations is more promising than the use of digital voice recorders, since the data obtained are more informative. However, the information obtained from digital voice recorders is important for assessing the internal activity. In the remaining periods, stable low activity in the burrow was observed. Thus, it is possible to distinguish the four phases type of activity of the Russian desman in the burrow.

Discussion

The results of works in the aviary of Rutovskaya and Kulikov (2013) can explain the high frequency of noise of the Russian desman in the burrow. Their observations in the experimental tunnel showed that every ten steps the desman 10 to 30 times touches the walls of the tunnel with the tip of the proboscis, with 45.4 % of touches falling on the ceiling. Almost half as many touches (27.9 %) are on the floor. The walls of the tunnel account for about 10 % of contacts (Rutovskaya and Kulikov 2013).

According to Onufrenya and Onufrenya (2016) Russian desmans marked with radio transmitters were active for a considerable part of the day. In all seasons of the year, they were out of shelters for at least 10 to 11 hours. On average, different animals are active from 11.4 to 15.5 hours. Or 48 to 65 % of the total time of day. The averaged duration of the activity phase of all observed animals was 12.5 hours of the day (Onufrenya and Onufrenya 2016). According to our averaged data, the desmans in the hole are not active seven hours a day, and seventeen hours are active in the hole. Moreover, a large proportion of activity in the hole falls at night.

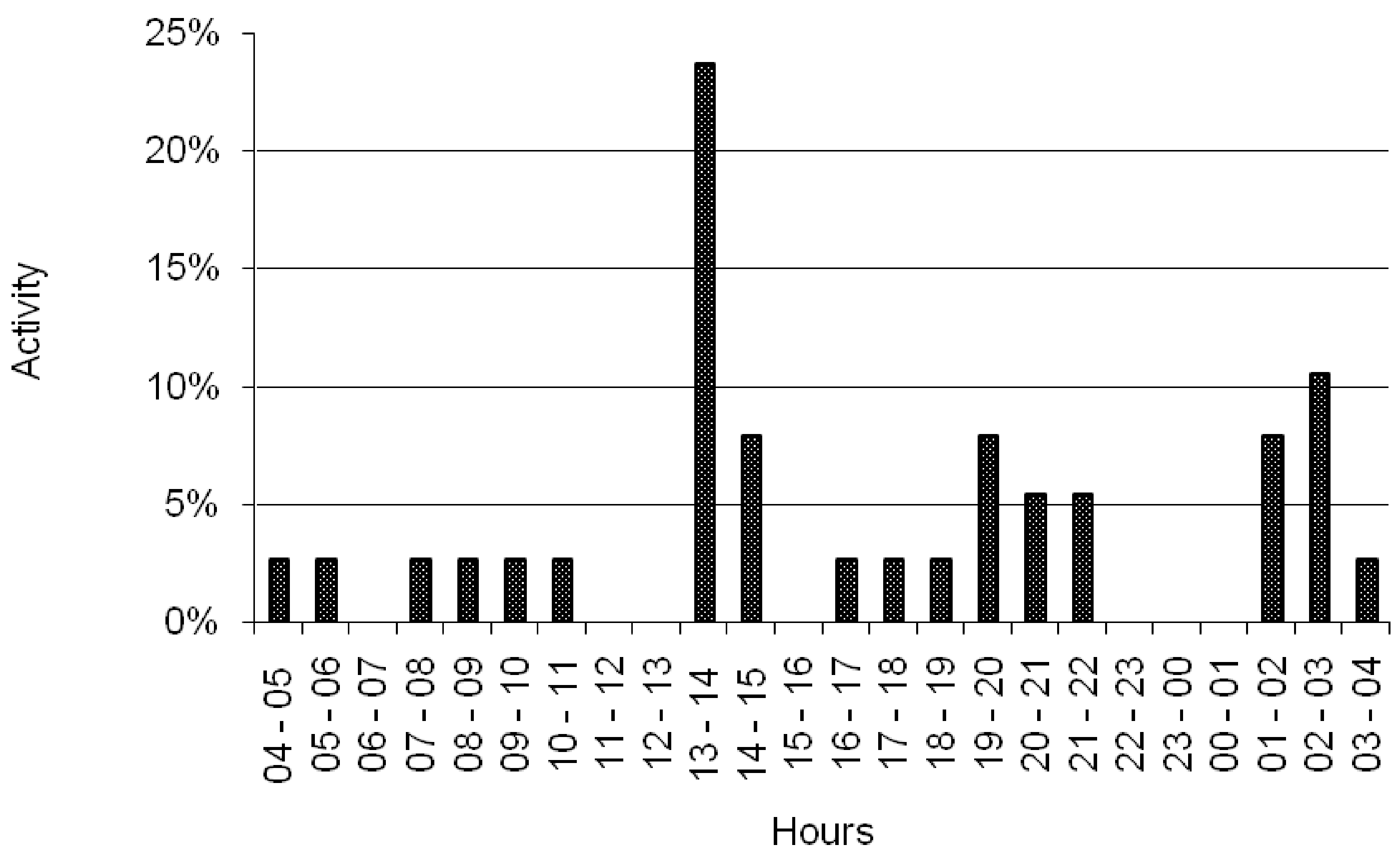

Figure 3. The daily activity of the Russian desman in summer months.

Directly in water, of the Russian desman can be from 3.2 to 11.6 hours a day. On average, for different animals, this indicator is 5.3 to 9.0 h (Onufrenya and Onufrenya 2016). Studies of the activity of the Pyrenean desman (*Galemys pyrenaicus*) to detect habitat or absence in the French Pyrenees were carried out using an automatic radio tracking system (Stone and Gorman 1985; Stone 1987). For the Pyrenean desman obtained two separate periods of activity for the period May-July. The day period of activity is short, the night period is longer. Every day the beginning and termination of activity for all desman was highly synchronized. This can be explained from the point of view of ecological resources of production and social ecology of the species.

Some others were the results of studies of the Pyrenean desman in the work of Melero *et al.* (2014). On average, individuals spent more time inactive than active, with 36.51 % of active radiolocations, and 9 to 10 h of activity per day. In general, the activity of desman was mainly nocturnal, although the activity pattern differed between autumn and spring. During autumn, individuals presented two nocturnal, or exceptionally three, activity bouts with an average duration of five hours each, separated by one (exceptionality 2) inactive period of 100 min average duration that commonly happened at 14:00 approximately, and a single diurnal activity bout of 73.75 min on average without any inactive period, but diurnal activity was longer (Melero *et al.* 2014).

Thus, summing up our own data and data of other researchers on the activity of the Russian and Pyrenean desmans, we can conclude that both species have a polyphasic rhythm. We realize that with the help of voice recorders we could not characterize the full rhythm of desman activity, as it was done by other researchers using radio telemetry. However, undoubtedly our data supplement and expand information about desman's activity in the hole. Therefore, digital voice recorders are indispensable in studies of normal activity and determining the employment of a hole. This method is expensive for the rapid identification of residential burrows, which is valuable for accounting work. With the help of the proposed method, in perspective, results can be obtained for the phases of the activity of difficult-to-investigate semi-aquatic mammals, which will be of undoubted significance in comparative terms.

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Associated editor: Lazaro Guevara
Submitted: March 27, 2018; Reviewed: June 24, 2019;
Accepted: January 6, 2020; Published on line: February 18, 2020.