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Camera traps in beaver burrows: monitoring of species diversity, habitat and season effects

Key words: camera traps, beaver burrows, mammals, species diversity, habitat and season effects, Lithuania

Introduction

Camera traps have quite a long history of use in wildlife research (see Locke et al. 2012 for review). In majority, these tools were applied for detecting large and mid-sized game animals in surface terrestrial habitats (O'Connell et al. 2011). Implementation of the infrared-triggered technology camera traps became potentially available for studying of much smaller animals and in the more closed space, however few publications on this can be found in scientific literature.

Here we present quite a new approach of camera trap usage – detecting mammals that use subterranean cavities developed by beavers (*Castor fiber*). Beavers are regarded as ecosystem engineers creating favourable environments for a number of species, including mammals (e.g. Wright et al. 2002; Müller-Schwarze, Sun 2003; Rosell et al. 2005). Beaver burrows are numerous structures in banks of water bodies (Ulevičius et al. 2009). The morphometric parameters of beaver burrows (Table 1) allow potentially to enter these cavities by animals up to the medium size (fox, raccon dog, badger).

The main aim of present research was to evaluate camera trap method to monitor mammals visiting beaver burrows as well as to analyse effects of basic environment factors (habitats and season) to the visiting intensity and detectability of mammals in beaver burrows.

Material and methods

Morphology of beaver burrows

Beaver burrows can be defined as quite large underground cavities made by beavers for safety purposes. Many of these structures penetrate into the water body banks nearly as much

Table 1 Some morphometrical parameters of beaver burrows in drainage ditches in Middle Lithuania (adapted from Ulevičius et al. 2009)

Parameter	n	Mean ± SD	Min	Max
Burrow length, m	204	7.8 ± 3.5	2.5	19.5
Height of burrow cavity, cm	17	39 ± 8	26	50
Width of burrow cavity, cm	17	49 ± 4	41	54

as 8 meters (Table 1). Mean length, hight and width of burrow cavities result in mean volume of about 1.5 m^3 per one statistical burrow. Given statistics represent only those burrows that were excavated by beavers for temporary needs (shelter in case of sudden alert, etc.), in contrast of permanent burrows that are permanently occupied by beavers. Number of temporary burrows in beaver sites can be very high. E.g. in Middle Lithuania, we estimated mean density reaching more than 30 burrows per one km of drainage ditches occupied by beavers (Ulevičius et al. 2009).

Temporary burrows usually have a shallow entrance from water side wich often exposes in low water level to be available for visiting by the not semi aquatic mammals. Entrances of permanent burrows are much deeper under the water. These burrows are maintained by beavers, so, have longer longevity than the temporary ones. Temporary burrows spontaneously collapse after some time, however, beavers dig new burrows, thus, development of a beaver burrow system in time has a cumulative character. Often distal parts of temporary burrows are connected to other burrows or exposed to surface through holes that are used by beavers to move to a source of food safely. Consequently, a temporary beaver burrow usually is not a closed cavity with the entrance under water, but rather an open underground corridor which is available for many visitors.

Study area

Area of our study plot is 548 km^2 and locates in Molėtai District (eastern Lithuania) (Fig. 1). The basic features of the territory are: hilly landscape, high fragmentation of forests, absence of large rivers, dense network of drainage ditches, and extensive agriculture. Beavers usually occupy here depressions between hills, thus, restoring and maintaining wetlands, once existed but later drained or exploited for peat. Density of beaver sites in this area was extremely high – 22.7 sites/1000 ha. Level of cumulative impact of the beaver alterations on landscape reaches about 11 % of total landcover, which is considered to be very high.

Fig. 1 Location of the sudy area in eastern Lithuania (black square).

Camera traps

We used *Reconyx PC800 HyperFire Professional Semi-Covert IR* cameras with the following basic technical specifications: trigger speed – 0.2 sec; image data – time, date, temperature and Moon phase; IR flash range – up to 21 m; battery life – up to 40 000 images; image resolution – 3.1 Mp or 1080P HD; operating temperature: -40° to +60 °C.

Original platform was designed to mount a camera (Fig. 2). Frame of this platform was made from the steel profile and camera was attached to a wooden plate by plastic strip. Two legs penetrating into the burrow's floor allowed to fix camera in a proper position.

To install a camera, we have searched for a beaver burrow, which preferably had a complex configuration (connected to a whole burrow system) and enough space to place a camera. Then we have tested the direction and extent of a burrow cavity using steel rod. Once appropriate burrow was found, we made a hole in a burrow's ceiling to install a camera. Trough this hole we evaluated slope and exact direction of a burrow cavity towards entrance and then fix an activated camera. Finally, we have carefully repaired a hole using strong wooden sticks, debris, etc.

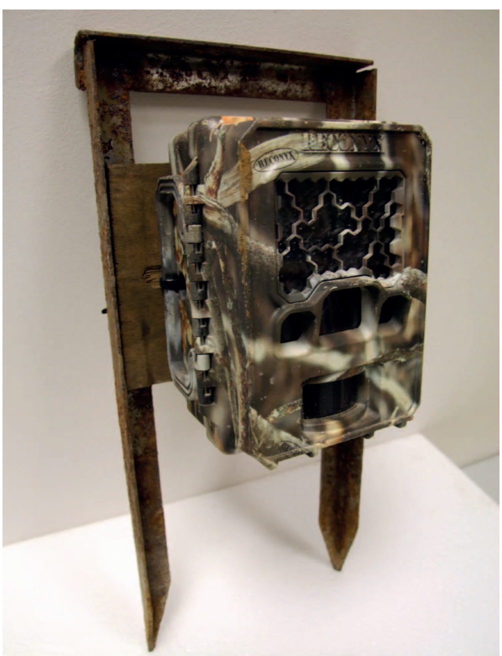

Fig. 2 Camera fixed on the platform is ready to be installed into the beaver burrow. Photo by A. Ulevičius.

Activated cameras were exposed in beaver burrows from 30 to 117 days uninterruptedly.

Habitats and seasons

Beaver sites in which we have installed the camera traps, were classified into the three categories by the following habitats:

1. rivers – natural water streams with the water yield more than 5 m^3/sec; beavers burrow in the river banks; significant fluctuations of the water level; no beaver dams;
2. drainage ditches – artificial water streams with the water yield less than 0.5 m^3/sec; beavers burrow in the canal slopes; moderate fluctuations of the water level; strong beaver damming activity;
3. wetlands – extensive swampy areas as a result of beaver activities; beavers burrow in steeper slopes on wetland margins.

Catching events (a camera trap exposition for a time period in one beaver burrow) were grouped by two seasons:

1. warm season – from April to October with mean t= +10.6 °C;
2. cold season – from November to March with mean t= -0.8 °C.

Parameters and sample size

We used definition of effective trigger – a camera activation event resulting in an animal photos which enable to recognize species (other taxon) of animal that activated a camera. Once camera was activated, it produced 3–5 photos per one trigger to enhance probability of catching an animal. Consequently, if an animal was not recognizable from these photos, it was classified as ineffective trigger. Ineffective triggers were activated not only by mammals, but also by other moving things (falling ground and drops of water, spiders, moving roots, etc.). Number of effective triggers per 30 days was a standardized indicator for estimates of use of beaver burrows among species.

We counted only those effective triggers which were separated by time intervals not shorter than 5 minutes for the same animal species. Time intervals were not taken into account when successive effective triggers were activated by different animal species.

Totally, 37 beaver burrows during 2013–2015 were studied, with total amount of 6692 effective triggers (Table 2).

Results and discussion

Seventeen species (or taxons) of mammals were registered visiting beaver burrows. The bank vole *Clethrionomys glareolus* was the absolute dominant among all the registered mammals. The American mink *Neovison vison* dominated among carnivores (Fig. 3). The smallest visi-

Table 2 Sample sizes

Habitat	Warm season		Cold season	
	Number of burrows studied (catching events)	Number of effective triggers	Number of burrows studied (catching events)	Number of effective triggers
River	4	102	5	1602
Drainage ditch	5	447	9	1272
Wetland	7	875	7	2394
Total	16	1424	21	5268

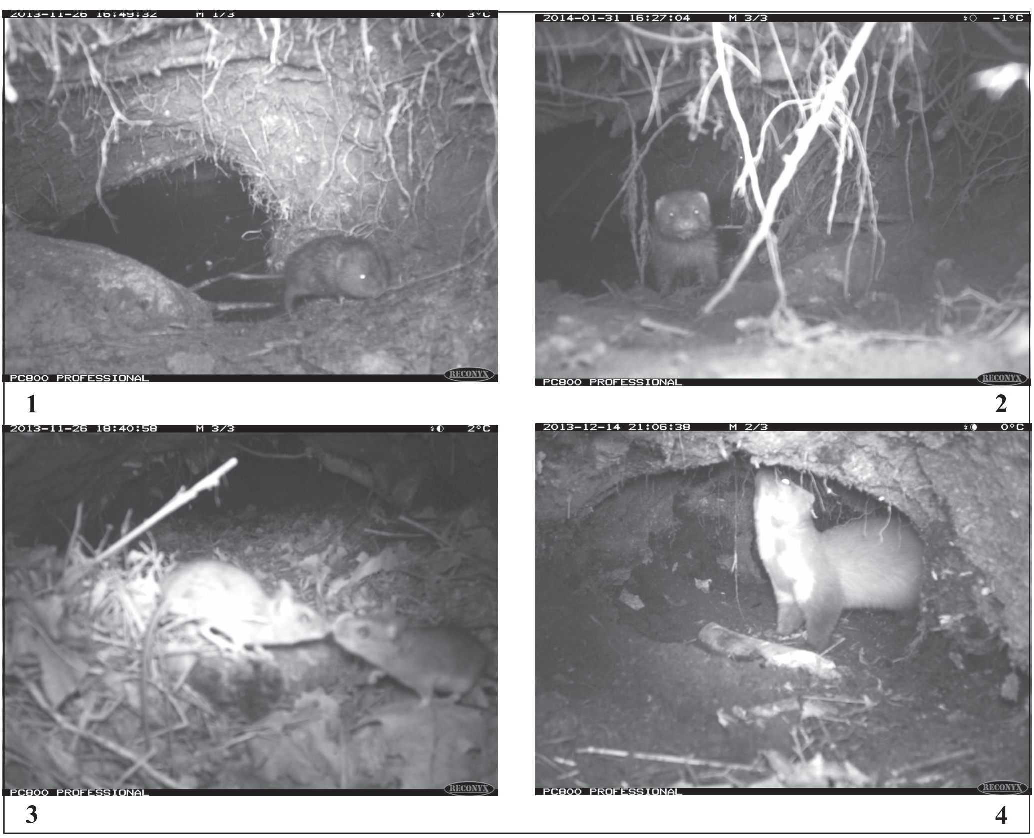

Fig. 3 Examples of mammal photos taken in beaver burrows. 1 – bank vole (Clethrionomys glareolus), 2 – American mink (Neovison vison), 3 – yellow necked mouse (Apodemus flavicollis), 4 – stone marten (Martes foina).

tors were shrews *Sorex* spp. The badger *Meles meles* and red fox *Vulpes vulpes* were the biggest who were registered in beaver burrows. It is interesting that beavers themselves were very rarely recorded in photos. This can be explained by fact that we have monitored only temporary burrows used by beavers very rarely.

It took approximately 40 days from a camera installation moment to register majority of mammal species (Fig. 4). Cumulative number of registered species grew up fast in the first 10–15 days later slowed down considerably and the list of species usually was added by rare visitors.

First fixes were different among species. Generally, rodents were the first who were fixed by cameras (Table 3). Bank vole showed the shortest time since camera installation day – 7.8 days in average. Carnivores have appeared much later. E.g. martens and American mink started to fix on 26.5 and 27.7 day on average, respectively. This suggests, carnivores being more sensitive than rodents to the camera presence or burrow disturbance during camera installation. This can be important for practical application of the camera trap method. Small and medium sized carnivores may need more time to adapt to cameras as the new objects in their environments. Thus, camera traps should be exposed for enough time to register majority of potential species. In our case this time sould be at least 40 days.

Visiting of beaver burrows varied considerably among mammal species (Table 4). Bank vole was registered in all catching events with relatively largest mean number of effective triggers (almost 42 effective triggers per 30 days). No other species (taxon) has demonstrated such a high frequency of occurrence and visiting intensity. Subdominant group of shrew (Soricidae) species consisted of three species: *Neomys fodiens, Sorex minutus* and *S. araneus*. Not allways it was possible to decide wich species of shrews is in a photo, so, we have not distinguished among species. Shrews are quite common visitors of beaver burrows. Yellow-necked mouse was the third by visiting intensity and shared the second place with shrews by frequency of occurrence. Small mammals obviously prevailed in beaver burrows.

Predators were the other ecological group of mammals visiting beaver burrows. American

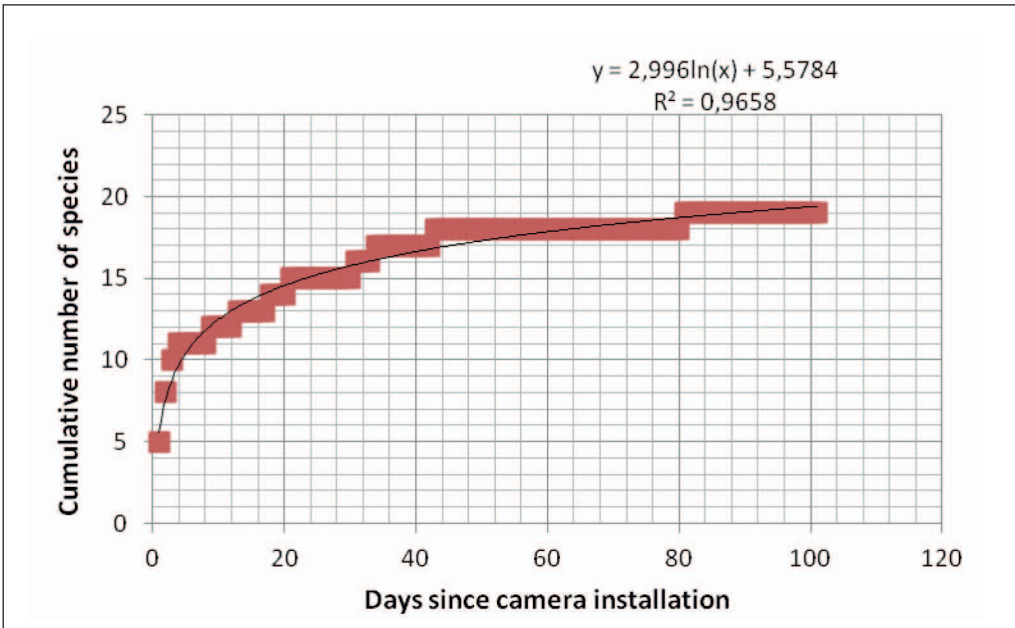

Fig. 4 Cumulative number of mammal species recorded in beaver burrows versus days since camera trap installation.

Table 3. First triggers among mammal species since camera installation (habitats and seasons pooled together, n=37)

Species (taxon)	First trigger (mean number of days since camera installation)	Number of catching events
Clethrionomys glareolus	7.8	37
Ondatra zibethicus	13	2
Arvicola terrestris	16	5
Sciurus vulgaris	17	1
Apodemus flavicollis	18	27
Soricidae	18.2	31
Castor fiber	21	1
Apodemus agrarius	22.7	6
Martes spp.	26.5	11
Neovison vison	27.7	30
Lutra lutra	31.6	10
Mustela putorius	39.6	11
Nyctereutes procyonoides	48.3	4
Talpa europaea	51.7	3
Mustela spp.	53.1	10
Vulpes vulpes	60.3	3
Meles meles	89	2

mink dominated among other predators, though its mean number of effective triggers was much lower than this of small mammals. However, frequency of occurrence of American mink was relatively high – 0.73. Martens (not distinguished among two species – stone and pine martens) as well as otter and polcat were also common visitors of beaver burrows. Raccoon dog showed somewhat less interest in beaver burrows than mustelids.

Finally, there was a group of mammals that showed very low visiting intensity (less than 0.1 effective triggers/30 days) and frequency of occurrence (up to 0.1). These can be called accidental visitors including beaver. We already mentioned why beaver use his own burrows so rarely. Red squirrel may be regarded as an unexpected species. Photos show that possible purpose of visit was storage of acorns in underground cavity. Muskrat was found very rarely in beaver burrows despite some beaver wetlands were inhabited by this rodent. Usually, muskrats build their own shelters (lodges and burrows), and possibly they do not need to use beaver burrows.

We found no habitat effect on visiting intensity of beaver burrows neither among species nor ecological groups of mammals (Table 5). Some logically explanable, however, statistically not significant differences among habitats were revealed. E.g., visiting intensity of bank vole was tended to be lower in drainage diches, whereas that of striped mouse, on the contrary, grew up in this habitat. One of possible causes for this can be less amount of forested habitat in surroundings of a drainage channel. For ecological groups of mammals the differences were also inconspicous. On the other hand, these data show, that drainage ditches transformed by beavers can be attractive habitats for many small and medium sized mammals, especially for American mink, martens, thus discharging

Table 4 Number of effective triggers/30 days and frequency of occurrence among mammal species visiting beaver burrows (habitats and seasons pooled together, n=37)

Species (taxon)	Mean number of effective triggers/30 days	Frequency of occurrence (positive events : all catching events)
Clethrionomys glareolus	41.73	1.00
Soricidae	15.20	0.84
Apodemus flavicollis	4.66	0.84
A. agrarius	2.09	0.14
Neovison vison	1.70	0.73
Martes spp.	0.64	0.32
Lutra lutra	0.39	0.30
Mustela putorius	0.29	0.24
Nyctereutes procyonoides	0.18	0.14
Arvicola terrestris	0.14	0.05
Mustela spp.	0.07	0.11
Meles meles	0.04	0.08
Vulpes vulpes	0.04	0.05
Ondatra zibethicus	0.01	0.03
Talpa europaea	0.01	0.03
Sciurus vulgaris	0.01	0.03
Castor fiber	0.01	0.03

predators press on the whole hydrographical network. One of reasons of absence of the statistically significant habitat effect can be high variation of visiting parameters among catching events, which in many cases exceeded the mean. Seem like many local factors influence these parameters more strongly than does the habitat factor. Here, we pooled together both seasons, which also has contributed the variation (see next). This decision was made to preserve larger samples among habitats, however, in the future, seasons should be analysed separately due stronger effect of this factor (see next).

Season effect was obviously more pronounced than that of habitats, with significant tendency of increase towards cold season. Shrews have shown the most expressed difference, perhaps because in cold season they recquire more soft microclimate conditions due their high energy expenditures and higher availability of winter food in underground cavities. The same tendency was observed for small rodents, except the yellow necked mouse, which is seemed to be related to storage of winter food and therefore less active in cold season. Higher concentration of small mammals may attract predators to beaver burrows more intensively in cold season than in the warm one.

Our results show that the camera trap method is very effective to monitor mammal diversity in underground structures. Total catching effort was 2764 camera trap-days and the total yield of catchings comprised 6692 effective triggers, thus, making 2.42 effective triggers per one trap-day or 242 effective triggers per 100 trap-days. In comparisson with the traditional snap trap method, camera traps look much more efficient, because in the snap trap catchings very rarely the maximum limit of 100 ind. per 100 trap-days can be reached in the ground surface habitats (Balčiauskas, Juškaitis 1997).

Table 5 Mean number of effective triggers/30 days among mammal species and ecological groups of mammals visiting beaver burrows in different habitats (seasons pooled together)

Species (taxon)*	Mean number of effective triggers/30 days			
	Rivers n=9	Drainage ditches n=14	Wetlands n=14	Kruskal-Wallis, p
Clethrionomys glareolus	54.02	25.53	50.03	0.2644
Soricidae	3.39	16.15	21.84	0.1029
Apodemus flavicollis	1.78	5.90	5.27	0.1229
A. agrarius	0	5.48	0.03	0.4245
Neovison vison	1.20	2.90	0.83	0.7448
Martes spp.	0.10	1.34	0.27	0.5005
Lutra lutra	0.40	0.52	0.26	0.2984
Mustela putorius	0.58	0.33	0.07	0.6101
Nyctereutes procyonoides	0.30	0.03	0.26	0.8004
Arvicola terrestris	0	0.06	0.31	0.9504
For ecological groups:				
Small mammals	59.18	53.13	77.48	0.3697
Carnivores	2.28	5.09	1.42	0.3879
* Only species (taxons) with mean number of effective triggers higher than 0.1 are included				

Table 6 Mean number of effective triggers/30 days among mammal species and ecological groups of mammals visiting beaver burrows in different seasons (habitats pooled together)

Species (taxon)*	Mean number of effective triggers/30 days		
	Warm season n=16	Cold season n=21	Mann-Whitney, p
Clethrionomys glareolus	26.48	53.35	0.1010
Soricidae	3.38	24.20	0.0092
Apodemus flavicollis	6.76	3.06	0.1109
A. agrarius	0.19	3.53	0.7130
Neovison vison	0.88	2.33	0.9511
Martes spp.	0.22	0.95	0.6347
Lutra lutra	0.17	0.56	0.4254
Mustela putorius	0.12	0.42	0.1253
Nyctereutes procyonoides	0.19	0.18	0.6902
Arvicola terrestris	0.06	0.21	0.9633
For ecological groups:			
Small mammals	36.86	84.35	0.0073
Carnivores	1.39	4.26	0.2144
* Only species (taxons) with mean number of effective triggers higher than 0.1 are included.			

Our earlier investigations of small mammals in beaver burrows using the snap trap method revealed catching efficiency of 68 ind. per 100 trap-days (Prankaitė 2013).

We have registered majority (about 67 %) of small and medium sized mammals (except bats and dormice) inhabiting fragmented landscape of Lithuania (Balčiauskas et al. 1999). This demonstrates usefulness of camera traps not only for estimating beaver impacts but also for contribution of distribution and species diversity data, which are well documented.

Visiting intensity of beaver burrows by small mammals clearly differs from that of carnivores. These differences could be comparable with respective densities of the two ecological groups of mammals. Other reason might be that small mammals seemed to be more sedentary than carnivores. Photos of bank vole were particularly densely arranged through time in many catching events and this allows to suspect many individuals of this species living in the same beaver burrow for a long time, thus, producing more photos per time. Bank vole was dominant species also on beaver lodges as evaluated by using snap traps (Ulevičius, Janulaitis 2007). Small mammals could be a reason why predators visit beaver burrows. Diet of all predators registered here contains small mammals (Prūsaitė 1988). Synchronic increase of visiting intensity of beaver burrows by small mammals and predators in cold season could partially support this hypothesis. On the other hand, we have photos of American mink eating frogs in beaver burrows, so, using them as a safe place for feeding.

Conclusions

1. Camera traps is a proper method to monitor mammal species visiting beaver burrows. 17 species (or taxons) of mammals were registered in beaver burrows. The bank vole *Clethrionomys glareolus* was the absolute dominant.
2. It takes approximately 40 days to register majority of species. However, small mammals are gathered faster from a camera installation moment than are carnivores.
3. We found no habitat effect on visiting intensity of beaver burrows neither among species nor ecological groups of mammals. However, season effect was obviously more pronounced with significant tendency of increase towards cold season.
4. There was a significant variation in visiting intensity among catching events. In majority of events SD exceeded the mean. This indicate rather a number of local factors influencing the studied parameter.

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Abstract

We present quite a new approach of camera trap usage – detecting mammals that use subterranean cavities developed by beavers (*Castor fiber*). This non-invasive method is developed to study quite a secret aspect of the key stone species impacts to animal communities – the burrowing activity of beavers. Camera traps is a proper method to monitor mammal species visiting beaver burrows. 17 species (or taxons) of mammals were registered in beaver burrows. The bank vole *Clethrionomys glareolus* was the absolute dominant and American mink *Neovison vison* dominated among carnivores. It takes approximately 40 days to register majority of species. However, small mammals are gathered faster from a camera installation moment than are carnivores. We found no habitat effect on visiting intensity of beaver burrows neither among species nor ecological groups of mammals. However, season effect was obviously more pronounced with significant tendency of increase towards cold season. There was a significant variation in visiting intensity among catching events. In majority of catching events standard deviation exceeded the mean. This indicate rather a number of local factors influencing visiting intensity.

Zusammenfassung

Kamera-Fallen in Biberbauen: Monitoring der Artenvielfalt, Habitat- und jahreszeitliche Effekte

Eine neue Methode zur Nutzung einer Kamera-Falle wird vorgestellt, um Säugetiere zu beobachten, die unterirdische Röhren und Baue des Bibers (*Castor fiber*) bewohnen.

Diese nicht-invasive Methode wurde entwickelt, um verschiedene Aspekte des Einflusses von Schlüsselarten in Tiergemeinschaften zu studieren im Zusammenhang mit den Grabaktivitäten des Bibers. Kamera-Fallen sind dafür eine geeignete Methode, um Säugetiere in Biberbauen zu beobachten. 17 Arten (oder taxons) konnten in den Biberbauen nachgewiesen werden.

Die Rötelmaus (*Clethrionomys glareolus*) war absolut vorherrschend und von den Beutegreifern war der Mink (*Neovison vison*) dominant. Durchschnittlich wurde an 40 Tagen aufgenommen, um die Mehrzahl der Arten zu erfassen. Jedoch sind kleine Säugetiere zu schnell in ihren Bewegungen für die Kamera gewesen, während bei Beutegreifern durchaus gute Aufnahmen gemacht werden konnten.

Es wurde weder ein Habitateffekt gefunden zur Intensität der Besuche der Biberbaue noch zwischen den Arten und auch nicht zwischen ökologischen Gruppen von Säugetieren. Vorauszusehen war, dass ein saisonaler Effekt mit einem signifikanten Trend während der kalten Jahreszeit auftrat. Es bestand eine signifikante Variation zwischen den Besuchen und den Aufnahmeereignissen. Standard Deviation überschritt das Mittel in der Mehrzahl aller Aufnahmeereignisse. Dies zeigt umsomehr, dass eine Anzahl lokaler Faktoren Einfluss auf die Intensität der Besuche hatte.

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