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The Use of a Camera Trap System for Monitoring the Movement of Forest Animals Through the Wildlife Crossing in Napchanie

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1. Introduction

In recent years, the intensive development of road infrastructure, particularly expressways and motorways, has resulted in a high-scale fragmentation of landscape. The desire to move the infrastructure away from human settlements and sights of high natural value has led to a situation in which new road projects separate elements of landscape and prevent free migration of animals for feeding and mating purposes. One crucial element considered when planning new infrastructure facilities is environmental compensation. In order to compensate for the fragments of landscape they irrevocably seized control over, investors carry out actions aimed at restoring migration routes and wildlife corridors. An example of such action is designing and constructing overpasses and wildlife crossings along line investments. This is quite common in Poland, were wildlife crossings have been constructed in numerous locations across the country. A given crossing can be considered well-designed only after its use has been verified. Such verification can be performed through studies carried out with PIR sensors, continuous monitoring systems or systems that record on detecting movement. Such tools, however, require a considerable amount of financing and conducting additional construction work. This paper describes how a monitoring system based on inexpensive portable camera traps was designed and applied. The monitoring performed with the use of this system allowed to determine behaviour patterns of animals passing through the lower wildlife crossing (Iwiński et al. 2019).

2. Literature overview

Monitoring the environment and its phenomena with the use of portable video cameras is a scientific method that appeared in the literature as early as in the 1960s. First attempts to record images were made in 1956 (Cutler, Swan, 1999). Technological progress together with lower costs of the equipment resulted in a very intensive development of this method between 2009 and 2016. Over that period, portable camera traps started to be used on a mass scale. (Stachowicz et al. 2017). Simple cameras with built-in memory, powered by integrated or replaceable batteries, made monitoring animal behaviour much easier (Rovero et al., 2013). Stationary devices require a permanent power source. Data they record need to be transferred or stored on external carriers. But first of all, the installation process of stationary devices or their whole systems has an impact on the environment. Portable camera traps have an unquestionable advantage – their installation is non-invasive and they can be mounted on any element that belongs to the infrastructure or to the environment. They do not require to be permanently connected to any power source. The installation process of such devices can help to avoid problems that may arise from changes in the environment e.g. results of vegetation or overgrowing of the monitored area Camera traps do, however, have some disadvantages – they are easy to steal and they easily suffer damage caused by animals. It is also problematic to gather material from more than one device. Portable devices are an optimal solution for monitoring animal behaviour in problematic areas such high mountains, glaciers (Sangay et al., 2014) or forests located far from power sources.

When monitoring animals with camera traps, the key issue is to place the devices properly. Jackson and others (2013) suggest that for animals using narrow crossings (with a width of < 2.5 m), the optimal solution would be to place two cameras mounted at an angle of 45° opposite to each other, pointing to the direction of migration. Such position was indicated as the one ensuring the highest efficiency of the system. Cameras should be placed in a way that corresponds to the to features of the area that is monitored. Installation should be preceded by initial tests. Weather conditions and the type of populations monitored should be taken into consideration on selecting the proper equipment (Noss et al., 2013, Stratford, Naholo 2017).

Applying devices that record material after detecting movement may cause problems with interpreting data. A high number of observations made in a short period of time may be misinterpreted. Dividing animals into groups may be incorrect, as animals moving one after another often do not constitute separate populations. Therefore, in order to interpret the results correctly, it is necessary to adopt an appropriate methodology and apply it consistently to avoid errors (LaFleur et al. 2017). A well-designed and well-operated system of camera traps is invisible to animals and allows to record more objects than an observer. It also allows to learn secrets about species, as animals do not feel constrained when they cannot see the devices (Stratford, Naholo 2017). Cameras, especially the PIR sensor and IR illuminators can be noticed by forest animals (Rovero et al. 2013).

3. Aim, scope and methodology of the study

The aim of the study was to determine the possibility of using a monitoring system designed according to an original concept. This system consists of portable recording devices – camera traps. They allow to determine the behaviour of animals that pass through the wildlife crossing in wintertime. As it is difficult to use constant power supply and there is no way to send data in real time, the system designed consists of several recording devices that were able to cover the whole width of the wildlife crossing in Napchanie.

The monitoring system is based on ScotGuard HC-SG520 cameras that were selected at the stage of initial tests from three types of camera traps, the two other being Hunting Trial Camera HC-300M and Redleaf 1006. The type selected allows to record sound and image at any time of the day or night thanks to a built-in pyroelectric sensor. The built-in IR illuminators allow to record grayscale images during periods of day with insufficient sunlight and at night. Each camera is equipped with 4 IR diodes that emit light with a wavelength range of 940 nm (invisible for humans). According to the technical specification, the diodes can illuminate the area with a maximal length of 36.57 m and with a visibility radius of circa 60°. Camera traps react in less than one second to movement detected in the field of view of the pyroelectric sensor that is placed just under the lens of a 5 Megapixel CMOS image sensor. The pyroelectric sensor operates on 5 sensitivity levels. According to the information provided by the manufacturer, it is able to detect movement in a distance of 25 m from the device and within a radius of 55°. The cameras are powered by AA batteries (4 x 1.5 V). The images recorded are stored on memory cards (maximum 32 GB), which ensures that the device can operate without maintenance for the time required to take 3000 pictures and 3 months. The operating time of the device depends on the number of activities, the duration of the IR diodes illumination and the air temperature.

The first stage of the study involved a comparison of 3 camera types in order to select the optimal device that would carry out research on location in Napchanie. The testing process included a verification of data provided in the technical specification of the cameras. HC-300M and RL1006 cameras were rejected at the initial stage due to higher operating costs (both types require 8 batteries in each device). Moreover, it was problematic to set appropriate frames in HC-300M (the camera is operated with an infrared remote control). On the other hand, the RL1006 camera trap had problems with the PIR sensor, which did not react to a clear crossing of the camera's field of vision. It is worth to mention that both RL1006 and HC-300M have better image sensors than the SG520 type, however, due to the nature of research, they were rejected. The next stage was to verify the ability of the SG520 camera trap to register image. The device's operating time (and standby time), the visibility of angles and distance of the lense, the PIR sensor, the illuminator and weather resistance were all verified in test conditions. The results of the verification differed from the data included in the technical specification of the device. The radius of movement detection was much wider than mentioned in the specification, while the distance of effective detection was shorter. It is also worth mentioning that that the visibility level of the lens, as well as the level of illumination, are much higher than included in the specification. It was possible to effectively illuminate objects located nearly 40 m from the device, however, it is worth to point out that such distance could have been achieved due to the nature of the test location (tests carried out in the structure located in Napchanie indicated that the maximum distance of effective illumination was 32 m). The last parameter analyzed was the period the device can operate in maintenance-free and on battery power supply. In test conditions, the result was 35 days. The optimal operating period, however, should be 4 weeks – considered as a period when the device takes more night pictures and operates without any power shortage or the lack of storage space on the portable disc. Angles and distances were verified with a portable laser rangefinder in a closed area located within the premises of the Poznań University of Life Sciences.

SG520 cameras were installed in the lower wildlife crossing under the Expressway S11 in the village of Napchanie. The crossing is located under a two-part flyover suspended over the riverbed of the Sama river and is designed for large and medium-sized animals. The crossing is 30-meter wide. It is divided by the river and two rows of concrete pillars that support the flyover. The crossing is not equipped with natural infrastructure guiding forest animals. Instead, there are safety nets that protect the expressway and the junction from the intrusion of forest animals. The crossing features many elements of technical infrastructure such as a drainage ditch protected by stones and nets, as well as absorptive wells. This is against the principles of designing wildlife crossings. The river divides the crossing into 2 fragments with a width of 12 m and 14 m respectively. Both fragments are divided into smaller parts by pillars with a diameter of 1 m. The sizes of those parts are: 12 m, 2 m, 10 m and 2 m. The crossing is 4 metres high. There is a gap between the lines of the expressway, which startles animals that pass through this crossing. The crossing is surrounded by concrete retaining walls. At the entrance, there are strips of vegetations made of densely planted bushes. The floor is covered with a mixture of sand and humus. This corridor joins two parts of the forest separated by the Expressway S11.

The devices were installed with the use of straps and cable ties in a non-invasive manner on the elements of infrastructure of the crossing. The support of the crossing was selected to be the main monitoring point as it ensured visibility in all directions and allowed to identify the species and the number of animals moving through the structure.

In the course of tests carried out in the structure and according to the methodology suggested by Noss and others (2014), it was established that placing 3 devices at 120° intervals will allow to correctly monitor the whole wildlife crossing. To ensure the correct operating of the devices and to protect them against theft, the crossing was equipped with an additional device whose field of view covered the entire object. The cameras were programed to record 30-second videos with a minimal delay of 1 second between the PIR sensor detection and the beginning of the recording. The sensitivity of the sensor and the power of IR illuminators were adjusted to the prevailing conditions (the amount of vegetation cover). Camera traps recorded videos with a resolution of 720 px, which was a balance between the size of the recorded file and the ability to read and analyze the image. Animals were monitored continuously throughout the winter period i.e. from 21 December 2018 till 23 March 2019. Battery exchange and data collection took place every 21 days. Videos were transferred to a separate collective disc and were subject to further analysis. It focused on the following elements:

- species,
- number of animals,
- pace of movement and behaviour,
- exact time of passage,
- route selected to pass through the structure.

Data were compiled in a spreadsheet in order to identify a typical behaviour each species demonstrates on using the wildlife crossing.

4. Results

The seasonal monitoring resulted in 752 unique images of animal migrating through the wildlife crossing (Table 1). 77% of videos were recorded at night with the use of IR illuminators. Wild boars were recorded 280 times, which made them the species that used the crossings most frequently. They were followed by roe deer (102), deer (84) and the category of farm animals and humans (83). 67 foxes and 4 racoon dogs were also recorded. It should be noted that the group of farm animals included birds. They were, however, impossible to identify due to the the fast pace of migration.

Table 1. List of images recorded with the use of the monitoring system

Observation		1	2	3	4	5	Total
Number of videos:		83	0	208	100	211	752
At daytime		3	9	37	3	67	169
At nighttime		50	1	171	7	144	583
Empty		4	1	27	9	41	132
Successful		49	9	181	1	170	620
Species	Wild boar	1	7	101	4	67	280
	Roe deer	2	4	33	8	15	102
	Deer	1	8	15	2	18	84
	Fox	7	0	13	6	31	67
	Rackoon dog	0	0	3	1	0	4
	Others (humans, pets)	8	0	6	0	9	83

The number of migrations depends on weather conditions and the time of day. By analyzing the daily distribution of usage and the images recorded, it is possible to identify behaviour patterns of 3 animal species that pass through the structure most frequently. Moreover, the video material collected indicates that different parts of the crossing are used depending on the time of day and on the species of user. Regardless of the time of day, wild boars migrate through the entire width of the crossing, without paying attention to any possible danger. They usually move in tight groups, running at high speed, slowing down only when they leave the crossing and approach the drainage ditch located next to the vegetation strip in front of the crossing. An opposite behaviour pattern can be observed among migrating deer. They seem to be extremely consistent as they move through the crossing. They migrate in groups, one after another. One deer enters the crossing only when the other starts to leave it. One interesting phenomena is the fact that deer use specific fragments of the crossing depending on the time of day. During daytime, they use the main migration route that leads between the widest supports. They move quickly, without paying attention to any danger. At night, however, they use the narrow fragments of the crossing located between the supports and the riverbed, as well as the narrow fragment located on the northern side of the Sama river. Those fragments are somehow sheltered from the rest of the passage and can be a form of protection for the animals. Another of the groups analyzed were roe deer. They used the crossing as if it had been their place of feeding. They were frequently spotted playing and relaxing in the main part of the crossing. This was particularly evident during snowfall, when most of the roe deer fed under the expressway on grass that was not covered with snow. Roe deer were mostly observed during daytime. They migrated fast only when startled. Under such circumstances, roe deer run into the direction opposite to the startling factor, without paying attention to any other danger.

Due to the proximity of houses and to the fact that the object is located in the valley of the Sama river, a large group recorded in the videos were humans and farm animals. The wildlife crossing is frequently used by pets (cats and dogs spending time or playing in the crossing) and people taking walks or walking their dogs. Many of the people recorded were photographers that carry out outdoor sessions in the valley of the river. It is worth to mention that human presence does not significantly affect the migration of animals. There was a decrease in the number of animal migrations immediately after humans passed through the crossing. However, in a perspective of 24 hours, the number of migration did not change.

5. Discussion and conclusion

In recent years, studies on the inventory and the behaviour of forest animals have been closely connected with minimizing costs and making use of the rising mobility of equipment. Disadvantages and problems of applying camera traps in scientific research have not prevented them from becoming one of the basic measuring devices used for inventorying mammals (Meek et al. 2012). This is confirmed by the analysis of the number of research carried out with the use of portable cameras conducted by Stachowicz in several scholarly publications (Stachowicz et al. 2017). It indicated a huge increase in the use of camera traps that began after 2009. Low maintenance costs and low prices make camera traps an interesting alternative to permanent monitoring systems connected to power lines and to monitoring conducted by qualified personnel. Studies have indicated (De Bondi et al. 2010) that the level of species identification achieved by camera traps was the same as the one achieved by qualified personnel. Therefore, camera traps can be an economical alternative applied in research not involving animal tagging. The difficulties of using ready-made cameras can be compensated by the use of modular solutions based on Raspberry Pi computers that can be fully regulated by users and easily adapted to environmental need (Nazir et al. 2017). The application of the aforementioned devices shall be and extension of this study. The high efficiency of ready-made recording devices has been demonstrated in this study. It is worth to mention that the operating costs of camera traps, excluding the cost of purchase, are almost 9 times lower than the costs of traditional inventory methods (De Bondi et al. 2010, Meek, Pittet 2012).

The lower crossing in Napchanie is used by big game (wild boars, roe deer, deer) and is a corridor joining forest complexes that enables migrations between different habitats.

An inexpensive monitoring system allows to record the migration of forest animals with an efficiency of over 82%. It can be successfully applied in wildlife crossings with a width up to 30 m. HC-SG520 devices can operate successfully throughout the period of 21 days, and provide continuous observation.

Migrating animals show specific behaviour patterns and, depending on the species and the time of day, use different part of the crossing. Information about they behaviour obtained through monitoring can be used for securing traffic routes or as training materials for drivers.

The presence of anthropogenic elements does not cause a decrease in the number of animal migrations. However, since the crossing is located in the vicinity of settlements, it is frequently used by humans and pets, which may startle forest animals.

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Abstract

The development of road and railway infrastructure leads to landscape fragmentation. Environmental compensation is an important aspect developing communication networks. It can be achieved through designing and constructing green infrastructure that joins habitats separated by human activity. This article describes an attempt to create a system of monitoring forest animals with the use of portable devices (camera traps) in a wildlife crossing located under the line of Expressway S11 near the riverbed of Sama in the Wielkopolska Voivodeship. The crossing for large animals was created there to join habitats located within Poznan city limits with the forest complexes outside of Poznań. The system proposed in this article is intended to evaluate the use of the crossing by animals and to identify behavioural patterns of animals passing through the structure. Authors proved that it is possible to create an economical and efficient monitoring system of forest animals without electrical supply and without any data transmission system. In addition, authors manage to identify some behaviour patterns of migrating forest animals, different of each species. This can be helpful in designing and maintaining wildlife crossings. The system consisted of 4 cameras that monitored the whole crossing; 3 of them were recording videos from the central point while the one was used for control purposes. It was established that using even 1 device is enough to successfully monitor the animals migrating through the crossing. The monitoring process was carried out with the use of HC-SG520 cameras, which allowed to record image after triggering the pyroelectric detector. It was also possible to monitor animal movement in nighttime, thanks to the illumination provided by IR diodes Cameras recorded 30-second videos and saved them on SD cards that were replaced every 21 days.

HC-SG520 cameras were selected in the course of tests that involved 2 other types of devices. The efficiency of the equipment used was 82%, only 17% of videos recorded did not feature any migrating animals. It was observed that the crossing is used mostly by wild boars, roe deer and deer. Due to the proximity of human settlements, the crossing is used by humans and pets, which can affect the functionality of the structure and the freedom of migration. Most migrations (78%) take place during the night. The behavioural patterns of forest animals identified throughout the study, can be later applied in ways of protecting roads from animal intrusion or can serve as educational material for drivers.

Keywords:
camera trap, environmental monitoring, wildlife crossing.

Wykorzystanie systemu fotopułapek do monitoringu ruchów zwierzyny leśnej przez ekodukt Napachanie

Streszczenie

Rozwój infrastruktury drogowej i kolejowej powoduje zjawisko fragmentaryzacji krajobrazu. Ważnym aspektem rozbudowy sieci komunikacyjnych jest kompensacja przyrodnicza. Jednym z narzędzi realizacji tych zadań jest projektowanie i budowa zielonej infrastruktury służącej do łączenia siedlisk, które zostały rozdzielone ze względu na bariery liniowe. W artykule podjęto próbę wykonania systemu monitoringu zwierzyny leśnej przy wykorzystaniu przenośnych urządzeń rejestrujących (camera trap) na ekodukcie pod nitką drogi ekspresowej S11 w ciągu koryta rzeki Samy w województwie wielkopolskim. Przejście dla zwierząt dużych powstało w tym miejscu w celu połączenia siedlisk leżących w granicach miasta Poznania z kompleksami leśnymi powiatu poznańskiego System ten służyć ma ocenie wykorzystania przejścia przez zwierzęta oraz wskazania wzorców zachowania zwierząt w trakcie korzystania z tego typu infrastruktury. Autorzy wskazali, że istnieje możliwość wykonania taniego i skutecznego systemu monitorowania zwierzyny leśnej bez konieczności doprowadzenia energii elektrycznej oraz systemu przesyłu danych. Dodatkowo wskazane zostały wzorce zachowania zwierzyny w zależności od gatunku migrujących osobników, co może być pomocne przy projektowaniu jak i pielęgnacji tego typu rozwiązań. Zaprojektowany system monitoringu składał się z 4 kamer monitorujących całą powierzchnie przejścia dla zwierząt, 3 z nich realizowały nagrania z centralnego punktu, natomiast 4 z niech pełniła funkcję kontrolną. Zauważono, że wykorzystanie już jednego urządzenia pozwala na skuteczne monitorowanie zwierząt na ekodukcie.

Do monitoringu wykorzystano urządzenia HC-SG520, które umożliwiały rejestrowanie obrazu po wybudzeniu czujnika piroelektrycznego i monitorowanie ruchu również po zmroku zw względu na wykorzystywanie oświetlania za pomocą diod IR. Kamery rejestrowały 30 sekundowe materiały video i zapisywały je na kartach SD, które wraz z bateriami wymieniane były co 21 dni. Kamery HC-SG520 zostały wybrane po przeprowadzeniu testów wykorzystujących 2 inne tego typu urządzenia. Skuteczność zastosowanego sprzętu wyniosła ponad 82%, urządzenia zarejestrowały zaledwie 17% filmów pustych, na których nie można było zauważyć migrującej zwierzyny. W wyniku monitoringu zwierząt zauważono, że z przejścia korzystają przeważnie dziki oraz sarny i jelenie. Ze względu na bliskość zabudowy mieszkaniowej – przejście jest intensywnie wykorzystywane zarówno przez ludzi jak i przez zwierzęta domowe – co może mieć wpływ na funkcjonalność ekoduktu i ograniczać swobodę migracji. Większość migracji (78%) odbywa się w ciągu nocy. Zaobserwowane wzorce zachowania zwierzyny leśnej mogą być wykorzystane do szeroko pojętej tematyki zabezpieczania dróg przed wtargnięciem zwierzyny jak i służyć jako materiały edukacyjne dla kierowców.

Słowa kluczowe:
fotopułapki, monitoring środowiska, przejścia dla zwierząt