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METHODOLOGICAL REQUIREMENTS FOR IDENTIFYING LODGES COLONIZED BY EUROPEAN BEAVERS *CASTOR FIBER* L. WITH THE USE OF THERMAL IMAGING TECHNOLOGY – PRELIMINARY RESULTS

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Key words: European beaver, *Castor fiber*, thermography, beaver lodges, monitoring.

Abstract

The presence of colonized beaver lodges in a given area may be difficult to confirm during European beaver population surveys. The existing inventory methods do not provide unquestionable results. To avoid survey errors in the future, this study was undertaken to determine whether thermal imaging could be used to confirm the presence of beaver settlements in the analyzed area. The number of beaver colonies estimated using a traditional method that involves the identification of beaver tracks and a method based on an analysis of infrared measurements was different. It was found that thermography could be a useful tool for determining the presence of active beaver colonies, but its effectiveness is dependent upon a number of methodological considerations.

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METODOLOGICZNE UWARUNKOWANIA WYKORZYSTANIA TERMOWIZJI DO OKREŚLANIA ZASIEDLENIA STANOWISK PRZEZ BOBRA EUROPEJSKIEGO *CASTOR FIBER* L. – WYNIKI WSTĘPNE

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Słowa kluczowe: bóbr europejski, *Castor fiber*, termowizja, stanowiska bobrowe, monitoring.

Abstrakt

Potwierdzenie występowania rodzin bobrowych na danym stanowisku nie jest jednoznaczne, mimo wielu wskazujących na to oznak terenowych. Wyniki dotychczasowych metod inwentaryzacji mogą być zatem obarczone błędem. Podjęto badania, które pomogą uwiarygodnić efekty prac terenowych, mające na celu określenie możliwości wykorzystania termowizji do potwierdzenia zasiedlenia obszaru przez bobra europejskiego.

W eksperymencie stwierdzono, że liczba czynnych stanowisk bobrowych określona metodą tradycyjną, bazującą na oznakach bytowania zwierząt oraz w oparciu o analizę termogramów, była różna. Dowiedziono, że termowizja może być metodą wykorzystaną do określania czynnych stanowisk bobrowych, jednak jej skuteczność jest uzależniona od licznych uwarunkowań metodologicznych określonych podczas prowadzonych badań.

Introduction

Thermal imaging technology has numerous applications in industry, construction, rescue work, police and medicine (*Infrared thermography*… 2012, McCafferty 2007). It is used in veterinary to diagnose inflammations and diseases affecting locomotive and internal organs (Knizkova et al. 2007), and to determine the insulation values of animal fur coats (Cilulko et al. 2013). Thermographic cameras have also been used to analyze heat energy radiation from different body parts in mammals (Kuhn and Meyer 2009, Lancaster et al. 1997) and birds (McCafferty et al. 1998).

Thermal imaging is a modern research tool for collecting data about the nocturnal activity or presence of animals in selected habitats (Belant and Seamans 2000, Christiansen et al. 2014, Ditchkoff et al. 2005, McCafferty 2007). The European beaver is an important species promoting biodiversity (Janiszewski et al. 2014). The secluded lifestyle of

Castor fiber is a frequent cause of errors in beaver population surveys. A beaver family can control more than one site on its territory, and those sites can be separated by considerable distance. Not all parts of the controlled territory are utilized equally by beavers (ŻUROWSKI 1992, WHEATLEY 1997, JANISZEWSKI and HANZAL 2015). The very presence of a beaver family in a given territory can create numerous problems during population surveys. The existing survey methods did not guarantee that the evaluated territory was inhabited by beavers at the time of the inspection. In numerous cases, abandoned lodges, burrows and dens were mistakenly classified as active sites (WHEATLEY 1997).

To avoid survey errors in the future, this study set out to evaluate the applicability of the thermal imaging technology in confirming habitat colonization by the European beaver.

Materials and Methods

The study was conducted in the Wigry National Park in north-eastern Poland. The park has one of the oldest populations of the European beaver in Poland which dates back to the mid 20th century (ŻUROWSKI and KASPERCZYK 1986). The study was divided into three stages:

– stage I: traditional field survey of beaver sites,

– stage II: measurements performed with a thermographic camera to confirm the colonization status of sites identified in stage I,

– stage III: analysis of thermograms to identify lodges that are and are not inhabited by beavers.

Stage I. The information collected during a survey of beaver sites, conducted by the task forces of the Wigry National Park, constituted baseline data. The entire park area was surveyed. A territory colonized by one beaver family was classified as a family site. Active beaver sites were identified based on the presence of:

– winter food stores,

– lodge, burrows and dens,

– diversion dams raising the water table,

– incisions in trees, and shrubs, and scent mounds.

The GPS coordinates of the evaluated sites were marked on a map.

Stage II. The presence of beavers in the sites identified in stage I was confirmed with the use of a thermographic camera. The ThermoPro TP8 thermographic camera with an uncooled microbolometer array with 384 × 288 pixels was used. The camera had a thermal sensitivity of 0.08°C to 30°C and temperature range of -20°C to +800°C (down to -40°C and up to

2000°C, optional). The camera had a built-in digital video sensor with a resolution of 1280 × 1024 pixels, a wide-angle 16 mm lens and a 100 mm lens. It featured a touch-screen external display with a resolution of 640 × 480 pixels, which was used to observe changes in the temperature of the analyzed surfaces. Measurements were performed with an accuracy of 1% of the reading.

The temperature on the surface of beaver lodges, burrows and dens classified as inhabited in stage I was measured with the use of the thermographic camera. Thermographic measurements were performed on the day following the completion of stage I to minimize the risk of beavers abandoning the examined sites.

The exact hour of the thermographic measurement and weather conditions were recorded during the survey conducted in stage II of the study:

– air temperature [°C],
– insolation [presence or absence],
– precipitation [presence or absence],
– snow cover [presence or absence],
– wind [m s^{-1}].

Stage III. Thermograms were analyzed in the Guide IR Analyzer (v. 2010-04-05) program. The maximum and minimum temperature values [°C] in the acquired images were normalized (palette bar). The average temperature across the entire lodge surface was determined. Depending on the shape of the lodge, measurements were performed with the use of elliptical and circular shapes (Figure 1). Maximum and minimum temperatures were marked in every thermogram. Differences in temperature in each evaluated site were interpreted.

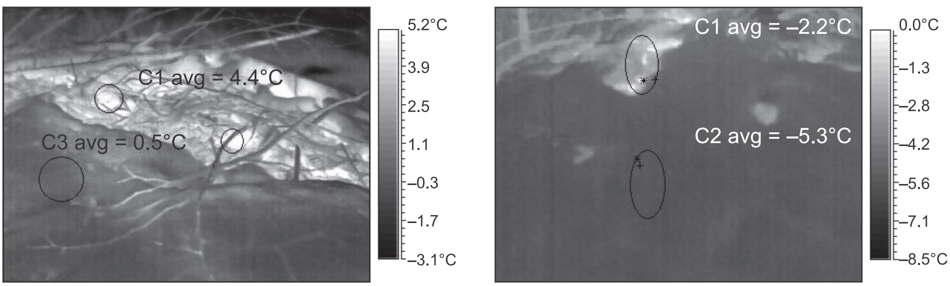

Fig. 1. Thermograms with temperature distribution across the surface of the analyzed lodges which confirm the presence of beavers

Stage III operations were performed by a person who did not participate in stages I or II to eliminate bias in computer analyses of the obtained thermograms.

The study was conducted between 15 November 2014 and 15 February 2015. Beginning and end dates were determined based on previous surveys of active European beaver sites and the relevant research guidelines (JANISZEWSKI et al. 2007, JANISZEWSKI and MISIUKIEWICZ 2012).

Results and Discussion

Stage I

A total of 123 signs testifying to the presence of the European beaver in the examined territory were found during a traditional field survey. They included inhabited and abandoned lodges, burrows and dens, as well as the presence of diversion dams raising the water level. The information acquired during stage I was used to select 40 beaver sites for thermographic analysis. Thermographic data revealed that 11 of the selected sites were not inhabited by *Castor fiber* during the study (Table 1).

Table 1

Number of sites classified as inhabited and uninhabited by beavers during each stage of the study

Stage	I		II		III	
Evaluation	inhabited	uninhabited	inhabited	uninhabited	inhabited	uninhabited
Number of sites	29	11	22	18	34	6

The field survey of beaver sites used in stage I of this study had been previously successfully applied by researchers in other regions of Poland. JANISZEWSKI et al. (2007) determined the presence of 1019 active beaver sites in the Province of Mazowsze (Central Poland) based on 4889 beaver tracks identified in the analyzed area. Thus, it can be assumed that the method is effective and provides relatively reliable results.

Stage II

The results of stage II revealed that the thermographic camera was most effective in measuring the temperature on the surface of beaver lodges. The attempts to determine the presence of beavers inside burrows and dens were ineffective or did not produce conclusive data. The above could be attributed to the structure of burrows and dens, most of which have entrances under water, therefore, their interior temperature cannot be directly determined with a thermographic camera. The layer of soil above lodge corridors also made it impossible to measure temperature differences. For this reason, thermographic measurements were performed only in lodges in successive analyses.

In stage II, detailed measurements were performed in 40 beaver lodges. The average temperature on the surface of lodges classified as inhabited in stage I was around 3.0–3.5°C higher than ambient temperature (Figure 1). An analysis of thermograms revealed that 18 of the 40 analyzed lodges did not bear any signs indicative of beavers (Table 1).

An analysis of weather conditions during the study demonstrated that thermographic measurements were most effective on overcast winter days when lodges were covered with snow. The most reliable thermographic readouts were produced when ambient temperature was below -5°C. The accuracy with which the presence of beavers was determined inside lodges increased with a drop in ambient temperature due to higher thermal contrast. On cloudless days when the surface of lodges was heated by sunlight, snow-covered ground was characterized by smaller differences in surface temperature. Sun rays heated dark-colored elements of lodge structures, such as tree branches, which led to errors in thermographic readouts and data interpretation problems. These observations indicate that measurements performed on sunny days could falsely imply the presence of beavers in all analyzed lodges, including abandoned structures.

Thermographic data collected on days when wind speed exceeded 4 m s^{-1} and on snowy days were also difficult to interpret. Wind and snow cooled the surveyed surfaces, which produced confusing results. Freshly fallen wet snow which filled crevices in beaver structures and blocked ventilation shafts in lodges was the greatest source of interpretation errors. In these situations, clear temperature stratification was not observed in thermograms, which led to the possibly mistaken conclusion that the analyzed lodges were not inhabited by beavers.

The observations performed in one of the analyzed sites delivered particularly interesting results. Winter food reserves had been accumulated by beavers near the examined lodge approximately three months before the beginning of the study, which suggested the site was colonized. On 21 January 2015, an adult beaver was spotted swimming in the vicinity of the site, and it hid inside the structure. Thermographic measurements on the surface of the lodge were performed immediately after the observation. Measurements were conducted in the morning (9 a.m.), on a snowy and windy day (8 m s^{-1}) with an ambient temperature of around 0°C. The animal had been spotted entering the lodge, but the heat emitted by the beaver was not registered by the camera. The lodge was examined repeatedly on 5 February 2015 at around 8 a.m., on a windless (2 m s^{-1}) and clear day with ambient temperature of -3°C. Fresh and clear signs of beavers were found in the site, but the presence of animals was not registered by the thermographic camera. The lodge was examined again at 1 p.m. on the same day, and this time, the thermographic readout confirmed the presence of beavers inside the lodge. These results suggest that thermographic measurements are most effective when conducted in the afternoon, probably because beavers are nocturnal animals that forage for food during the night. Beavers return to lodges in early morning hours when temperature inside the structure is low. Interior temperature rises as beavers remain in the lodge, but this process is relatively slow. For this reason, measurements performed in early morning hours were not reliable because beavers needed more time to generate sufficient amounts of heat and rise the temperature inside the lodge.

Situations like those encountered in this study considerably influence the effectiveness of thermographic cameras, the reliability of thermographic readings in detecting the presence of animals, and measurements of temperature distribution across the analyzed surfaces. To account for these drawbacks, the surveys in this study were performed on overcast days, in the afternoon, when the analyzed surfaces were covered by snow. These conditions contributed to clear thermal contrast between the tested surfaces, and they supported accurate measurements.

A negative impact of solar radiation on thermography's accuracy during field surveys of wild animal populations has also been described by other authors (BOONSTRA et al. 1994, GARNER et al. 1995, DITCHKOFF et al. 2005, BUTLER et al. 2006, MCCAFFERTY 2007, HILSBERG-MERZ 2008). Both our findings and the results reported by other researchers show that solar irradiance is the most important potential source of error in thermal imaging, which should be taken into account in field research.

Stage III

The thermograms obtained in stage II were analyzed with the use of a computer program. The results demonstrated that the presence of high thermal contrast is required to confirm the presence of beavers inside lodges. Data were processed in the Guide IrAnalyzer to reveal that 6 of the 40 lodges examined in stage II were not inhabited by beavers. The presence of beavers was confirmed in the remaining 34 lodges (Table 1).

Due to certain behavioral and environmental factors, it may be difficult to use technical devices for monitoring the distribution and activity of beaver families and individual animals (THOMSEN et al. 2007). The most widely used and recommended method for monitoring the daily and annual activity patterns of beavers is wildlife radio telemetry (LANCIA et al. 1979, ARJO et al. 2008). JOHN and KOSTKAN (2009) used the Global Positioning System and the Geographic Information System for mapping environmental diversity and beaver activity. All of the described methods support effective monitoring of beaver populations, but they also have certain limitations. BLOOMQUIST and NIELSEN (2009) relied on a remote videography system to characterize the behavior patterns of beavers inside lodges and bank dens. According to the cited authors, the main disadvantage of the applied method was that they could not monitor entire beaver colonies because only animals passing through the field of view were recorded.

Conclusions

The results obtained in each stage of the study revealed differences in the number of sites that were correctly identified as active beaver sites based on the characteristic signs and thermographic measurements. In the total number of 40 analyzed lodges, 11 were classified as uninhabited in stage I and 18 in stage II. The thermograms analyzed in stage III revealed that only 6 of the 40 tested sites were not colonized by beavers (Table 1). The highest number of lodges classified as uninhabited was determined in stage II, and the lowest number – in stage III.

The classification of beaver lodges as inhabited or uninhabited in stage III was consistent with the results obtained in stages I and II of the study, and it confirmed beyond doubt that 6 lodges were not colonized. A comparison of the results noted in stage I and stage II indicates that only one beaver site was differently classified. The remaining stage I data were partially consistent with stage II findings, which suggests that 4 more lodges were not inhabited by beavers. An analysis of pooled results from stages III and I indicates with full certainty that 10 of the 40 examined lodges were not colonized by beavers.

The effectiveness of thermographic measurements in surveys of active beaver sites is largely determined by the applied research method and the researchers' ability to correctly interpret the results. The use of thermographic cameras can be fraught with problems due to the limitations posed by variable weather conditions and the hour of measurement. For this reason, thermographic cameras do not appear to be highly useful in beaver surveys. However, they can be used in individual cases to confirm the presence of animals in the analyzed sites.

Thermal imaging has not been widely used for field surveys of beaver colonies to date. Therefore, our findings can provide a basis for further research into beaver populations.

The results of this study support the formulation of the following methodological recommendations for surveying active beaver sites with the use of thermal imaging technology:

1. Thermographic measurements should not be performed under the following weather conditions:

– absence of snow cover,
– sunny days,
– falling snow,
– ambient temperature above -2°C,
– wind speed higher than 4 m s^{-1}.

2. Thermographic measurements produce the most reliable results when performed under the following conditions:

– ambient temperature below -5°C,
– beaver lodges are completely covered with snow,
– measurements are performed not earlier than two days after the last snow fall,
– fully overcast skies,
– measurements are conducted in the afternoon,
– windless weather.

Our findings indicate that thermographic cameras can be used as an auxiliary tool during traditional surveys of active beaver sites, but they should not constitute the only method of measurement during such surveys.

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