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Review Article

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MONITORING PROPOSITION OF THE EUROPEAN BADGER (*MELES MELES*)

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Abstract. The paper presents proposed methods for monitoring the European badger in Poland. In addition to the characteristics of the species, habitat requirements, threats and conservation perspectives are discussed. Based on literature data, indicators were developed to provide reliable information on population size and habitat condition. Furthermore, an example of a completed observation card and the resulting assessment is provided. Data collected in the recommended manner may help to learn about the current situation of badgers in Poland and thus contribute to the implementation of appropriate measures for their protection.

Key words: European badger (*Meles meles*), habitat quality, population abundance, badgers' occurrence, species monitoring.

INTRODUCTION

To date, the European badger has not been fully inventoried in Poland. There are also no estimates at the national level to assess the population size and observe population growth trends (Borowski 2001). Despite this, the species is considered to be common in all regions of the country and does not require additional protection (Pucek 1984). The inventories carried out were only of a local scale and their results date back several decades (Goszczyński and Skoczyńska 1996; Jędrzejewska and Jędrzejewski 1998; Goszczyński 1999; Kowalczyk et al. 2000). For this reason, no monitoring manual dedicated to badgers has been published either. Unfortunately, when comparing data collected in Poland to European data, badger density appears to be alarmingly low (Pelikan and Vackar 1978; Rodriguez et al. 1996). The following work has been developed with the aim of identifying easy-to-apply observation methods, the results of which will provide valuable information on the species. The measures listed are based on knowledge drawn from the literature and adapted to the capabilities of the average observer. Factors favouring the badgers' presence were taken into account, detailing their most important needs. Criteria such as dietary components, preferred substrate or vegetation in the immediate vicinity of active sites were therefore set. Carrying out this type of survey will provide a better understanding of the nature of badgers and perhaps lead to changes in their current perception as a non-threatened species.

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SPECIES INFORMATION

Systematic affiliation
Order: *Carnivora*.
Family: *Mustelidae*.

Legal status and threat to the species
International law.
Bern convention.

National law for Poland
Species protection – not included.

IUCN Threat Category
IUCN Red List – LC

Polish Red Book of Animals. Vertebrates – not included
Red List of Threatened and Endangered Animals in Poland – not included

Species description
The European badger (Meles meles) is a predator of the Mustelidae family. Due to its lifestyle, its body is strongly built and stocky, which makes it much easier to navigate underground corridors. The small and flattened head is a contrast to the wedge-shaped body (its shape is cylindrical and widening towards the back). Perched on a short and massive neck, there is no clear separation between it and the rest of the torso. The muzzle is muscular and flexible, ending in a black nose, around which the skin takes on a characteristic supple form – Kurek and Piechnik (2017) describe it as similar to rubber. Its role is to protect the dirt-sensitive nostrils, and the aforementioned property allows badgers to deflect it from the upper jaw. This is of particular importance when foraging and digging the ground. The eyes, on the other hand, are small and deeply set, and the ears are short, rounded and with a prominent white tip, attached to the skull. This positioning represents another adaptation to an underground lifestyle. The short limbs are characterised by considerable musculature, giving them adequate strength for later use in digging burrows and tunnels. For this reason, the front paws are wider and provided with longer claws, while the hind paws remain relatively narrow. The claws themselves, on the contrary, are strong and blunt-tipped, and the badger has no way of retracting them (Kurek and Piechnik 2017). They are therefore systematically shortened during den scrambling and during movement. The claws of the hind limbs wear down as the animal ages, allowing older individuals to be easily identified (Neal 1958). Because badgers are footed animals (or, according to some sources, semidigitigrade) (Polly and MacLeod 2008), their feet and forelegs must be suitably constructed to take up the entire weight of the body when walking (Raichev 2010). The standard badger movement sequence assumes that the wrist and heel are not in contact with the ground (an exception to this rule occurs, of course, on soft and miry ground). If you look at the soles of the paws, you will notice the five fingertips, the interdigital pad, as well as the wrist or heel pad, depending on which limbs are considered (distinguishing between fore and hind limbs). The tail of badgers is unusually short in relation to the rest of the body, as its length ranges between 7.5 and 13 cm – this represents approximately 20% of the animal's total length (Kurek and Piechnik 2017). In contrast, the reports of Sumiński et al. (1993) indicate more detailed, but at the same time quite different measures: tail length was determined in the range 12.5–17 cm; hind limb length 7.5–13 cm; ear length 3.5–7 cm. All these data may vary depending on: the latitude

in which the study is conducted, the season, and the sex of the individuals analysed (Kurek and Piechnik 2017). In doing so, males are slightly larger than females, but this relationship is not proportional to body weight – even with small differences in height, they can be noticeably heavier. Weight gain is seasonal and dependent on the time of year. The largest gains are observed in autumn, just before the winter sleep phase – badgers weigh about 15–17 kg then. In summer, this value drops to 8–13 kg (Sumiński 1989; Szyjka et al. 2014).

Correctly identifying the sex of badgers based on their external appearance is not easy. Although they do not show clear sexual dimorphism, several differentiating characteristics can be observed. Males usually have broader and shorter heads with full cheeks and thicker necks, a larger trunk circumference (Sumiński 1989) and a rather slender tail, taking on a lighter colour on the top than in females. In addition, their skull is slightly more convex and the tip of the snout is rather dull (Szyjka et al. 2014). Both sexes have three pairs of nipples, but in females these are more developed (Harris and Yalden 2008). The colouration of badgers is dominated by a light silver tone, which can be seen all over the trunk and on the tail. The sides of the body, on the other hand, show straw-coloured highlights, the density of which can vary from individual to individual. For this reason, their coat can range in colour combinations from silvery-grey to greyish-yellow (Abramov 2003). There are two black bands running along the head, starting in the middle of the muzzle and curving towards the lower lip. These pass higher up through the eyes and the bases of the ears, and continue along the neck ending only at the nape of the neck. A distinctive broad white band extends from the tip of the nose and runs across the forehead and crown of the head. The same markings are also visible on the lower parts of the head and on the sides of the head from where they run backwards for much of the length of the neck (Neal 1958). On the ears the coat turns black, except for their tips, which remain white. The lower part of the neck, chest and legs are black. The belly, on the other hand, has a lighter brown tinge and the groin area is brownish-grey. The bare skin often shines through here as well, due to the significant thinning of hair on the underside of badgers' bodies (Neal and Cheeseman 1996). In general, southern European badgers are slightly lighter in colouration than badgers from continental and northern populations (Abramov 2003).

Species biology

The range of European badgers covers most of Europe – however, they do not occur in Iceland, the Faroe Islands, Shetland, the Hebrides, Orkney (Griffiths and Thomas 1997), nor within the Arctic Circle and therefore in northern Scandinavia and Russia. The boundary separating European and Asian badger populations runs along the Volga River, while European and Caucasian badgers are not clearly separated (Piza Roca et al. 2014). The boundary between their ranges is assumed to be in the North Caucasus, although in some places their territories overlap, potentially leading to hybridisation of the two subspecies (they are compatible with each other) (Abramov and Puzachenko 2007). Badgers can be found in deciduous and mixed forests, as well as in clearings, pastures, tree rows and various types of thickets and hedgerows (Zejda and Nesvadbová 1983). In addition, they have adapted to suburban and urban conditions, where they inhabit, for example, parks (Piza Roca et al. 2014). In Poland, however, such cases are extremely rare, as badgers lead a secretive lifestyle and by nature shy away from human contact. There are only a few cases of badgers establishing burrows in open areas (Nadolska and Bartmańska 2003). In settled areas, badgers use several types of shelter to meet their basic behavioural needs. The first of these is, of course, burrows, which serve a variety of functions depending on the badgers' preferences. Four types of burrows are distinguished in this respect:

1. Main burrows: they have an elaborate system of corridors and several entrance holes; they serve as a winter hide and as a rearing area for young.

2. Accompanying burrows: a complex of individual burrows some 50 to 150 m away from the main burrows, accessed by paths trampled on the surface; they serve a similar function to the main burrows.
3. Auxiliary: rarely used, remaining at some distance from the main burrows, not connected by paths; used when the main site is abandoned.
4. Side burrows: poorly developed (with one or two entrances), used only for short stays.

However, the presented classification may not be practical for monitoring a site that is not well explored. For convenience, therefore, a simplified classification may be used, taking into account only primary burrows and secondary burrows. Observation of daily badger activity will then make it possible to determine which burrows are used permanently and which only serve as backup shelters (Kowalczyk et al. 2004). Note that burrows will be more numerous the larger the area is annexed by badgers (Revilla et al. 2001). Other types of hiding places (dense vegetation or the hollows of decayed trees) are more of an ad hoc solution, used for example when returning from night-time foraging. In addition to the above, a characteristic activity of badgers is digging latrines – these are always located outside their burrows.

The number of individuals arriving in the same territory depends largely on its area and the availability of food (Kruuk 1978). Badgers form stable groups of varying ages and sexes whose members share a territory and occupy a common burrow. Woodroffe and MacDonald (1993) report that the size of a single group remains between 2 and 25 individuals. Despite this, badgers are not willing to share an area with unfamiliar individuals during the breeding season. More competition is shown in this respect by males, which may duel with each other in order to take over territory (Gallagher and Clifton-Hadley 2005). In other circumstances, representatives of each group show a high degree of tolerance between each other (Kowalczyk et al. 2003; Revilla 2003). Given the lifestyle of badgers, grouping does not seem to have an obvious justification. As they are nocturnal and forage alone – a theory where they would need the support of other predators to forage would not work. As earthworms are the main component of the badger diet, it is likely that the social structure model chosen by the badgers is conducive to the formation of specific cooperation – individuals residing in areas with fewer earthworms can use the hiding places and resources of areas richer in food without conflict (Kruuk 1989). Badgers start their activity at dusk and only finish in the morning, before sunrise. In summer, when the nights are considerably shorter, such a situation would not be possible, so badgers also remain active during the day. They then leave for foraging before sunset and only return after sunrise (Sidorchuk et al. 2014). The foraging base consists of earthworms – larger species are preferred, e.g. Lumbricus terrestris or earthworms of the genus *Dendrobaena* spp. (Goszczyński et al. 2000), insect larvae and pupae, amphibians and reptiles, dead birds and bird eggs, smaller rodents, and plant material (including fruit and seeds) (Kurek and Piechnik 2017). When taking food of animal origin, they leave easily visible digging and rutting marks on the substrate (Pigozzi 1989).

Distribution of the species in Poland

In Poland, this predator is a common species and occurs throughout the country (Pucek 1984). So far, no detailed studies have been carried out on this issue, so it is difficult to assess badger dispersal, but several regional studies present data on their density in selected areas (Borowski 2001). The highest abundance was found in the Suwałki Landscape Park, where it was 5.9 individuals per 10 km^2 (Goszczyński 1999). The second most abundant area is central Poland (the study was conducted near Rogów), where the density was 3.1 individuals per 10 km^2 (Goszczyński and Skoczyńska 1996). The fewest badgers were recorded in Puszcza Białowieska, where the density ranged from 1.3 to 1.6 individuals per 10 km^2 (Jędrzejewska and Jędrzejewski 1998; Kowalczyk et al. 2000). Comparing these results to European-wide

observations (where the average density of individuals per 10 km^2 ranged from 3 to 9.8) (Pelikan and Vackar 1978; Rodriguez et al. 1996), it can be concluded that there are relatively few badgers in Poland.

MATERIAL AND METHODS

Monitoring concept

To date, the European badger has not been subject to regular monitoring in Poland, so there is a lack of up-to-date information on its numbers and the condition of the entire population. The collected data refer only to single locations, which, when translated on a larger scale, may prove inadequate. Given the level of understanding of this species in terms of morphology and behaviour, an observation methodology can be developed that is fairly simple to apply and also does not involve prohibitive costs. The following study contains suggested actions which may raise awareness of badger activity, thus contributing to the knowledge of their population density in Poland. The protocols drawn up may prove helpful in documenting badger numbers on a nationwide level.

Indicators and evaluation of the conservation status of the species

Population status indicators

The following methodology is based on the monitoring manual for the European otter (Lutra lutra), authored by Jerzy Romanowski, Tomasz Zając and Katarzyna Kozyra (Romanowski et al. 2015). To determine the status of the national badger population, 4 indicators were provided (Table 1 and 2), three of which: "proportion of positive finds of the species", "population index" and "annual population growth rate" should be considered mandatory. "Proportion of positive finds of a species" is not authoritative for estimating the abundance of individuals, as it only gives a general idea of the distribution of active sites. Only by supplementing with the indicator "population index" the desired result can be achieved. On the basis of this information, the species can be classified as abundant, sparse or rare. An annual population growth rate is used to observe changes in badger numbers in subsequent years (not used in the first year of monitoring). "Population density" is only relevant from the point of view of regional monitoring, e.g. as supporting material for the layout of conservation plans for national parks.

Table 1. Population status indicators

Indicator	Measure	Measurement/determination method
Proportion of positive finds of the species	%	Percentage of monitoring points where the species was recorded, calculated according to the formula: number of positive detections/ number of all monitoring points at the site * 100
Population index	%	Index calculated according to the formula: $I = p/10 + 10\ [\log(x + 1)]$, where: p – percentage of positive monitoring points, x – average number of faeces per positive monitoring point
Annual population growth rate	numerical value	Index calculated according to the formula: $r = (\ln I_t - \ln I_o)/t$, where: r – annual population growth rate, I_t – population index obtained in the current monitoring period, I_o – population index obtained in the year preceding the current monitoring or from the period when the surveys started, t – number of years between I_t and I_o
Population density	N/10 km^2	Abundance per 10 km^2 of study area determined by field surveys (based on tracks found and evidence of activity and habitation)

Table 2. Valorisation of population status indicators

Indicator	Evaluation		
	FV	U1	U2
Proportion of positive finds of the species	>60	40–60	<40
Population index	>15%	10–15	<10
Annual population growth rate	r ≥ 0	$-2 \leq r < 0$	$r < -2$
Population density	≥2/10 km^2	0.6–1,9/10 km^2	<0.6/10 km^2

FV – favourable status, U1 – unsatisfactory status, U2 – bad status.

Cardinal indicators

Not distinguished.

Habitat status indicators

The following indicators have been selected to best meet the environmental requirements of badgers, while remaining outside the influence of human pressures. Key issues here are the availability of food (particularly earthworms, which are a major component of the badgers' diet) and the desired vegetation pattern. The immediate vicinity of the site should also respond to the badgers' primary need to use shelter (Table 3 and 4).

Table 3. Habitat status indicators

Indicator	Measure	Measurement/determination method
Food base	numerical value	Value determined on the basis of sub-indices defining abundance and type of foraging base
Preferred vegetation	numerical value	Value determined on the basis of sub-indices giving the frequency of preferred plant formations and their species composition
Substrate type	numerical value	Value determined by the percentage of monitoring points where the substrate provided the opportunity to dig burrows and offered easy access to the foraging base
Level of anthropopression	numerical value	Value determined on the basis of distance from national and provincial roads, railways and buildings

Table 4. Valorisation of habitat status indicators

Indicator	Evaluation		
	FV	U1	U2
Food base	>0.80	0.50–0.80	<0.50
Preferred vegetation	>0.65	0.40–0.65	<0.40
Substrate type	>50% of the substrate is soil that provides burrowing and foraging opportunities	10–50% of the substrate is made up of soils that provide burrowing and foraging opportunities	<10% of the substrate is made up of soils that provide burrowing and foraging opportunities
Level of anthropopression	>0.70	0.50–0.70	<0.50

FV – favourable status, U1 – unsatisfactory status, U2 – bad status.

Cardinal indicators

Not distinguished

Population assessment

All indicators are equivalent and only the lowest score awarded is taken into account for the final assessment.

Habitat status assessment
As with the population assessment, all indicators are equivalent and only the lowest score awarded is taken into account for the final assessment.

Conservation perspectives
The conservation outlook for a species consists of the predicted variation in population and habitat status, which affect the conservation prospects for the species over the next 10 to 15 years. In order to maintain a promising outlook, it is important to properly identify potential threats. In the case of badgers, these will include disease, environmental degradation, road accidents and poaching.

If a rating FV is given for both parameters (i.e. habitat and population), the outlook can be considered favourable. If the grades awarded are different the lower grade is adopted. The exception to the rule will be the occurrence of fortuitous factors that we can anticipate to be eliminated in the near future – the outlook rating may then be raised. When predicting possible changes in population status, special attention should be paid to the annual population trend index, which is the most authoritative conversion factor here.

Overall assessment
Ratings from all parameters (population, habitat and conservation perspectives) are taken into account and an overall rating is given, according to the lowest parameter rating.

Description of the monitoring research
Selection of monitoring plots and their suggested size
A monitoring site should be established in a location where environmental conditions are favourable for badgers. Forests and areas of dense vegetation are therefore the best choice. The site should be large enough for a maximum of 200–600 m radius of monitoring points. There should be no or minimal overlap between the ranges of the individual points. The recommended area for surveys is at least 25 km^2.

Method of taking research
Determination of population status indicators
Proportion of positive findings of the species: record all traces of badger activity at the selected site and divide by the number of monitoring points established in the study area. To obtain a percentage, the result should still be multiplied by 100.

Elements indicating the presence of badgers in a given area include: tracks, signs of foraging (they form characteristic holes several centimetres deep), burrows, latrines, faeces.

Population index: In order to make the relevant calculations, it will be necessary to find sites where badgers leave faeces (these are latrines and territory boundaries). The average number of faeces per positive monitoring point should be used in the given formula:

$$I = p/10 + 10\,[\log(x + 1)]$$

where:
p – percentage of positive monitoring points,
x – average number of faeces per positive monitoring point.

Annual population growth rate: calculated from the second year of monitoring. Provides an overview of potential changes in the population, with positive values indicating positive predictions and an increase in badger numbers, and negative values indicating a decrease in badger numbers and a reduction in density. The following formula is used to calculate it:

$$r = (\ln I_t - \ln I_o)/t$$

where:
r – annual population growth rate,
I_t – population index obtained during the current monitoring period,
I_o – population index obtained in the year prior to the current monitoring, or from the period when the study began,
T – number of years between I_t and I_o.

Population density: this method of determining badger abundance differs from the calculation of the population index and its annual trends in terms of the study area. The use of the 'population density' indicator works well for areas smaller than 25 km^2 where no monitoring points are designated. This method is based on recorded signs of badger activity, which provide a basis for estimating badger density. The use of photo-traps can be a great help here.

Determination of indicators of habitat status

The proposed methods were developed (and partly modified) based on the monitoring methods manuals for otter, beaver and *Astacus astacus* (Romanowski et al. 2015; Strużyński 2015; Zając et al. 2015.

Food base: in order to determine the value of the available food base, it is necessary to verify sub-indicators consisting of: biomass of invertebrates and small vertebrates, species diversity of invertebrates and small vertebrates, sites that favour invertebrates and small vertebrates. Biomass and species diversity are determined on the basis of self-identification or interviews with expert persons (e.g. foresters) and published data on the subject. Sites favourable for invertebrates and small vertebrates have a percentage character, which is defined by the proportion of such acreage in relation to the total area surveyed (Table 5 and 6).

Table 5. Food base – subindicators

Indicator	Measure	Measurement/determination method
Biomass of invertebrates and small vertebrates	g/m^2	Average biomass of invertebrates and small vertebrates converted per m^2
Species diversity of invertebrates and small vertebrates	N	Average abundance of species observed at a monitoring site
Sites favouring invertebrates and small vertebrates	%	Percentage of areas where invertebrates and small vertebrates are readily accessible (soft soils, above-ground bird nests, dense scrub)

Table 6. Food base – valorisation of subindicators

1.	Biomass of invertebrates and small vertebrates	Points
a)	>10 g/m^2	1
b)	8–10 g/m^2	0.5
c)	<8 g/m^2	0
2.	Species diversity of invertebrates and small vertebrates	
a)	>30	1
b)	15–20	0.5
c)	<15	0
3.	Sites favouring invertebrates and small vertebrates	
a)	>60%	1
b)	40–60%	0.5
c)	<40%	0

Preferred vegetation: consists of a percentage determination of the preferred vegetation formations and their species composition at each monitoring point. From the values obtained, an average is drawn, which constitutes the assessment of this indicator. To determine the above, the sub-indices must be determined (Table 7 and 8).

Table 7. Preferred vegetation – subindicators

Indicator	Measure	Measurement/determination method
Presence of preferred plant species	%	Percentage of monitoring points on site where preferred tree and shrub species were recorded (species of the genera *Quercus* spp. – oaks, *Carpinus* spp. – hornbeams, *Pinus* spp. – pines)
Proportion of preferred plants	%	For each monitoring point, assess the percentage of preferred tree and shrub species (*Quercus* spp. – oaks, *Carpinus* spp. – hornbeams, *Pinus* spp. – pines); the indicator value is the average percentage proportion of preferred species from all monitoring points
Proportion of areas covered with dense vegetation	%	For each monitoring point, assess how much of it is covered by trees and shrubs; the indicator value is the average of the values for each monitoring point

Table 8. Preferred vegetation – valorisation of subindicators

1.	Presence of preferred plant species	Points
a)	Preferred tree and shrub species present at more than 40% of monitoring points	1
b)	Preferred tree and shrub species present at 20–40% of monitoring points	0.5
c)	Preferred tree and shrub species present on less than 20% of monitoring points	0
2.	Proportion of preferred plants	
a)	Preferred tree and shrub species make up more than 50% of the total species on average	1
b)	Preferred tree and shrub species make up an average of 20–50% of all species	0.5
c)	Preferred tree and shrub species represent less than 20% of the total species on average	0
3.	Proportion of areas covered with dense vegetation	
a)	The contained vegetation covers on average more than 40% of the monitored area	1
b)	The contained vegetation covers on average 20–40% of the monitored area	0.5
c)	The contained vegetation covers on average less than 20% of the monitored area	0

Substrate type: in this section, attention should be paid to whether the substrate at the individual monitoring points was of suitable quality. The soils preferred by badgers are quite soft and moderately compact – these include, for example, clays or sandy substrates (but not dry and loose). Dusty and clayey soils that allow burrows to be dug and earthworms to be found are suitable. Once these factors have been characterised, the percentage for the whole site of monitoring points with suitable substrate should be calculated. Level of anthropopressure: this indicator identifies the extent to which badger habitat has been modified by human activity. It therefore takes into account three sub-indicators consisting of national and provincial roads, railways and the proximity of buildings (Table 9 and 10).

Table 9. Level of anthropopression – subindicators

Indicator	Measure	Measurement/determination method
National and provincial roads	%	Percentage of monitoring points in the vicinity of which (within the 200 m buffer zone) the presence of national and provincial roads was recorded
Railway lines	%	Percentage of monitoring points in the vicinity of which (within the 200 m buffer zone) the presence of active railway lines was recorded
Proximity to buildings	%	Percentage of monitoring points in the vicinity of which, at a maximum distance of 100 m, dense buildings were recorded

Table 10. Level of anthropopressure – valorisation of subindicators

1.	National and provincial roads	Points
a)	<20%	1
b)	20–30%	0.5
c)	>30%	0
2.	Railway lines	
a)	<10%	1
b)	10–20%	0.5
c)	>20%	0
3.	Proximity to buildings	
a)	<10%	1
b)	10–40%	0.5
c)	>40%	0

Date and frequency of testing

The best time to carry out observations is during the period of increased badger activity, which is in spring. Surveys carried out in conditions which allow tracks to be easily seen, thus in autumn and winter, will also be effective. It is recommended to repeat monitoring every 3 years.

Research equipment and materials:

– GPS receiver,
– topographical map (suggested scale 1:10 000 or 1:25 000),
– notebook and pencil,
– camera,
– pptional photo trap.

RESULTS AND DISCUSSION

Example of a completed species observation card at a site

Species observation card for the site	
Name of species	English and Latin names, author according to current nomenclature European badger *Meles meles* (Linnaeus, 1758)
Name of site	Name of monitored site Białowieża Forest
Type of site	Research/reference Research
Protected areas where the site is located	Natura 2000, nature sanctuaries, national and landscape parks, ecological sites, documentary sites, etc. Białowieża National Park
Geographical coordinates	Give the geographical coordinates (GPS) of the focal point of the site N XXº XX’ XX’ E XXº XX’ XX
Altitude above sea level	Specify the altitude of the site or the range from ... to ... meters 145–176,3

Species observation card for the site	
Site area	Indicate the size of the area in hectares, a or m^2 10 520 hectares
Description of site	Describe the location and character of the site, the manner of use The monitoring site comprises the area of the Białowieża National Park
Habitat characteristics of the species at the site	Describe the character of the habitats at the site The European badger's habitats are mainly burrows located within the Białowieża Forest. The area is entirely covered by mixed forest of known species composition (there are oaks and hornbeams preferred by badgers).
Species information on the site	Synthesised information on the occurrence of the species at the site, research to date and other relevant facts; results of surveys from previous years The presence of the European badger is recorded in the monitored section. Research conducted in 1998 by Jędrzejewska and Jędrzejewski showed that the density of individuals per 10 km^2 was 1.3–1.6 individuals. This was confirmed by Kowalczyk's observations in 2000.
Is monitoring in subsequent years required?	Write yes/no; in the case of 'no' justify Yes
Observer	Name and surname of monitoring contractor at the site Agata Borucka
Observation date	Date of all observations 7.05.2022, 1–3.07.2022

Conservation status of the species at the site			
Parameter/indicators	Indicator value and commentary	Evaluation	
Population			
Percentage of positive finds of the species	Percentage of monitoring points where the species was recorded 65.70%	FV	U1
Population index	Indicator calculated according to a formula based on the proportion of positive monitoring points and the average number of droppings per point 12.48%	U1	
Annual population trend index	Indicator calculated according to a formula based on the population index value at two consecutive monitoring stages Not analysed in the first year of monitoring	XX	
Population density	Abundance per 10 km^2 of study area Not analysed in national monitoring	XX	

Habitat					
Food base	biomass of invertebrates and small vertebrates	Average biomass of invertebrates and small vertebrates converted per m^2 11.30 g/m^2	Points 1	FV	FV
	species diversity of invertebrates and small vertebrates	Average abundance of species observed at a monitoring site 38	Points 1	FV	
	sites favouring invertebrates and small vertebrates	Percentage of monitoring points on site where the presence of preferred tree and shrub species was recorded 89%	Points 1	FV	
Preferred vegetation	presence of preferred plant species	Udział procentowy punktów monitoringowych na stanowisku, na których odnotowano obecność preferowanych gatunków drzew i krzewów 89%	Points 1	FV	
	proportion of preferred plants	Average percentage of preferred plants at monitoring points 77%	Points 1	FV	

Preferred vegetation	proportion of areas covered with dense vegetation	For each monitoring point, assess how much of it is covered by trees and shrubs; the indicator value is the average of the values for each monitoring point 60%	Points 1	FV	
Substrate type		Percentage of monitoring points where the substrate provided the opportunity to dig burrows and offered easy access to the foraging base 60%		FV	
Level of anthropopression	national and provincial roads	Percentage of monitoring points in the vicinity of which (within the 200 m buffer zone) the presence of national and provincial roads was recorded 3%	Points 1	FV	FV
	railway lines	Percentage of monitoring points in the vicinity of which (within the 200 m	Points 1	FV	
	proximity to buildings	Percentage of monitoring points in the vicinity of which, at a maximum distance of 100 m, dense buildings were recorded 5%	Points 1	FV	
Conservation perspectives		The conservation outlook for a species consists of the predicted variation in population and habitat status, which affect the conservation prospects for the species over the next 10 to 15 years. In order to maintain a promising outlook, it is important to properly identify potential threats. In the case of badgers, these will include disease, environmental degradation, road accidents and poaching. No factors were found to threaten the studied badger population		FV	
Overall assessment					U1

Despite the fact that badgers are not under protection, it is worth monitoring their numbers, particularly given the scant data available to date on the subject. A factor which further reinforces the need for this type of monitoring is the hunting harvest of badgers. Hunting in regions of low badger density may contribute to their total depletion. Data from 2007/2008 indicate that badger culling amounted to 3,500 individuals, which is more than ten times higher than in the early 1990s, when 340 individuals were shot (Kamieniarz and Panek 2008). In the following years, the harvest was even higher, as indicated by the hunting reporting data compilation of the PZŁ Research Station in Czempiń in the 2018/19 season – the badger cull was then 6,500 individuals. With such increases in values, it is advisable to control the badger population, with particular emphasis on observing its numbers. Furthermore, limiting the influence of hunters would effectively reduce the degree of anthropopression, which is a necessary step to carry out effective conservation of the species.

Among other factors posing a threat to badger populations are diseases, road accidents, poaching and habitat fragmentation. The negative effects of these factors can be remedied to a large extent, e.g. by increasing the distribution of rabies vaccines in forests and creating environmental islands between roads, which would provide a natural barrier for animals and help to keep them away from danger. In agricultural landscapes, it is also worth remembering to leave mid-field scrub where badgers can find shelter (Kurek and Piechnik 2017).

The optimal habitat for badgers is dense forest stands (deciduous and mixed forests, especially oak- and hornbeam-forests) and areas covered with dense shrubby vegetation, such as thickets or hedgerows (these are particularly important in agricultural and open landscapes as they act as mid-field shelter) (Zejda and Nesvadbová 1983; Piza Roca et al. 2014). Badgers also find their way quite well into pine forests (Kurek 2011). Another element conditioning the

selection of a site for colonisation is soil fertility, which translates into the availability of a food base. Suitable geological conditions favourably influence the diversity of the soil fauna, which is one of the most important components of a badger's diet (Dunwell and Killingley 1969). A preference towards more dusty soil and high loam content has also been shown – substrate with this texture is more readily chosen for burrow establishment, as it is more compact, which ensures the durability of extended corridors and cavities (Kurek et al. 2014). Loose sandy substrates are explicitly avoided in favour of soils of intermediate heaviness, such as, for example, some clays (Revilla et al. 2001). However, impervious clays and other very heavy soils should be excluded from this pledge (Dunwell and Killingley 1969).

The shape of the landscape and its relief is also important. The most favourable conditions are provided by escarpments and small hills, where badgers can establish burrows using the slope of the terrain (Zejda and Nesvadbová 1983). In the winter season, this is of additional importance, as they are more likely to choose south-facing slopes, where snow will last for less time. In mountainous areas, on the other hand, the presence of rock crevices and caves that can serve as refuges has a significant impact on the occurrence of badgers. Indeed, above 700 m above sea level, this is the only form of hiding places available to them (Mysłajek et al. 2012).

CONCLUSIONS

The current number of badgers in Poland is unknown, which makes it very difficult to take any measures conducive to maintaining the population in good condition. There are also no regular inspections of their habitats, so a substantive assessment is impossible. Despite this, the species is not excessively demanding, which gives reason to believe that possible reintroductions will not be problematic. Poland's landscape largely meets the requirements of badgers, but in the absence of recent data it is not possible to determine whether it is used by them.

The proposed monitoring methods are a potential solution to the problems listed above and can bring real benefits to wildlife in general. The inclusion of species protection or protection of areas where badger sites are located could prove to be an extremely important step towards improving environmental quality. Increasing biodiversity and renaturating areas that could potentially be annexed by badgers can result in a reduction in the degree of anthropopressure that also threatens other animals and plants. Thus, a sustainable nature management policy will also be strengthened.

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PROPOZYCJA MONITORINGU BORSUKA EUROPEJSKIEGO (*MELES MELES*)

Streszczenie. W pracy przedstawiono proponowane metody monitoringu borsuka europejskiego na terenie Polski. Poza charakterystyką gatunku zostały omówione wymagania siedliskowe, zagrożenia oraz perspektywy ochrony. Na podstawie danych literaturowych opracowano wskaźniki pozwalające uzyskać rzetelne informacje o liczebności populacji i stanie siedliska. Dodatkowo podano przykład wypełnionej karty obserwacji oraz wynikającą z niej ocenę. Dane zbierane w zalecany sposób mogą pomóc poznać aktualną sytuację borsuków w Polsce i tym samym przysłużyć się do wdrożenia odpowiednich środków ich ochrony.

Słowa kluczowe: borsuk europejski (*Meles meles*), jakość siedliska, liczebność populacji, występowanie borsuków, monitoring gatunkowy.