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Carnivores, even-toed ungulates, lagomorphs and large rodents in Polish national parks

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Using questionnaires completed by 284 national park field workers I evaluated the occurrence and population dynamics of large mammals from 1996 to 2005 in all 23 Polish national parks. A total of 29 species were found: 15 carnivores, 8 even-toed ungulates, 2 lagomorphs and 4 large rodents. The greatest population growth was seen in the beaver *Castor fiber*, the red fox *Vulpes vulpes*, and three non-native species (American mink *Mustela vison*, racccoon *Procyon lotor* and fallow deer *Dama dama*) while the greatest population decline occurred in two other non-native species (muskrat *Ondatra zibethicus* and mouflon *Ovis orientalis musimon*) and to a lesser degree in the native brown hare *Lepus europaeus*. The richest and most natural large mammalian fauna occurred in the Carpathian parks (Bieszczady NP, Magura NP, Tatra NP and Pieniny NP) as well as in the eastern part of the country (especially Białowieża NP and Biebrza NP), and the poorest was found in the Sudeten parks and in the west. There was a statistically significant correlation between mammal species richness and park size, longitude as well as the degree of disturbance in and around the park (negative correlation).

Introduction

A network of national parks in Poland was developed during the second half of the 20th century (Olaczek 1994). Currently there are 23 national parks having a total surface area of 3145.1 km^2, which is slightly more than 1% of the country's total surface area (Denisiuk 2004a, 2004b, Tworek *et al*. 2004). Mammals found in these parks have not been thoroughly researched. Monitoring and methodical ecological research on entire groups of large mammals have been carried out in only a few parks e.g. in Białowieża NP (Jędrzejewska *et al*. 1997, Jędrzejewska & Jędrzejewski 1998) and Magura NP (Jamrozy & Tomek 1997, 2003).

Information concerning various large mammals come primarily from Białowieża NP and include the European bison *Bison bonasus* (Krasińska *et al*. 2000, Rouys *et al*. 2001) as well as carnivores — the wolf *Canis lupus* (Musiani *et al*. 1998, Jędrzejewski *et al*. 2004), the Eurasian lynx *Lynx lynx* (Jędrzejewski *et al*. 2002), the badger *Meles meles* (Kowalczyk *et al*. 2000, 2004), and the pine marten *Martes martes* (Zalewski 2001). Limited research in other Polish national parks has been carried out on the wolf and the European bison in Bieszczady NP (Perzanowski & Paszkiewicz 2000, Śmietana 2005) and on chamois *Rupicapra rupicapra*

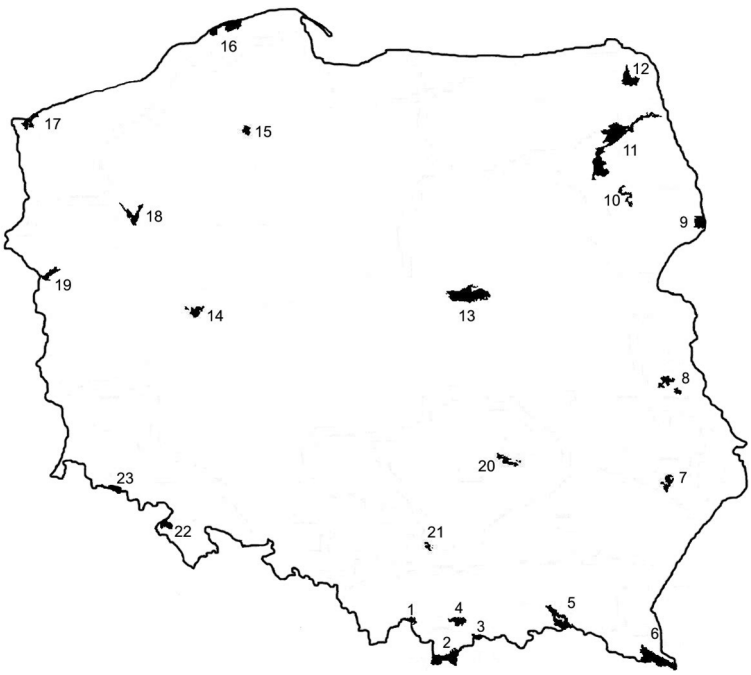

Fig. 1. Polish national parks. Carpathian parks: 1 = Babia Góra NP, 2 = Tatra NP, 3 = Pieniny NP, 4 = Gorce NP, 5 = Magura NP, 6 = Bieszczady NP; eastern parks: 7 = Roztocze NP, 8 = Polesie NP, 9 = Białowieża NP, 10 = Narew NP, 11 = Biebrza NP, 12 = Wigry NP; central-western parks: 13 = Kampinos NP, 14 = Wielkopolski NP, 15 = Bory Tucholskie NP, 16 = Słowiński NP, 17 = Wolin NP, 18 = Drawa NP, 19 = Warta Estuary NP; southern uplands parks: 20 = Świętokrzyski NP, 21 = Ojców NP; Sudeten parks: 22 = Góry Stołowe NP, 23 = Karkonosze NP.

tatrica in Tatra NP (Chovancova 2002, Jamrozy & Pęksa 2004). A general description of the mammalian fauna has been presented in natural science monographs of some parks — Tatra NP (Profus 1996), Babia Góra NP (Jamrozy 2003) and Magura NP (Jamrozy & Górecki 2003).

In this paper I evaluated the occurrence and population dynamics of carnivores, even-toed ungulates, lagomorphs and large rodents (red squirrel *Sciurus vulgaris* and larger) in all 23 Polish national parks. My evaluation was based on questionnaires completed by field workers in the individual parks.

Material and methods

Study area

Polish national parks (Fig. 1) represent various geographical regions and landscape categories. For this paper I divided them into five groups: (1) Carpathian parks, (2) eastern parks, (3) central-western parks, (4) southern uplands parks, and (5) Sudeten parks (Table 1). The smallest Polish national park is Ojców NP and the largest is Biebrza NP. Together all the parks have a mean size of 136.7 km^2 of which about 60% are forests and 10% waterbodies (Denisiuk 2004a 2004b).

Material and methods

Questionnaires gave the required information from numerous areas scattered throughout the country.

In 2006 I received 284 completed questionnaires from all the national parks (Table 1). An analysis of the questionnaires allowed me to determine which species of the researched mammals were found in each national park, and then to calculate mean indices of occurrence (abundance index) and changes in numbers (change index). I determined the occurrence of each species on a national scale by using two parameters: frequency (number of parks where a species was found) and mean abundance index (the total sum of abundance indices from each park divided by 23). Using the mean change index (the total of change indices in the parks divided by the number of parks where the species was found) I calculated the population dynamics of each species.

In order to establish why individual parks differed in numbers of large mammals I related species differences to park size (in km^2), its longitude and altitude and to the level of disturbance in the environment caused by man. I used five levels of disturbance (1 = very low, 2 = low, 3 = average, 4 = high, 5 = very high) based on habitat alteration in and around the parks, human population and the percentage of forest bordering the parks. The relation between indigenous species richness and the factors mentioned were analysed using Spearman rank correlation (r_s).

Questionnaires

Previously I had prepared and used questionnaires concerning the occurrence and population dynamics of animals for research in the Carpathian units of the Polish Hunting Association (Jamrozy 1994). These same questionnaires, with detailed instructions on how to fill them out, were distributed at the beginning of 2006 to the directors of all Polish national parks with request of distributing them amongst their most competent field workers. These were workers who had been working for at least 10 years in the field as either forest rangers or park guards. According to the directors, all of them were very familiar with the terrain and knew which mammals were found in their territory and could identify evidence of their occurrence (tracks, feeding grounds, dens, etc.).

The questionnaire had two parts, with the a list of mammalian species and possible answers. The possible answers were as follows (with the

Table 1. Some facts about Polish national parks.

National park[1)]	Date established	Size (km^2)	Mean longitude E/ latitude N	Level of disturbance[2)]
Carpatian parks				
1. Babia Góra NP (9)	1954	33.9	19.5°/49.6°	2.0
2. Tatra NP (13)	1954	211.6	20.0°/49.3°	2.5
3. Pieniny NP (9)	1954	23.5	20.4°/49.4°	2.5
4. Gorce NP (19)	1981	70.3	20.2°/49.6°	2.0
5. Magura NP (18)	1995	194.4	21.5°/49.6°	1.0
6. Bieszczady NP (18)	1973	292.0	22.7°/49.2°	1.0
Eastern parks				
7. Roztocze NP (13)	1974	84.8	23.0°/50.6°	2.0
8. Polesie NP (9)	1990	97.6	23.1°/51.5°	2.5
9. Białowieża NP (15)	1932	105.0	23.9°/52.8°	1.0
10. Narew NP (5)	1996	73.5	22.9°/53.1°	2.5
11. Biebrza NP (13)	1993	592.2	22.8°/53.5°	1.5
12. Wigry NP (14)	1989	150.8	23.1°/54.1°	2.0
Central-western parks				
13. Kampinos NP (19)	1959	385.4	20.6°/52.3°	3.0
14. Wielkopolski NP (12)	1957	75.8	16.8°/52.3°	4.0
15. Bory Tucholskie NP (11)	1996	48.0	17.9°/53.7°	2.0
16. Słowiński NP (12)	1967	186.2	17.3°/54.7°	3.0
17. Wolin NP (8)	1960	109.4	14.5°/53.9°	3.5
18. Drawa NP (16)	1990	113.4	16.2°/53.6°	2.0
19. Warta Estuary NP (8)	2001	80.4	14.8°/52.6°	3.0
Southern uplands parks				
20. Ojców NP (11)	1956	21.5	19.8°/50.2°	5.0
21. Świętokrzyski NP (11)	1950	76.3	20.9°/50.9°	4.0
Sudeten parks				
22. Góry Stołowe NP (12)	1993	63.4	16.4°/50.5°	3.5
23. Karkonosze NP (9)	1959	55.8	15.6°/50.8°	2.0

[1)] In parantheses the number of questionnaires received from individual national parks.
[2)] According to the author (habitat alteration, human population and forested areas around the parks): 1 = very low, 2 = low, 3 = average, 4 = high, 5 = very high.

number index in parenthesis): Part 1, occurrence: (a) species occurring frequently or rather frequently (3); (b) occurring regularly but not numerous (2); (c) rare, sporadic occurrences (1); (d) not found (0); (e) don't know (–); Part 2, changes in numbers between 1996 and 2005: (a) a significant increase in numbers (+2); (b) species seen which had not been seen previously (+2); (c) a slight increase in numbers (+1); (d) no changes in numbers observed (0); (e) a slight drop in numbers (–1); (f) a significant drop in numbers (–2); (g) don't know (–). Only one answer was allowed.

Results

Species occurrence

In Polish national parks there were 15 carnivores, 8 even-toed ungulates, 2 lagomorphs and 4 large rodents (Table 2). This included 13 common, indigenous species found in all or in the majority of the parks (21–23). The most common species were the red fox and the roe deer *Capreolus capreolus*, then th red squirrel, wild boar *Sus scrofa*, red deer *Cervus elaphus*, pine marten, brown hare, stone marten *Martes foina*, weasel

Table 2. The occurrence and tendencies of changes in the numbers of large mammals in Polish national parks from 1996 to 2005.

Species[1)]	Frequency of occurrence (*n*)[2)]	Abundance index[3)]	Change index[4)]
1. Red fox *Vulpes vulpes*	23	2.9	+1.0
2. Roe deer *Capreolus capreolus*	23	2.7	–0.1
3. Wild boar *Sus scrofa*	23	2.4	+0.5
4. Red squirrel *Sciurus vulgaris*	22	2.4	+0.1
5. Red deer *Cervus elaphus*	22	2.4	+0.3
6. Pine marten *Martes martes*	23	2.2	0.0
7. Brown hare *Lepus europaeus*	23	2.0	–0.4
8. Stone marten *Martes foina*	23	1.9	+0.1
9. Weasel *Mustela nivalis*	23	1.8	0.0
10. Common polecat *Mustela putorius*	23	1.7	–0.1
11. Badger *Meles meles*	22	1.7	+0.1
12. Beaver *Castor fiber*	18	1.7	+1.3
13. Otter *Lutra lutra*	21	1.6	+0.7
14. Stoat *Mustela erminea*	21	1.4	0.0
15. Raccoon dog *Nyctereutes procyonoides* (nN)	18	1.3	+0.7
16. Wolf *Canis lupus*	10	0.9	+0.5
17. Muskrat *Ondatra zibethicus* (nN)	13	0.8	–1.3
18. Moose *Alces alces*	12	0.8	+0.4
19. American mink *Mustela vison* (nN)	9	0.8	+0.9
20. Lynx *Lynx lynx*	10	0.7	+0.3
21. Brown bear *Ursus arctos*	6	0.4	+0.7
22. Wild cat *Felis silvestris*	3	0.2	0.0
23. European bison *Bison bonasus*	2	0.2	+0.7
24. Mountain hare *Lepus timidus*	2	0.1	0.0
25. Mouflon *Ovis orientalis musimon* (nN)	2	0.1	–1.2
26. Tatra marmot *Marmota marmota*	1	0.1	+0.7
27. Tatra chamois *Rupicapra rupicapra*	1	0.1	+0.6
28. Raccoon *Procyon lotor* (nN)	1	0.1	+1.5
29. Fallow deer *Dama dama* (nN)	1	0.1	+1.5

[1)] (nN) = non-native species; [2)] Number of parks where the given species are found; [3)] The total abundance index of individual parks divided by the number of all parks (indices: 3 = species occurring frequently, 2 = regularly but not numerous, 1 = rarely, 0 = not found); [4)] The total change index divided by the number of parks where a given species is found (indices: +2 = significant increase in numbers, +1 = slight increase, 0 = no changes, –1 = slight drop in numbers, –2 = significant drop).

Mustela nivalis, the common polecat *Mustela putorius*, badger, otter *Lutra lutra* and the stoat *Mustela erminea*. Of the rare species, the least rare is the Eurasian beaver, which is seen more frequently and is occupying new terrain. The wolf, moose *Alces alces* and lynx were found in about half of the parks, while the rarest species, the brown bear *Ursus arctos*, wild cat *Felis silvestris*, European bison, mountain hare *Lepus timidus*, Tatra chamois and the Tatra marmot *Marmota marmota longirostris* were found in only 1–6 parks. In the national parks there were also species not native to Poland — the relatively common raccoon dog *Nyctereutes procyonoides*, the muskrat and the American mink, and only in a few parks mouflon, fallow deer and raccoon.

Various park groups differed in numbers and mean indices of species found in them. These differences were primarily found in rare and non-native species (Fig. 2). Red foxes, roe deer and red squirrels were the most numerous everywhere. The situation was the same for less numerous species: the brown hare, pine and stone martens, weasel and the common polecat. The status for the remaining species differed in individual park groups.

The number of indigenous species found in Polish national parks correlated positively with the size of these parks ($r_s = 0.54$, $p < 0.05$) and with longitude ($r_s = 0.73$, $p < 0.05$), and negatively with the level of disturbance ($r_s = –0.65$, $p < 0.05$). On a national scale there was no significant correlation between the number of species and altitude, however, in mountainous parks the correlation was negative ($r_s = –0.83$, $n = 8$, $p < 0.05$). The relationship between the number of species and park size was more distinct in non-mountainous parks ($r_s = 0.65$, $n = 15$, $p < 0.05$), in mountainous parks it was not significant ($r_s = 0.48$).

Carpathian parks

The highest position in frequency ranking apart from the red fox was held by red deer and then roe deer and pine marten. All three large European carnivores also ranked high in the Carpathian parks. It was the easiest to see wolves in Magura NP, Bieszczady NP and Gorce NP, lynx in Gorce NP and Babia Gora NP, and brown bears in Tatra NP and Bieszczady NP. The extremely rare wild cat and the beaver, which is very rare in mountains, were found in the three Carpathian parks (Bieszczady, Magura and Pieniny NP), whereas the European bison occurred only in one (Bieszczady NP). The brown bear, wild cat, chamois and the marmot (the last two were limited to Tatra NP) were only found in the Carpathian Mountains. The Carpathian parks were characterized by richness of native species and the sporadic presence of the non-native raccoon dog (in Magura and Bieszczady NP) and the muskrat (in Pieniny NP; Table 3).

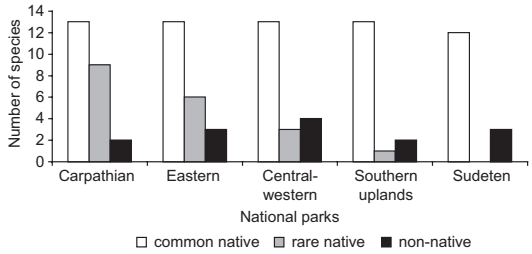

Fig. 2. Comparison of the number of mammals in separate groups of Polish national parks.

Eastern parks

The eastern parks ranked second, after the Carpathian parks with respect to large numbers of mammalian species. Wild boar and, in more forested parks, red deer were the most numerous of the common species. In all areas there were also beavers and moose. Wolves were seen regularly in Polesie NP, while in the remaining parks they occurred sporadically. Lynx were present in Białowieża NP, Roztocze NP and (sporadically) in Biebrza NP, mountain hares in Wigry NP and Biebrza NP, and the European bison only in Białowieża NP. In eastern parks raccoon dogs, American minks and muskrats were relatively frequent.

Central-western parks

In the group of national parks scattered throughout the extensive lowlands of Poland the red fox, roe deer, wild boar, red deer, beaver, pine

marten and the red squirrel were seen most frequently. Lynx, which was introduced a few years ago, was found only in Kampinos NP. In the same park moose were frequent but in other parks (Słowiński, Drawa, Bory Tucholskie NP) occurred more rarely. The American mink and the muskrat were relatively common in most of the parks, while fallow deer were seen only in Drawa and raccoon in Warta Estuary NP.

Southern uplands parks

Common species found in other regions were also found here with the exception of red deer which was absent (Ojców NP) or rare (Świętokrzyski NP). In Świętokrzyski NP otters and stoats were very rare. In both parks the beaver, raccoon dog and the muskrat occurred.

Table 3. The number of large mammalian species in Polish national parks.

National park	Number of species		
	Common[1)]	Rare[2)]	Non-native[3)]
Bieszczady	13	7	1
Magura	13	6	1
Białowieża	13	5	2
Biebrza	13	5	2
Pieniny	13	5	1
Tatra	12	5	0
Wigry	13	4	3
Roztocze	13	4	1
Kampinos	13	3	3
Polesie	13	3	2
Gorce	13	3	0
Babia Góra	13	3	0
Drawa	13	2	4
Narew	13	2	3
Słowiński	13	2	2
Świętokrzyski	13	2	1
Wolin	13	1	3
Warta Estuary	12	1	4
Bory Tucholskie	12	1	2
Ojców	12	1	2
Wielkopolski	12	1	2
Góry Stołowe	12	0	2
Karkonosze	12	0	2

[1)] Common indigenous species: *Vulpes vulpes, Capreolus capreolus*, *Sus scrofa*, *Sciurus vulgaris*, *Cervus elaphus*, *Martes martes*, *Lepus europaeus*, *Martes foina*, *Mustela nivalis*, *M. putorius*, *Meles meles*, *Lutra lutra*, *Mustela erminea.*

[2)] Rare indigenous species: *Castor fiber*, *Canis lupus*, *Alces alces*, *Lynx lynx*, *Ursus arctos*, *Felis silvestris*, *Bison bonasus*, *Lepus timidus*, *Marmota marmota*, *Rupicapra rupicapra.*

[3)] Non-native species: *Nyctereutes procyonoides*, *Ondatra zibethicus*, *Mustela vison*, *Ovis orientalis musimon*, *Procyon lotor*, *Dama dama.*

Sudeten parks

The parks in this group had the fewest numbers of mammals, and no beavers, otters or rare species. Common species here were similar to those in other national parks, with the red fox and red deer being most common. Of the non-native species, in addition to the mouflon (not found in any other region), the raccoon dog and the muskrat occurred only sporadically.

Population dynamics

In all Polish national parks it was possible to identify mammalian species that increased in numbers between 1996 and 2005 (Table 2). Of the species found in at least several parks the greatest population growth was seen in the Eurasian beaver and then the red fox and American mink. A tendency towards increase was also observed in the otter, raccoon dog, brown bear, wolf and wild boar. Of species observed in only one or two parks, the greatest increase in population was found in the raccoon (Warta Estuary) and in fallow deer (Drawa). A lesser increase occurred in the European bison (Białowieża and Bieszczady NP), the marmot and the chamois (Tatra NP). Only the muskrat and the mouflon (found only in the Sudeten) had a distinctive decrease in numbers. The brown hare declined to a lesser extent. According to the response of field workers, the populations of all the other species remained stable.

Discussion

Comments about questionnaire-conducted research

Although questionnaires are commonly used in the social sciences, especially in sociology

(Daniłowicz 1992), their use in investigating the ecology of game animals is not unusual (e.g. Cederlund & Lindström 1983, Bartmańska & Nadolska 2003). In Poland questionnaires were used to analyze nationwide changes in the distribution and population dynamics of the moose (Tomek 1977) and the American mink (Brzeziński & Marzec 2003) as well as the lynx (Jamrozy 1990) and the brown bear (Jakubiec 2001) in the Carpathians.

Field workers of national parks who completed the questionnaire knew their area very well and therefore could accurately evaluate the occurrence and population dynamics of the mammals found there. According to Beveridge (1962) the objectivity of this type of research increases when the questionnaires: (1) are repeated several times (in this case up to 20 times in each park); (2) are completed by people who are interested in the subject of the questionnaire; and (3) deal with changes that occur in well-known situations (the second part of the questionnaire dealt with these changes). These conditions were met in the majority of cases in this study.

In spite of the probability of subjective individual evaluation, the above-mentioned circumstances and the large numbers of respondents, who were very familiar with the terrain, make the data concerning the occurrence and population dynamics of medium and large-sized mammals in Polish national parks reliable. However, the use of "abundance" of different species may not be comparable, e.g. "abundant" fox population and "abundant" hare population may not indicate the same absolute density. So, for instance, the index 2.9 for the fox may not represent a higher density than the index 2.0 for the brown hare.

Large mammals in Poland and in Polish national parks

All species of carnivores, even-toed ungulates, lagomorphs and large rodents that are found in Poland can also be seen in Polish national parks, with the exception of a few species typical to steppe habitats; the European and spottet souslik *Spermophilus citellus* and *S. suslicus*, the common hamster *Cricetus cricetus* and the steppe polecat *Mustela eversmanni* (Pucek 1981, Razowski 1991, Głowaciński 2002). Of the 8 large and medium-sized species not native to Poland, two were not seen in any national park: the rabbit *Oryctolagus cuniculus* and the sika deer *Cervus nippon*. Of the rare native species the chamois and the marmot were seen in only one national park (Tatra NP). Many others occurred more frequently and were more numerous in national parks than elsewhere in the country (e.g. European bison, brown bear or wild cat). According to Okarma *et al*. (2002), the wild cat occurred only in two parks: Bieszczady NP and Magura NP. However, in this study it was also found in Pieniny NP thanks to reliable field observations during the summer of 2002. Furthermore, one animal was killed by a car in the vicinity of the park during the summer of 2004 (J. Bodziarczyk pers. comm.). Protective measures and the founding of national parks in the Polish and Belarus Białowieża Primeval Forest (Pucek 1991, Krasiński 1994) saved the European bison from extinction. Similarly the creation of national parks in the Polish and Slovakian Tatras rescued the threatened Tatra chamois subspecies from extinction (Jamrozy *et al*. 2007). This study showed that mammalian species richness increased with an increase in park size towards the east (and among mountainous parks towards the south), and with decreasing levels of disturbance in and around the park.

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