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Changes of Forest Flora Composition in Vicinity of Dens of Red Fox and Setts of Euroasian Badger

ABSTRACT: Denning and sett construction made by the red fox and Eurasian badger may cause changes in forest vegetation. These changes relate to both the cover and the species composition of forest-floor vegetation, with some plant species being eliminated and some promoted in the vicinity of dens and setts. In general, there is a reduction in the number and coverage of acidophilous, oligotrophic and skiophilous species, and a promotion of basophilous, eutrophic and heliophilous ones. There is also a decline in the abundance and cover of geophytes, chamephytes and phanerophytes, and an increase in the role of bryophytes (as well as therophytes and hemicryptophytes in the case of badger setts). Where dens are concerned, species characteristic for the Vaccinio-Piceetea Br.-Bl. 1939 and Querco-Fagetea Br.-Bl. et Vlieg. 1937 classes are less significant, and those typical for Artemisietea vulgaris Lohm., Prsg et R.Tx1971950 more significant. On badger setts, species characteristic of the class Epilobietea angustifoliae R.Tx. et Prsg 1950 are also more significant. The disturbanes brought about by the activity of badgers are more evident than those induced by foxes, but they do not differ in terms of their ecological nature.

KEY WORDS: Vulpes vulpes L., Meles meles L., denning, zoopression, vegetation disturbance, Tilio-Carpinetum

1. INTRODUCTION

The scope of the animals impact on plant communities is a broad one; knowledge on this issue is related to phytophagy, seed dispersal, mechanical damage to plants and the transformation of habitats. The work done hitherto on the zoogenic alteration of phytocoenoses has tended to look at the role of such animals as ungulates, rodents and lagomorphs, insectivores, birds and insects or other invertebrates. Studies involving carnivores have been in turn connected with territoriality, habit and dietary preferences, population dynamics, vulnerability to disease and even the regulation of energy flow in the ecosystem. However, beyond a few observations as to the plants growing over badger setts, made by the way of zoological research (Wijngaarden and Peppel 1964, Neal and Roper 1991, Goszczynski 1993), the influence of mammalian predators on vegetation has not hitherto been subject to analysis.

In Poland more than ten species of carnivorous mammals occur. However it was decided to concentrate the research on species as large as possible, in order that the results of their impacts might be more facili-
tated to study. At the same time, any species involved needed to be widespread, so that there would be easy to locate examples of their residence places in the field. These criteria were met by the fox and badger; both species are characterised by their large home ranges, their ability to use a range of ecosystems and their diversified diets. Their important interaction with the environment is connected with digging of burrows, termed dens (or earths) and setts respectively. They occur in a variety of different phytocoenoses like forests, grasslands and boundary strips as well as the ruined structures of built-up areas. From the point of view of the disturbing activity the research under discussion has to focus on the most natural ecosystems used by badgers and foxes i.e. forest communities. This way the aim of the research was to determine the influence of the excavation and utilisation of dens and setts by foxes and badgers on the floristic composition of forest phytocoenoses.

2. STUDY AREA

The work was done in forested areas in central Poland (Rogów Forest District, Fig. 1). This area was chosen for its high densities of both species, and for the fact that the sites in which they were to be found were already well known (Goszczyński, pers. comm.). The forests of the District com-

![Diagram](image-url)

**Fig. 1.** Localisation of research plots (1-14) inside study forests (Rogów District, Central Poland).
Changes of flora caused by fox and badger

prise several sub-divisions with a total area of more than 3500 ha. The major part of the area consists of cambisols (brown soils), followed by luvisols (podsolic soils), both having originated from silts or sands deposited on clays (Konecka-Betley et al. 1993). The potential natural vegetation of the study site are mainly the oak-lime-hornbeam forest - *Tilio-Carpinetum* Tracz. 1962 and *Melitti-Carpinetum* Sokol. 1976 (65%), and the acidophilous oakwoods - *Fago-Quercetum petraeae* R. Tx 1965 (17%) (Zielony et al. 1993). Considerable areas of forest have been undergoing marked degeneration sensu Olaczek (1972), including the introduction of pine monocultures – over 80% of the area, and the invasion of neophytes – over 16% (Zielony 1993). The annual mean temperature for study area is of 7.2°C, while snow cover lies for (average) 65 days. The mean annual total precipitation is equal to 596 mm (Bednarek 1993).

3. MATERIAL AND METHODS

The studies were performed in places with utilised dens and setts located in mature or premature stands with well-developed forest-floor vegetation. The study areas selected were those around the entrances to holes, which relief had been distorted by the animals’ digging out of earth from setts and dens. Control sites were in turn considered to constitute a surrounding ring of land 4 m wide, extending beyond a 4-metre transitional zone, which was excluded from analysis. The mean size of research plots was 230 m² (SD=203.70), n=7; while that of control areas was 340 m² (SD=95.79), n=7. In August 1997, phytosociological relevés after Braun-Blanquet (1928) were drawn up for these plots, being supplied with data for spring (May) of the following year.

Analysis of the differentiation of the species composition in the studied phytocoenoses was performed using the DCA method after Hill (1973), with the “CANOCO” program (Ter Brak 1998). The flora of sett and den sites was compared with that of the surrounding areas in terms of the role played by the species characteristic for the given class of associations (after Matuszkiewicz 2001) and the shares taken by different life forms (after Raunkiæer 1934), as well as by species of differing ecological numbers – characteristic for trophic status, soil reaction and level of illumination (after Zarzycki 1984). The statistical significance of the differences was assessed using the Student “t” test for matched pairs. Data on the type of soil, potential vegetation and stand characteristics were taken from forestry documentation (Biuro Urządzania Lasu 1989) and the literature (Zielony et al. 1993). The nomenclature of plants followed Mirek et al. (1995), that of bryophytes – Ochyra et al. (1992) and that of soils after FAO (1998).

4. RESULTS

The data from seven fox dens and seven badger setts were collected. The dens and setts were mainly found in haplic luvisols (podsolised soils), derived from the silts overlying sands or clays. Nearly all were found in typical oak-lime-hornbeam forest, *Tilio-Carpinetum typicum* Tracz. 1962, with only one being located in the mesotrophic variant of *Tilio-Carpinetum calamagrostietosum* Tracz. 1962. Specifically, the dens were located under pine stands with an admixture of oak and hornbeam, with only one being beneath an oak-hornbeam canopy. In all of the communities the stands had full or near-complete closure, a well-developed shrub layer and – in most cases – an almost continuous herb layer with bryophytes occurring sporadically only. On average, badger setts had more than twice as many exits as fox dens, and occupied the area more than twice larger (Table 1).

The den/sett areas differed from control areas in having much more uncovered ground. The difference is significant in the case of foxes’ dens. The degree of coverage of the remaining layers of the phytocoenosis (i.e. of trees, shrubs and bryophytes) were not found to differ significantly when control and study sites were compared. The flora growing over setts and dens was found to differ in composition from that of control areas, lacking a number of species present there, but also having the species otherwise absent in the forest phytocoenosis (Table 2). In comparison with the flora of fox dens, that
Table 1. Characteristics of research plots (1-14), in forests of study area (Fig.1). Soil and tree stand features taken from forest management plans and literature (Biuro Urządzania Lasu 1989, Konecka-Betley et al. 1993).

| Category of plot | fox dens | | badger setts |
|------------------|----------|----------|
| Plot number (Fig. 1) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Sett/den area [m²] | 150 | 50 | 100 | 200 | 30 | 250 | 40 | 300 | 200 | 200 | 100 | 400 | 400 | 800 |
| Number of entrances | 7 | 5 | 4 | 4 | 1 | 7 | 3 | 15 | 7 | 4 | 9 | 21 | 7 | 17 |
| Soil type | luvisol | luvisol | luvisol | luvisol | luvisol | cambisol | luvisol | cambisol | cambisol | luvisol | luvisol | cambisol | luvisol |
| subtype | stagnic |haplic | haptic | haptic | haptic | haptic | haptic | haptic | haptic | haptic | haptic | haptic | haptic |
| kind | e/si/g/cl | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa | e/si/g/sa |
| texture | si | cl-si sa | cl-si sa | si | si | si | si | si | si | si | si | si | si |
| Tree stand | dominant species | pine | pine | pine | pine | pine | pine | pine | oak | pine | pine | pine | pine | pine |
| biomass [%] | 90 | 80 | 60 | 80 | 80 | 70 | 70 | 80 | 100 | 100 | 100 | 80 | 80 |
| age in years 1997 | 106 | 23 | 59 | 95 | 85 | 85 | 33 | 68 | 88 | 74 | 82 | 89 | 64 | 49 |
| Potential vegetation | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct | T-Ct |

soil kind | e si - eolic silts | e si - silt | g sa - glacifluvial sands | cl sa - clayey sand | g cl - glacial clays | cl-si sa - clayey-silty sand |

potential vegetation | T-Ct - Tilio-Carpinetum calamagrostietosum | T-Ct - Tilio-Carpinetum typicum
of badger setts was characterised by a higher frequency of the species characteristic for this kind of site, as well as more non-forest species of otherwise sporadic occurrence. The plant species linked more specifically with dens and setts include: *Moehringia trinervia* (L.) Clairv., *Stellaria media* (L.) Vill., *Geum urbanum* L., *Poa nemoralis* L., *Urtica dioica* L., *Dactylis* sp., *Sambucus nigra* L. and the bryophyte *Dicranella heteromalla* (Hedv.) Schimp. The species “avoiding” dens and setts in turn include *Rubus fruticosus* L., *Anemone nemorosa* L., *Luzula pilosa* (L.) Wild., *Pteridium aquilinum* (L.) Kuchn., *Melica nutans* L., *Vaccinium myrtillus* L. and *Dicranella heteromalla* (Hedv.), as well as seedlings of *Quercus petraea* (Matt.) Liebl. and *Sorbus aucuparia* L. emend. Hedl., and shrub-layer specimens of *Carpinus betulus* L., *Frangula alnus* Mill. and *Cerasus avium* (L.) Moench. (Table 2).

The number of species noted on dens and setts was also smaller than that in control areas of the surrounding forest. In the case of the dens of foxes, this difference achieved statistical significance (*P* = 0.05), with the dens of badgers being richer in species (Fig. 2).

The ordination of phytosociological relevés using the DCA method in qualitative analysis pointed to a first-axis shift of those relating to den and sett sites as compared with control ones. The direction of the shift may be described as a baso-hygro-eutrophic one. The ordination with respect to the second axis did not yield any unequivocal result, and neither did the ordination obtained from the quantitative analysis (Fig. 3).

The values for habitat indices calculated on the basis of ecological numbers are higher for the den/sett floras than for the controls as regards trophic status and soil reaction in the qualitative analysis where badger setts were concerned, and in quantitative analysis in regard to fox dens.

In the other cases, the differences do not attain statistical significance, though they again point to a tendency for indices of den/sett flora to be higher. An exception is the indicator of the light factor in the case of fox dens, as calculated from qualitative analysis which is lower than the one for its control plot (Fig. 4).

The differences in trophic status, soil reaction and light levels are reflected in the division for plant species as regards their affiliation to different phytosociological units. Den and sett areas have fewer coniferous forest species typical for classes *Vaccinio-Piceetea* Br.-Bli and *Quercetea robori-petraeae* Br.-Bl. et R.Tx.1943, as well as more restricted cover of the broadleaved forest species characterising

![Fig. 2. Differentiation of mean number of species per plot (250–350 m²) on fox dens and badger setts compared with surrounding forest. Mean values ± SD; n=7. Difference a vs b significant for *P* = 0.05.](image-url)
**Table 2. Floristic differentiation of examined plant communities on research plots in the study area inside forest of Rogów District (Fig. 1). Data collected within years: 1997–98, with application of Braun-Blanquet (1928) method. Sporadic, non-differentiating species are not included. Numbers indicate abundance of species: r - few individuals; + - up to 1%; 1 - 1 to 5%; 2 - 6 to 25%; 3 - 26 to 50%; 4 - 51 to 75%; 5 - 76 to 100% of the relevé area covered. Frames indicate connection of groups of species with categories of plots.**

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**Trees**

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### Changes of flora caused by fox and badger

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**Mosses**

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Fig. 3. Ordination of phytosociological relevés on research plots in study forest (Rogów District) (Fig. 1) obtained by DCA method (Hill 1973) in qualitative analysis.

Analysis based on number of species
soil fertility

Analysis based on coverage of species
soil fertility

Fig. 4. Differentiation of habitat conditions of dens/setts areas compared with surrounding forest controls. Results based on ecological indices of plant species after Zarycki (1984). Mean values ± SD, (n = 7).

** - difference significant for \( P = 0.01 \), * - difference significant for \( P = 0.05 \).
Querco-Fagetea Br.-Bl. et Villeg. 1937. They also have more ruderal and segetal species from the class *Artemisietea vulgaris* Lohm., Prsg et R.Tx. 1950 and *Stellarietea mediae* R.Tx., Lohm. et Prsg, 1950. Badger setts are in addition characterised by greater cover of forest clearings and forest-edge species of the classes *Epilobietea angustifoliae* R.Tx. et Prsg 1950 and *Rhamno-Prunetea* Rivas Goday et Garb.1961 (Fig. 5).

The differentiation in terms of the presence of plants of different life-forms also occur, as den and sett areas support fewer species of geophytes, chamephytes and phanerophytes. In the latter case it is true for both the ground-cover and shrub layers. When account is taken of the cover of species, a greater share of bryophytes, a lack of difference in presence of chamephytes, and a greater areal representation of hemicryp-

![Graph](image)

Species characteristic of:
- deciduous forest
- coniferous forest
- clearings
- meadows
- segetal sites

Fig. 5. Phytosociological differentiation of forest floor vegetation on dens/setts compared with surrounding forest controls, based on species characteristic for syntaxa after Matuszkiewicz (2001); n = 7.
trophophytes and therophytes at badger setts are noted (Fig. 6).

5. DISCUSSION

The results obtained are in line with previous observations of the plant species growing on badger setts. As in England and Scandinavia (Neal and Roper 1991), so also in the studied forest, den and sett areas are characterised by a greater presence of grasses, here represented by Dactylis sp., Poa palustris L. and P. nemoralis, as well as by the meadow herbs Rumex acetosa L., Achillea millefolium L. and Taraxacum officinale F.H.Wigg. Likewise the presence of eutrophic species like Urtica dioica, Sambucus nigra, Ranunculus repens L. or Galium aparine L. was recorded. In England it was possible to observe a considerable presence of field and ruderal weeds as represented by Carduus sp., Rumex sp., Galeopsis ladanum L. and Melandrium rubrum (Weigel) Garcke. However, standing

![Fig. 6. Differentiation of life forms of forest floor vegetation on dens/setts compared with surrounding forest controls, according to Raunkiaer (1934); n=7.](image-url)
in contrast to above situation, only sporadic occurrence of *Stellaria media* and *Convolvulus arvensis* L., as well as *Plantago major* L. and *Poa annua* L. at the studied forest sites were observed. A further result is the presence of species of forest-edge communities, like *Geum urbanum*, *Moehrinia trinervia*, *Chaerophyllum temulum* L. and *Rumex obtusifolius* L. – as associated with the slight disturbance of soil, as well as of such pioneer species as *Salix capraea* L., *Betula pendula* L. and the moss *Dicranella heteromala*.

Fig. 7. The influence of badger and fox on forest phytocoenosis.
The results prove a direct impact of carnivores on vegetation. Changes in forest ground cover under the influence of the excavation of burrows concern the ecological character of the flora. The digging out of dens and setts leads to the mechanical elimination of plants, with the sand throwing away from tunnels burying forest ground-cover components present hitherto. At the same time, a new initial habitat for colonisation by pioneer bryophytes and therophytes is created. Furthermore, the undermining of trees by way of tunnelling impairs them, with the result being partial defoliation or even full dieoff. The greater influx of light to the forest floor promotes the retreat of skio-phytes and the expansion of heliophytes. The used litter removed from dens and setts, food remnants, urine and faeces left in the vicinity of entrances enrich and alcalize the soil. This promotes the encroachment of eutrophic and basophilic elements of the flora, as well as the decline of acidophilous and oligotrophic elements. The penetration by foxes and badgers of non-forest communities gives rise to a transfer of the seeds of field, meadow and ruderal plants (Fig. 7).

The observed changes of phytocoenoses are similar to those of vegetation in areas occupied by the burrows of rodents. The impacts of the latter manifest themselves in changes of surface relief and soil properties (Jońca 1975 and the literature cited therein). Den and sett areas are also shown to diminish vegetation cover and to lower the number of species. Irrespective of this, an increase in the shares of certain species is noted, especially stoloniferous and rhizomatous ones tolerant of burial under soil, as well as therophytes, including segetal species (Rabotnow 1985, English and Bowers 1994). The observed changes can be regarded as of local but persistent nature, playing a significant role in community dynamics, being sort of a "renewal of vegetation" (i.e. a return to earlier successional stages), mainly as the shifting of litter and destabilisation of the soil (Rabotnow 1985, Swihart and Picone 1991, English and Bowers 1994).

The phytocoenoses under study are of oak-lime-hornbeam forest converted to pine stands. A question therefore arises as to whether the observed presence of baso-eutrophic species is more the result of habitat fertility being raised by animals, or of the removal of the acidifying pine litter that stimulates the development of acido-oligotrophic species. Another issue worthy of further consideration is the degree of persistence of the changes brought about, as well as their role in forest dynamics.

Description of zoogenic transformations of phytocoenoses may also serve in the baseline of measurements of the anthropogenic disturbances of plant communities. To date, the degree of human-induced disturbances have been measured by reference to patches undisturbed by biogenic factors. This type of control area has been employed from the time of the pioneer works on anthropopres-sure (e.g. Wagar 1967, Faliński 1975), through to the most recent work (e.g. Witkowska-Zuk and Andrzejewski 2002, Lemauviel and Roze 2003). It may be that the more proper frame would be provided by patches disturbed by animals, especially where the assessment concerns such distur-bances as trampling or eutrophization.

6. CONCLUSIONS

1. The excavation and utilisation of dens by foxes and setts by badgers change the floristic composition of forest phytocoenoses.

2. Compared with that of their surroundings, the flora of den and sett sites is characterised by a smaller share of forest species and a greater share of ruderal and pioneer species.

3. The characteristics of the flora of den and sett sites reveal an increase of pH and fertility of the soil.

4. The activities of both foxes and badgers induce similar kinds of change. However the intensity of habitat transformation at badger setts is greater than at foxes’ dens.

ACKNOWLEDGMENTS: The authors of this article would like to address their thanks to Prof. Jacek Goszczyński for making possible an access to his data of locations of dens and setts in Rogów forests and to Dr Jadwiga Mickiewicz for determination of moss species. This work was partially supported by the Polish Committee for Scientific Research (grant No. 5 P06 E 00110).
8. REFERENCES


Ter Brak C. J. F. 1988 – Canoco – a fortran program for canonical community ordination by [partial] [detrended] [canonical] correspondence analysis, principal components analysis (ver.2.1) – Groep Landbouw-wiskunde.Wageningen. pp. 95.


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