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Floristic diversity on the early medieval earthworks of Chełmno Land (Ziemia Chełmińska) in NW Poland

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Abstract: This study aimed at comparing the flora of 29 early medieval earthworks, characterised by various degrees of anthropogenic transformation, in order to demonstrate their role as refuges of rare plant species. The earthworks were classified according to their index of total synanthropization (WS_c), which was assumed to indicate the level of floristic transformation. The highest floristic diversity was observed on the earthworks exposed to moderate human impact, due to fragmentation of phytocoenoses. The high floristic diversity and sites of rare heliophilous species are threatened by the discontinuity of traditional forms of land use, i.e. grazing.

Key words: human impact, synanthropization, species richness, floristic diversity, ecological islands

ECOLOGY

1. Introduction

Earthworks are remains of early historical fortified settlements, which served as centres of administration. The present countryside landscape usually contains only remains of old ramparts, moats and access roads. Steep slopes of the ramparts protect the earthworks from cultivation. They were used for grazing, or simply left as wastelands and then successively colonised by forest communities. A unique feature of the earthworks, apart from their frequent isolation in the agricultural landscape, is the development of anthrosols in those areas. The soils are enriched with organic carbon, nitrogen and phosphorus down to substantial depths. They are also characterised by a high biological activity, the presence of carbonates and a slightly alkaline reaction (Bednarek *et al*. 2004). This is connected with the floristic peculiarity of earthworks, which aroused naturalists' interest already in the 18th century (Zabłocki 1958). The research done recently has proved that earthworks are ecological islands, refuges for rare species and relics of ancient crops (Buliński 1993; Celka 1999, 2002, 2004; Herbich 1996). Detailed floristic investigations carried out in the Wielkopolska region (western Poland) have demonstrated a relationship between the intensity of human management of the land and the diversity of earthwork flora (Celka 1999).

The objective of this study was to analyse and compare the flora in earthworks exposed to various degrees of human impact.

2. Material and methods

The investigations concerned the flora of 29 early medieval earthworks in the area of Chełmno Land, in the interfluve of the Vistula, Drwęca and Osa rivers (Fig. 1). The fieldwork was carried out in 2000-2003. A complete list of plant species was prepared for each of the earthworks. The flora was analysed in respect of the affiliation of particular species to the geographical-historical and socio-ecological groups (cf. Celka 1999, 2004). The index of total synanthropization (WS_c) of the sites and the level of transformation of the actual plant communities as compared to the potential ones were used to measure the degree of anthropogenic transformation of the flora (cf. Chmiel 1993). The index (WS_c) was calculated according to Jackowiak's (1990) formula:

$$WSc = \frac{Ap+An}{Sp+An} \times 100\%$$

where
Ap – number of apophytes (i.e. synanthropic native plant species),
An – number of anthropophytes (i.e. alien plant species),
and Sp – number of non-synanthropic spontaneophytes (i.e. non-synanthropic native plant species).

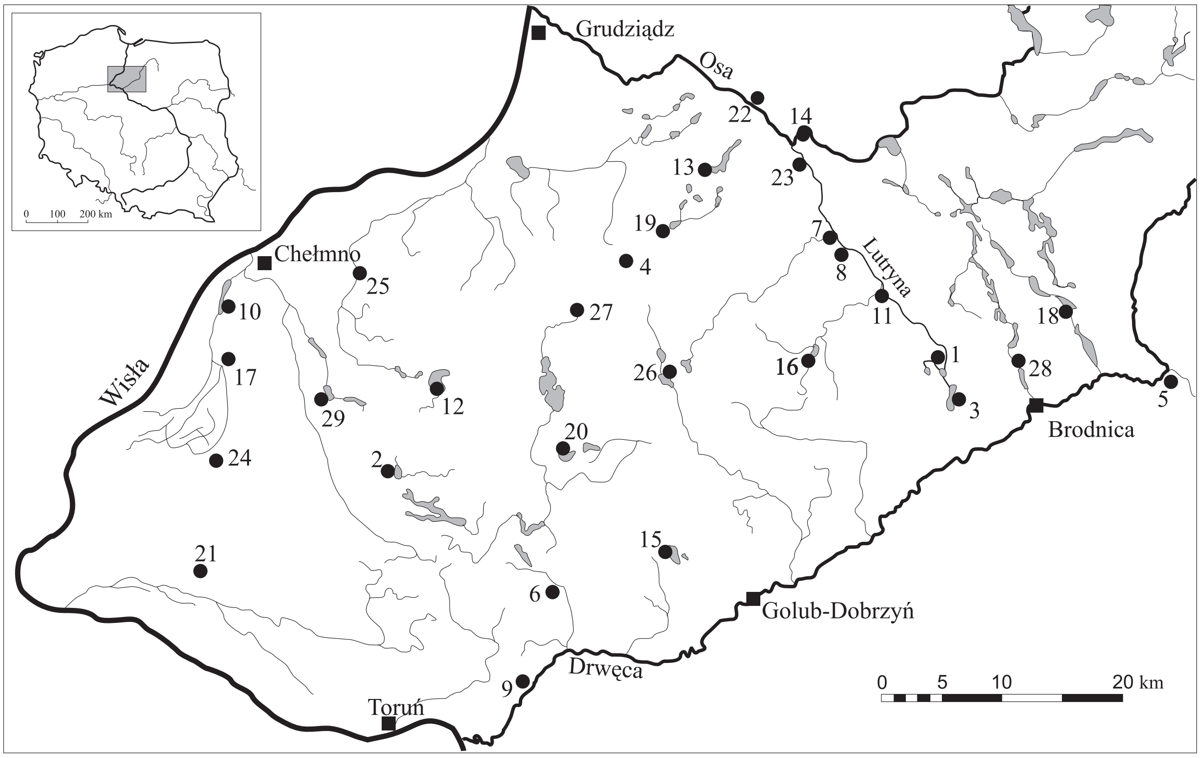

Fig. 1. Study area and location of earthworks (Chudziakowa 1994, modified)
Explanation: for earthworks names; see Fig. 2.

The synthetic assessment of the degree of hemeroby covered all the investigated sites, considering that there might be habitats of varied hemeroby within one earthwork. The species threat categories for the area of Chełmno Land were adopted from Rutkowski (1997). The Shannon diversity index was calculated with MVSP software, by using the average coverage values of the species in earthworks.

3. Results and discussion

The earthworks were assigned to 3 groups according to the degree of hemeroby. The first group, where non-synanthropic species prevailed (Fig. 2), were the least transformed, i.e. oligohemerobic. They were covered with natural forest stands: thermophilous oak woods, mesophilous deciduous forests and nitrophilous

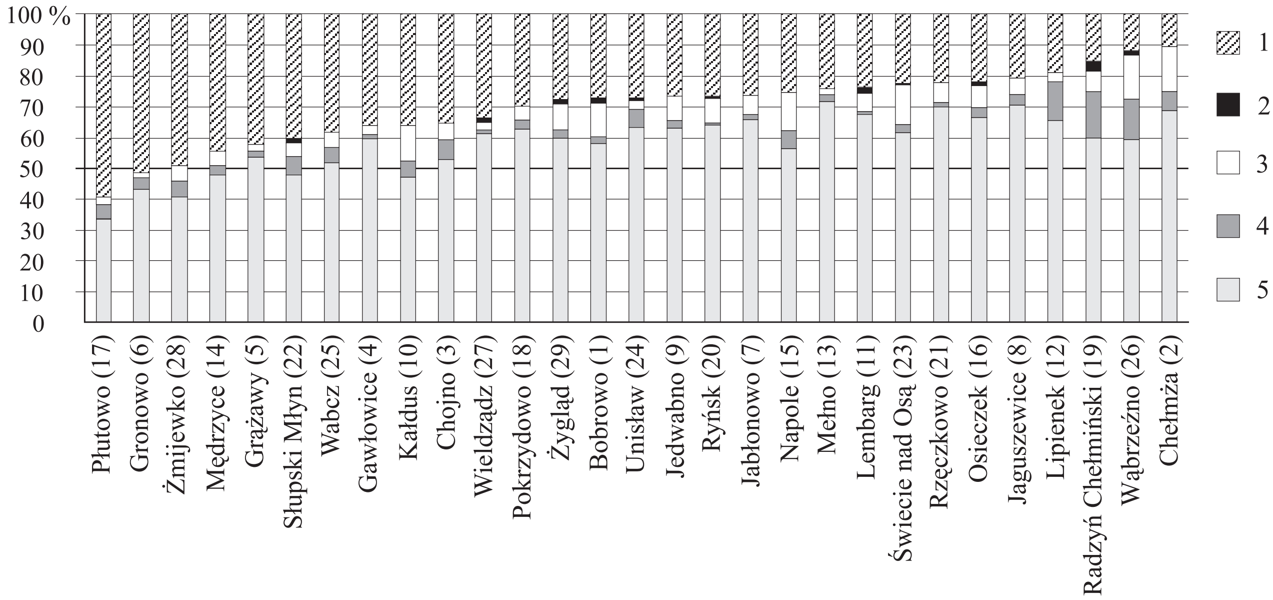

Fig. 2. Geographical-historical groups in the earthworks flora
Explanations: The earthworks are ranked according to the value of their total synanthropization index. 1 – non-synanthropic spontaneophytes; 2 – diaphytes; 3 – archaeophytes; 4 – kenophytes; 5 – apophytes

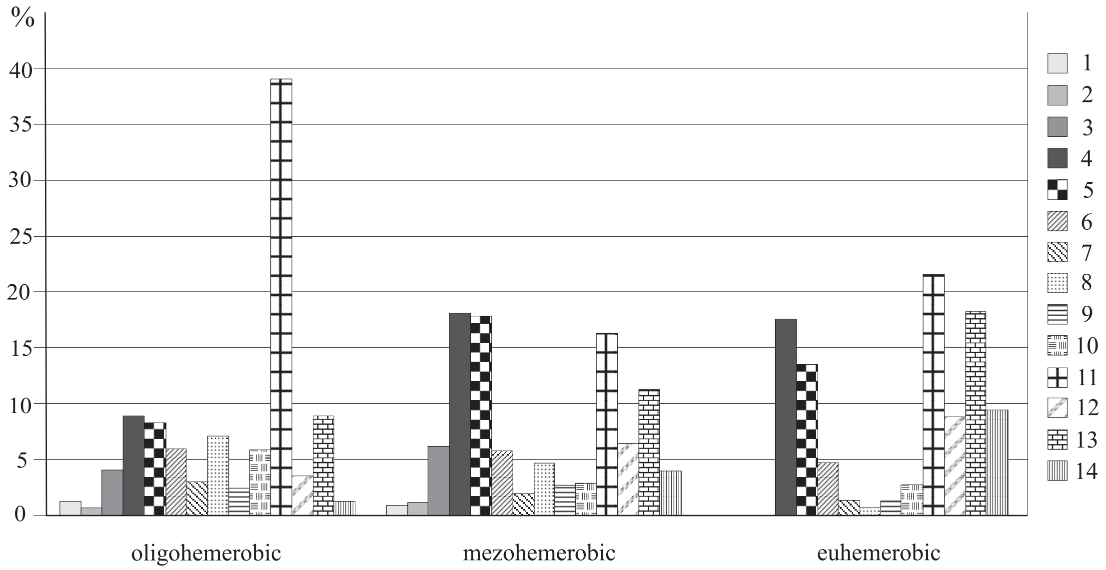

Fig. 3. Socio-ecological groups in the earthworks with various degrees of hemeroby
Explanations: 1 – aquatic communities; 2 – therophytes on waterlogged ground; 3 – emergent vegetation; 4 – meadows; 5 – sandy and xerothermic grasslands; 6 – thermophilous forest edges and thickets; 7 – forest clearings; 8 – coniferous forests and acid deciduous forests; 9 – riparian forests; 10 – alder forests and thickets; 11 – thermophilous oak forests, mesophilous deciduous forests and thickets; 12 – segetal communities; 13 – ruderal communities; 14 – others

shrub communities (Fig. 3). The second group, mesohemerobic earthworks, comprised the ones covered with timber forests or park plantings and a mosaic of grassland and shrub communities or forest, subject to burning and grazing of varied intensity. Their flora includes nearly equal amounts of species typical of meadow communities or xerothermic grasslands and of deciduous forests and nitrophilous shrub communities (Fig. 3). The third, euhemerobic group, included the heavily transformed earthworks of ruderal character, with the highest synanthropization indices, colonised by various types of phytocoenoses with a substantial participation of segetal weeds and species of unspecified plant association (Fig. 3).

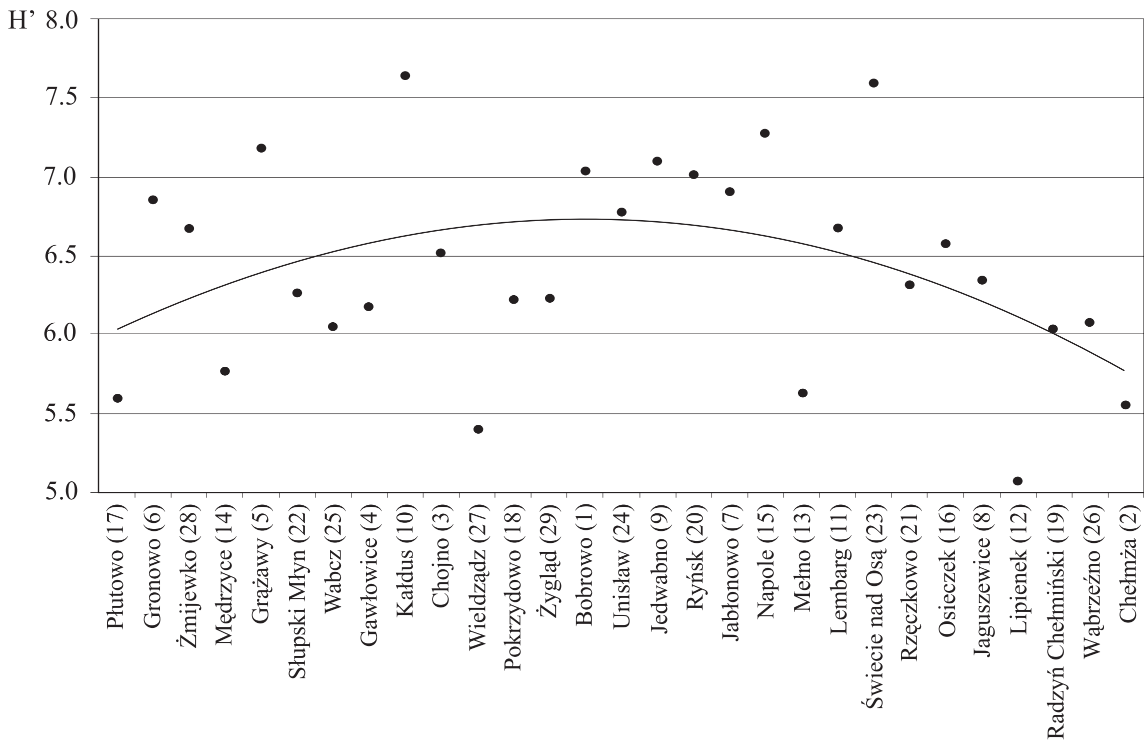

Fig. 4. Shannon diversity index (H' for $\log_2$) for the earthworks ranked according to the value of their total synanthropization index (trend line – polynomial)

As far as the number of species in the 3 groups of earthworks is concerned, the mesohemerobic habitats are characterized by the most diverse flora, with 103.7 species on average. Then come the oligohemerobic (83.7 species) and euhemerobic ones (52.3 species). The mesohemerobic earthworks are also the richest in rare species. As many as 13 species from the red list of threatened vascular plants of the Kujawsko-Pomorskie province were found there: 1 endangered (EN: *Lolium temulentum*), 8 vulnerable (VU: *Avenula pratensis*, *Cnidium dubium*, *Fragaria moschata*, *Hieracium echioides*, *Anemone sylvestris*, *Carex supina*, *Oxytropis pilosa*, *Stipa capillata*), and 4 species of lower risk (LR: *Corydalis solida*, *Festuca tenuifolia*, *Lavatera thuringiaca*, *Medicago minima*). There is also one vulnerable species in the oligohemerobic earthworks – *Cimcifuga europaea*. By contrast, no red-listed vascular plants were found in the euhemerobic habitats.

Values of the Shannon diversity index are relatively low in oligohemerobic earthworks. It initially shows a clear upward trend accompanying intensification of human activities, and reaches the highest values in the earthworks that have been moderately transformed, whereas a further increase in human impact results in a biodiversity decline (Fig. 4). The obtained results have proved the observations made by researchers e.g. Celka (1999) on the earthworks in the Wielkopolska region, Loster (1991) and Ratyńska (2003) in an agricultural landscape.

4. Conclusions

The high floristic diversity on the earthworks that were subject to extensive human management is connected with the fragmentation of phytocoenoses. These diversified habitats have become refuges for a number of plant species ousted from the intensively cultivated agricultural landscape. The high floristic diversity and sites of rare heliophilous species are threatened by the discontinuity of traditional forms of land use, i.e. grazing. The detailed record of the current state of the plant cover of the earthworks should be a first step to monitoring floristic changes in this type of habitats.

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