10.2478/v10067-012-0003-2

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN–POLONIA

VOL. LXVI, 2 SECTIO C 2011

DONATA SUDER

Department of Plant Ecology, Institute of Botany, Jagiellonian University
Kopernika 27, 31-501 Kraków, Poland

Participation of thermophilous species in plant communities of earthworks and castle ruins in the Western Carpathians

Udział gatunków ciepłolubnych w zbiorowiskach roślinnych grodzisk i zamczysk Karpat Zachodnich

SUMMARY

The work presents a part of a broader research program of the actual vegetation of 37 archaeological sites (25 earthworks and 12 castle ruins). Distribution of the studied areas in the Raba, Dunajec and Wisłoka river valleys (Western Carpathians) is shown in Figure 1.

The aim of this paper is to prepare a list and ecological analysis of thermophilous and xerothermic plant species occurring in the Carpathian fortress objects [OK}. Participation of these species was studied in 2006–2010. The presented results are derived from studies based only on the non-forest, open areas which were found at 22 archaeological sites.

This paper includes a list of 82 thermophilous and xerothermic species found within the investigated earthworks, castle ruins and their immediate neighbourhood. The species were distinguished on the basis of the analysis of 196 phytosociological relevés. Their characteristics (frequency classification, Raunkiaer's life forms, syntaxonomical and geographical-historical groups) are presented in Table 2.

The vast majority were taxa of classes: *Festuco-Brometea* (46%), *Trifolio-Geranietea* (17%) and *Rhamno-Prunetea* (10%) (Fig. 2). The most widespread thermophilous plant species on historical sites were: *Agrimonia eupatoria*, *Hypericum perforatum*, *Origanum vulgare* and *Pimpinella saxifraga*. Among thermophilous taxa of the studied areas native species (94%) (Fig. 4) dominate. Hemicryptophytes predominate in the spectrum of Raunkiaer's life forms with 64% share (Fig. 5). Particularly noteworthy is the presence of *Allium scorodoprasum*, *Lavatera thuringiaca* and *Origanum vulgare*, since these species are regarded as relics of former cultivation.

STRESZCZENIE

Celem prezentowanych badań było określenie udziału gatunków ciepłolubnych oraz analiza ich ekologicznego zróżnicowania w rozmaitych typach fitocenoz, jakie wykształciły się w miejscach, gdzie w przeszłości istniały warownie. Opracowanie jest częścią szeroko zakrojonych badań szaty roślinnej grodzisk i zamczysk w Karpatach Zachodnich.

Prace terenowe prowadzono na 37 pradziejowych i średniowiecznych obiektach archeologicznych w latach 2006–2010. Badaniami objęto 25 grodzisk i 12 zamczysk zlokalizowanych w dolinach trzech dużych rzek: Dunajca, Raby i Wisłoki. Rozmieszczenie stanowisk badawczych przedstawiono na rycinie 1. Grodziska i zamczyska w Karpatach zajmują partie szczytowe wzniesień. Cechuje je mozaikowość siedlisk miejsc otwartych i zalesionych. Za stanowisko badawcze przyjęto grodzisko lub zamczysko oraz bezpośrednie otoczenie obiektu (stoki wzgórz). Powierzchnia stanowisk była zróżnicowana i wahała się od 1,1 ha do 55 ha.

Materiał badawczy stanowią spisy flory oraz zdjęcia fitosocjologiczne wykonane metodą Braun-Blanqueta w kwadratach 5 m x 5 m, we wszystkich wyróżniających się fizjonomicznie, jednorodnych płatach. Dla potrzeb niniejszego opracowania przeanalizowano 196 zdjęć fitosocjologicznych jedynie z miejsc otwartych 22 obiektów badawczych. Na ich podstawie wyróżniono 82 gatunki roślin ciepłolubnych i kserotermicznych (tab. 2). W przeważającej większości były to taksony z klas: *Festuco-Brometea* (46%), *Trifolio-Geranietea* (17%) oraz *Rhamno-Prunetea* (10%) (ryc. 2). Rozpatrzono także spektrum form życiowych, grup geograficzno-historycznych i częstości występowania gatunków termofilnych na stanowiskach (ryc. 3–5). Najbardziej rozpowszechnione były: *Agrimonia eupatoria*, *Hypericum perforatum*, *Origanum vulgare* i *Pimpinella saxifraga*. Wśród taksonów ciepłolubnych obiektów archeologicznych Karpat Zachodnich dominują gatunki rodzime (94%) i hemikryptofity (64%). Stwierdzono również obecność 3 reliktów dawnych upraw: *Allium scorodoprasum*, *Lavatera thuringiaca* i *Origanum vulgare*.

Grodziska i zamczyska są ostoją wielu interesujących roślin naczyniowych, w tym także ciepłolubnych i kserotermicznych gatunków. Od lat postuluje się, by dawne warownie karpackie objąć właściwą formą ochrony ze względu na ich wysoką wartość kulturową, przyrodniczą i krajobrazową (1, 12, 13, 14, 15, 16).

Key words: thermophilous and xerothermic species, archaeological sites, earthworks, castle ruins, Western Carpathians, relics of cultivation

List of abbreviations: Ap – apophyte, Ar – archaeophyte, Kn – kenophyte, Sn – non-synanthropic spontaneophyte, Ch – woody chamaephyte, C – herbaceous chamaephyte, G – geophyte, H – hemicryptophyte, M – megaphanerophyte, N – nanophanerophyte, T – therophyte, F-B – *Festuco-Brometea*, T-G – *Trifolio-Geranietea*, R-P – *Rhamno-Prunetea*, K-C – *Koelerio-Corynephoretea*, Art – *Artemisietea vulgaris*, N-C – *Nardo-Callunetea*, Others: M-A – *Molinio-Arrhenatheretea*, Ep – *Epilobietea angustifolii*, Q-F – *Querco-Fagetea*, St – *Stellarietea mediae*

INTRODUCTION

This paper is a part of an extensive study concerning the plant cover of 37 archaeological sites (25 earthworks and 12 castle ruins) located in the Western Carpathians. All of them are the remnants of prehistoric and medieval strongholds. The earthwork is a site that was artificially fortified in the past by earthen or wooden banks. The castles were built of bricks or stone (9).

At present, the state of knowledge of the vegetation of the earthworks and the castle ruins in Poland is quite good and successfully developing. Studies on thermophilous plant species occurring

on the earthworks are also conducted but mainly in the northern Poland, e.g. by Dembicz and Sudnik-Wójcikowska (5) as well as Kamiński (6). However, information on xerothermic species in the flora of the chosen earthworks and castle ruins in the Western Carpathians is included in another work by Suder and Towpasz (13).

The presented study contains a list and ecological analysis of thermophilous and xerothermic species found within the investigated areas. The species were distinguished based on the author's own phytosociological studies.

MATERIAL AND METHODS

The investigations were conducted on 12 earthworks and 8 castle ruins in the Dunajec river valley, 2 castle ruins and 9 earthworks in the Raba river basin, and on 4 earthworks and 2 castle ruins in the Wisłoka river valley. Distribution of the studied areas is shown in Figure 1. The former Carpathian fortress objects [OK}occupy the peak elevation parts. They are characterized by the habitat mosaic of open and wooded areas. The investigated station was the earthwork or the castle ruin and the immediate surroundings of the object (the slopes of the hills). The studied areas were varied in size and ranged from 1.1 ha to 55 ha; dominated by objects with an area of 10 ha.

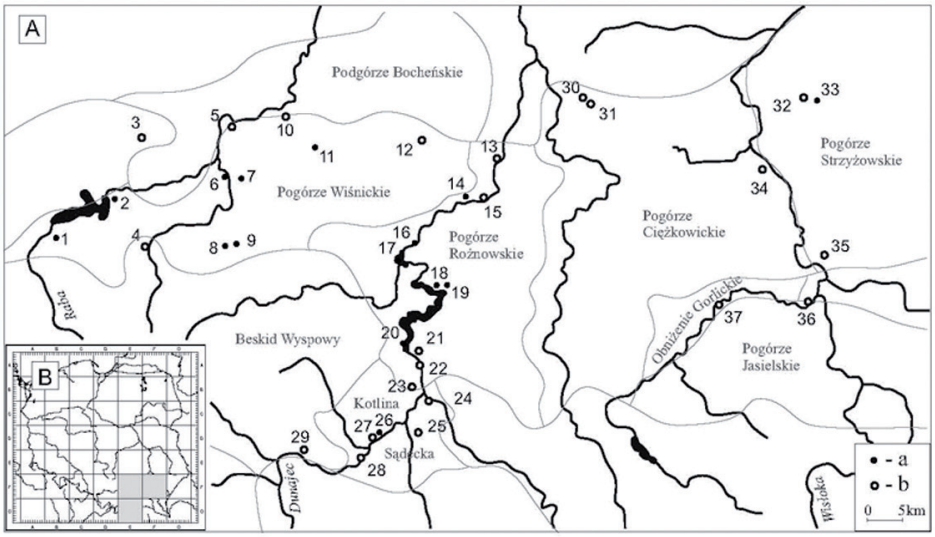

Fig. 1. Distribution of the investigated archaeological objects: A – against the background of physicogeographical regions according to Kondracki (7); B – acc. to ATPOL-square grid system; a – forest, wooded stands; b – non-forest, open stands chosen for this study.

1 – Myślenice, 2 – Dobczyce, 3 – Biskupice, 4 – Poznachowice Górne, 5 – Chełm, 6 – Chrostowa, 7 – Sobolów, 8 – Słupia, 9 – Tarnawa, 10 – Łapczyca, 11 – Kopaliny Pogwizdów, 12 – Jadowniki Bocheniec, 13 – Panieńska Góra, 14 – Melsztyn, 15 – Zawada Lanckorońska, 16 – Czchów, 17 – Wytrzyszczka, 18 – Rożnów Gryfitów, 19 – Rożnów Tarnowskich, 20 – Biała Woda, 21 – Kurów, 22 – Marcinkowice, 23 – Chełmiec Polski, 24 – Nowy Sącz, 25 – Biegonice, 26 – Podegrodzie Zamczysko, 27 – Podegrodzie Grobla, 28 – Naszacowice, 29 – Maszkowice, 30 – Tarnów, 31 – Zawada, 32 – Braciejowa Okop, 33 – Braciejowa Zamczysko, 34 – Przeczyca, 35 – Golesz, 36 – Trzcinica Wały, 37 – Biecz

Research material are floristic lists and phytosociological relevés conducted according to the Braun-Blanquet method (squares of 5m x 5m) taken during the vegetation seasons of 2006–2010. For the purposes of this study 196 phytosociological relevés were analysed, only from non-forest, open areas of 22 archaeological sites.

Frequency of the species was determined using a 4-point scale (Table 1). The following Table 2 contains only the thermophilous and xerothermic species. They are presented in alphabetical order and their nomenclature was given after Mirek et al. (11). Assignment to syntaxonomical groups was established according to Matuszkiewicz (10) and geographical-historical groups acc. to the works of various authors (2, 17, 18, 19, 20). Classification of synanthropic plants was given according to the Kornaś (8) and Celka (2) works. Relics of former cultivation were based on the study by Celka (3) and Raunkiaer's life forms by Zarzycki et al. (21).

Table 1. Description of the frequency categories of thermophilous plant species occurrence in the earthworks and castle ruins in the Western Carpathians

Frequency class	Frequency	No. of localities	%
I	very rare	1–2	<10%
II	rare	3–6	10,1–30%
III	frequent	7–13	30,1–60%
IV	common	14–22	60,1–100%

RESULTS AND DISCUSSION

82 thermophilous and xerothermic plant species were found in the studied fortress objects in the Western Carpathians (Table 2). Among them *Trifolium*, *Rosa* and *Campanula* are the richest genera. Together, they account for almost 15% of all recorded thermophilous species. Within other genera, 55 were represented by only one species.

Table 2. List of thermophilous species recorded within the investigated earthworks and castle ruins

Species	Syntaxonomical groups	Geographical-historical groups	Raunkiaer's life forms	Number of localities	Frequency classes
1	2	3	4	5	6
Acer campestre	R-P	Sn	M	7	III
Acinos arvensis	F-B	Sn	H,T	1	I
Agrimonia eupatoria	T-G	Sn	H	16	IV
Allium oleraceum	F-B	Sn	G	3	II
Allium scorodoprasum	F-B	Ar	G	3	II

1	2	3	4	5	6
Alyssum alyssoides	F-B	Sn	T	1	I
Astragalus cicer	T-G	Ap	H	1	I
Astragalus glycyphyllos	T-G	Sn	H	8	III
Betonica officinalis	F-B	Sn	H	3	II
Brachypodium pinnatum	F-B	Sn	H	8	III
Briza media	F-B	Sn	H	6	II
Campanula glomerata	F-B	Sn	H	2	I
Campanula persicifolia	F-B	Sn	H	1	I
Campanula rapunculoides	T-G	Sn	H	3	II
Centaurea scabiosa	F-B	Sn	H	12	III
Cerastium arvense	F-B	Sn	C	12	III
Cerinthe minor	F-B	Sn	H	1	I
Cichorium intybus	Art	Ar	H	9	III
Clinopodium vulgare	T-G	Sn	H	11	III
Cornus sanguinea	R-P	Sn	N	8	III
Coronilla varia	T-G	Sn	H	12	III
Crataegus monogyna	R-P	Sn	N	1	I
Crataegus rhipidophylla	R-P	Sn	N	6	II
Cuscuta epithymum	N-C	Sn	T	1	I
Danthonia decumbens	N-C	Sn	H	2	I
Dianthus armeria	F-B	Sn	H	2	I
Echium vulgare	Art	Sn	H	3	II
Erigeron acris	F-B	Sn	H,T	3	II
Euphorbia cyparissias	F-B	Sn	G,H	12	III
Euphorbia esula	St	Sn	H	10	III
Euphrasia rostkoviana	M-A	Sn	T	2	I
Festuca ovina	K-C	Sn	H	2	I
Filipendula vulgaris	F-B	Sn	H	1	I
Fragaria viridis	F-B	Sn	H	1	I
Galium verum	T-G	Sn	H	12	III
Genista tinctoria	N-C	Sn	Ch	4	II
Hieracium pilosella	N-C	Sn	H	4	II
Hypericum perforatum	F-B	Sn	H	17	IV

1	2	3	4	5	6
Jasione montana	K-C	Sn	H	2	I
Lathyrus tuberosus	F-B	Ar	H	4	II
Lavatera thuringiaca	F-B	Ar	H	1	I
Medicago falcata	F-B	Sn	H	13	III
Melampyrum nemorosum	T-G	Sn	T	5	II
Melilotus alba	Art	Sn	H,T	2	I
Melilotus officinalis	Art	Sn	H,T	6	II
Nepeta pannonica	F-B	Sn	C,H	3	II
Onobrychis viciifolia	F-B	Kn	H	1	I
Ononis arvensis	F-B	Sn	H,N	4	II
Origanum vulgare	T-G	Sn	C,H	14	IV
Pimpinella saxifraga	F-B	Sn	H	15	IV
Plantago media	F-B	Sn	H	6	II
Poa compressa	F-B	Sn	H	4	II
Polygala vulgaris	N-C	Sn	H	3	II
Potentilla argentea	K-C	Sn	H	3	II
Potentilla erecta	F-B	Sn	H	5	II
Primula veris	F-B	Sn	H	2	I
Prunus spinosa	R-P	Sn	N	11	III
Ranunculus polyanthemos	F-B	Sn	H	10	III
Rhamnus cathartica	R-P	Sn	N	1	I
Rosa canina	R-P	Sn	N	5	II
Rosa canina var. *dumalis*	R-P	Sn	N	1	I
Rosa gallica	Q-F	Sn	N	1	I
Salvia verticillata	F-B	Sn	H	5	II
Sanguisorba minor	F-B	Sn	H	1	I
Scabiosa ochroleuca	F-B	Sn	H	3	II
Sedum acre	K-C	Sn	C	1	I
Sedum maximum	F-B	Sn	G,H	5	II
Senecio jacobaea	F-B	Sn	H	9	III
Silene nutans	T-G	Sn	H	1	I
Thymus pulegioides	F-B	Sn	C	8	III
Tragopogon orientalis	M-A	Sn	H	4	II
Trifolium arvense	K-C	Sn	T	3	II
Trifolium aureum	K-C	Sn	H,T	1	I

1	2	3	4	5	6
Trifolium campestre	K-C	Sn	T	4	II
Trifolium medium	T-G	Sn	H	9	III
Trifolium montanum	F-B	Sn	H	1	I
Verbascum nigrum	Ep	Sn	H	1	I
Verbascum species	Art	Sn	H	7	III
Veronica teucrium	T-G	Sn	C	2	I
Vicia dumetorum	T-G	Sn	H	1	I
Viola hirta	T-G	Sn	H	1	I
Viscaria vulgaris	F-B	Sn	C,H	3	II

The average occurrence of 18 thermophilous plants was reported at individual stations. The least, just one thermophilous species (*Hypericum perforatum*), was found within the earthwork in Biskupice village (archaeological site No. 3). It is a wooded object of a small area. The largest objects are the earthworks in Poznachowice Górne (site No. 4), Jadowniki Bocheniec (site No. 12), Naszacowice (site No. 28), Zawada Lanckorońska (site No. 15) and Braciejowa Okop (site No. 32). These objects are also places where the participation of thermophilous species in plant communities was the highest. Within the studied area in Poznachowice Górne 43 thermophilous species were recorded, in Jadowniki 32, in Naszacowice as well as in Zawada Lanckorońska 31 and in Braciejowa Okop 26. The high number of thermophilous species is associated not only with a large area of the studied objects, but also with their habitat richness.

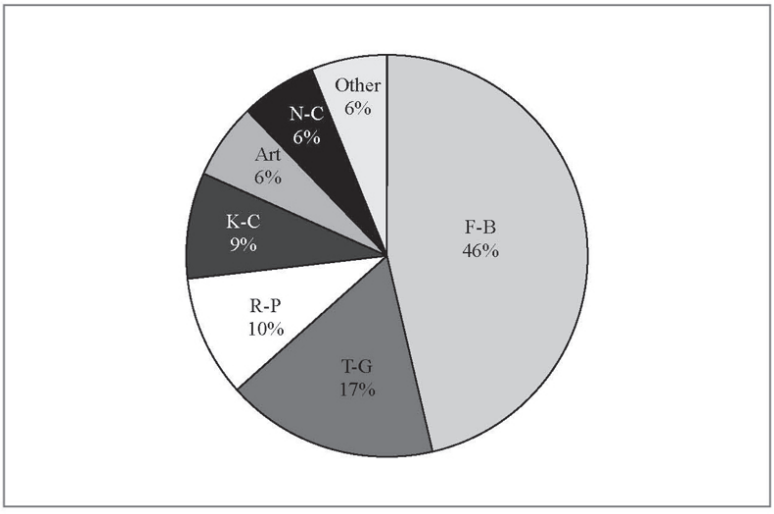

Fig. 2. Share of species belonging to the distinguished syntaxonomical groups in the total number of thermophilous species

The thermophilous and xerothermic plant species were assigned to 10 syntaxonomical classes (Fig. 2). Most plants belonged to the *Festuco-Brometea* class (46%). Also a significant share was accounted for by the species of *Trifolio-Geranietea* (17%), *Rhamno-Prunetea* (10%) and *Koelerio-Corynephoretea* (9%). The participation of other classes (*Artemisietea vulgaris*, *Nardo-Callunetea*, *Molinio-Arrhenatheretea*, *Epilobietea angustifolii*, *Querco-Fagetea*, *Stellarietea mediae*) was low.

The largest group, comprising more than half of all thermophilous taxa found in the Carpathian earthworks and castle ruins, were rare or very rare plant species which were noted at six or less studied areas (Fig. 3). There were only 4 common species: *Agrimonia eupatoria*, *Hypericum perforatum*, *Origanum vulgare* and *Pimpinella saxifraga*.

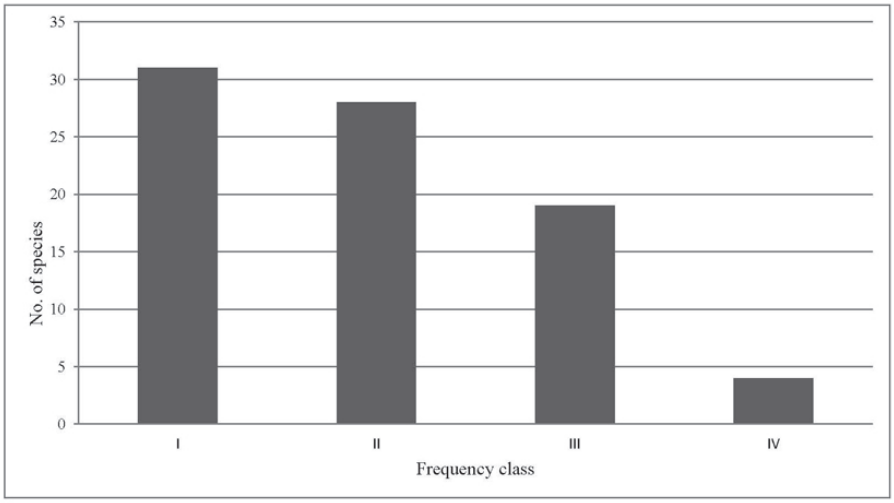

Fig. 3. Number of thermophilous species in the following frequency classes

Native taxa (94%) dominate over anthropophytes in the group of thermophilous taxa of the studied areas. Synanthropic flora consists of 6 species (including 1 apophyte – *Astragalus cicer*). Among alien species archaeophytes predominate: *Allium scorodoprasum*, *Cichorium intybus*, *Lathyrus tuberosus* and *Lavatera thuringiaca*. Only 1 kenophyte (*Onobrychis viciifolia*) was noted (Fig. 4). The flora of the earthworks of Wielkopolska is also dominated by native species (78%), but nearly half of them are apophytes (2). An exceptionally high index of flora synanthropization (over 70%) was assessed for two Masovian earthworks: "Błonie" and "Chlebnia". Apophytes have the largest share there (about 60%) (5). Differences in the degree of flora synanthropization are partially the result of using a different methodology by the authors of the studies. Celka (2), Dembicz and Sud-

nik-Wójcikowska (5) based the results of their research on an analysis of the total flora of investigated archaeological sites, but the results presented in this paper relate only to thermophilous species that have been recorded in phytosociological relevés from non-forest, open plant communities.

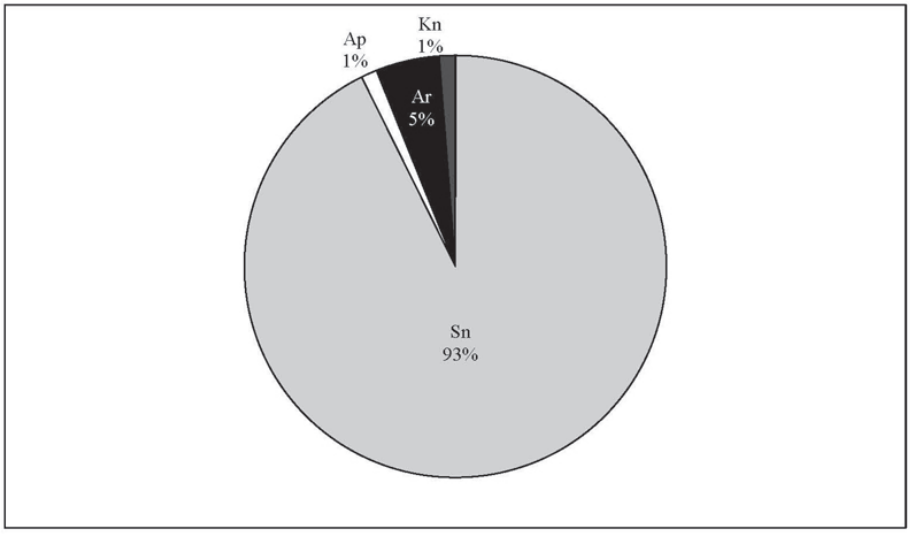

Fig. 4. Share of geographical-historical groups in the total number of thermophilous species

Analysing the spectrum of Raunkiaer's life forms among thermophilous plant species (Fig. 5) allows the distinction of 6 main groups: chamaephytes, geophytes, hemicryptophytes, megaphanerophytes, nanophanerophytes and therophytes. Just as in the flora of archaeological sites in the other regions of Poland, hemicryptophytes distinctly predominate with 64% share. Less numerous are therophytes (11 species), nanophanerophytes (9 species), herbaceous chamaephytes (7 species) and geophytes (4 species). Only one megaphanerophyte (*Acer campestre*) and woody chamaephyte (*Genista tinctoria*) were noted. Definitely the most common hemicryptophyte at the studied areas is *Hypericum perforatum*, while *Melilotus officinalis* is the most common therophyte and *Prunus spinosa* nanophanerophyte.

A group of cultivation relics, such as *Allium scorodoprasum*, *Lavatera thuringiaca* and *Origanum vulgare*, was also distinguished among thermophilous plant species. They are the phytoindicators of former strongholds and old settlements (4).

The prehistoric and medieval Carpathian fortresses are refuges for many interesting thermophilous and xerothermic species. For years, it has been postulated that the earthworks and castle ruins be protected due to their high cultural, natural and landscape value (1, 2, 12, 13, 14, 15, 16).

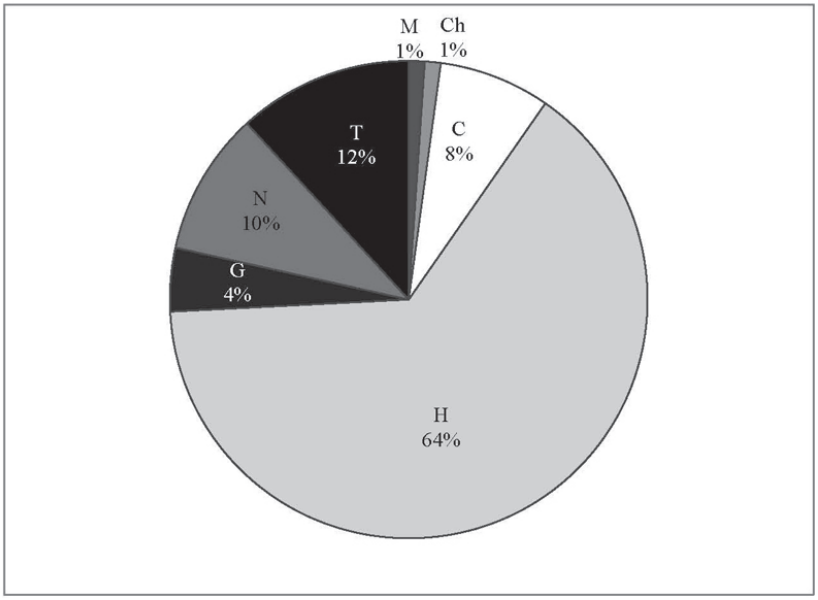

Fig. 5. Share of life form groups in the total number of thermophilous species

ACKNOWLEDGEMENTS

I would like to thank Krzysztof Suder for his helpful support during the study.

Scientific study financed from the resources earmarked for science in years 2010–2013 as the Research Project No. N N305 062839.

REFERENCES

1. Bartoszek W., Siatka D. 2008. Interesująca flora na górze Grodzisko w Beskidzie Wyspowym (Karpaty Zachodnie). Chrońmy Przyr. Ojcz. 64(4): 3–13.
2. Celka Z. 1999. Rośliny naczyniowe grodzisk Wielkopolski. Pr. Zakł. Takson. Roślin UAM w Poznaniu 9: 1–159.
3. Celka Z. 2005. Relikty dawnych upraw we współczesnej florze Polski. Bot. Guidebooks 28: 281–296.
4. Celka Z. 2007. Znaczenie badań nad współczesną florą naczyniową miejsc dawnego osadnictwa. In: Środowisko – Człowiek – Cywilizacja, tom 1. Seria wydawnicza Stowarzyszenia Archeologii Środowiskowej. Studia interdyscyplinarne nad środowiskiem i kulturą w Polsce. Makohonienko M., Makowiecki D., Kurnatowska Z. (eds), Bogucki Wydawnictwo Naukowe, Poznań, 221–231.
5. Dembicz I., Sudnik-Wójcikowska B. 2011. Flora i relikty upraw na grodziskach „Błonie" i „Chlebnia". In: Zróżnicowanie muraw kserotermicznych w Polsce. Streszczenia referatów i plakatów. Ogólnopolska Konferencja Naukowa, Lublin, 42–43.
6. Kamiński D. 2011. Ciepłolubne murawy na grodziskach wczesnośredniowiecznych ziemi chełmińskiej. In: Zróżnicowanie muraw kserotermicznych w Polsce. Streszczenia referatów i plakatów. Ogólnopolska Konferencja Naukowa, Lublin, 50–51.

7. Kondracki J. 2002. Geografia regionalna Polski. PWN, Warszawa.
8. Kornaś J. 1977. Analiza flor synantropijnych. Wiad. Bot. 21(2): 85–91.
9. Marszałek J. 1993. Katalog grodzisk i zamczysk w Karpatach. Wyd. Stanisław Kryciński, Warszawa.
10. Matuszkiewicz W. 2008. Przewodnik do oznaczania zbiorowisk roślinnych Polski. PWN, Warszawa.
11. Mirek Z., Piękoś-Mirkowa H., Zając A., Zając M. 2002. Flowering plants and pteridophytes of Poland – a checklist. In: Biodiversity of Poland 1. Mirek Z. (eds.), W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, 1–442.
12. Siatka D. 2008. Charakterystyka florystyczna stanowisk archeologicznych Chełm (Podgórze Bocheńskie) i Grodzisko (Beskid Wyspowy). MSc manuscript Instytut Botaniki Uniwersytetu Jagiellońskiego, Kraków.
13. Suder (Siatka) D., Towpasz K. 2010. Rośliny kserotermiczne grodzisk i zamczysk w dolinach Raby, Dunajca i Wisłoki. In: Ciepłolubne murawy w Polsce – stan zachowania i perspektywy ochrony. Ratyńska H., Waldon B. (eds.), Wydawnictwo Uniwersytetu Kazimierza Wielkiego, Bydgoszcz, 425–432.
14. Suder D., Towpasz K. 2010. Interesting species of vascular plants of the chosen earthworks and castles in the Raba, Dunajec and Wisłoka river valleys. Acta Soc. Bot. Pol. 79 (Suppl. 1): 56.
15. Suder D. 2010. Walory przyrodnicze grodziska w Chełmie na Podgórzu Bocheńskim (Kotlina Sandomierska) i jego otoczenia. Chrońmy Przyr. Ojcz. 66(6): 437–445.
16. Suder D. 2011. Trawy (*Poaceae*) we florze wybranych grodzisk i zamczysk w Karpatach Zachodnich. Fragm. Flor. Geobot. Polonica 18(2): 331–340.
17. Tokarska-Guzik B. 2005. The establishment and spread of alien plant species (kenophytes) in the flora of Poland. Pr. Nauk. Uniw. Śląskiego w Katowicach 2372: 1–192.
18. Zając A. 1979. Pochodzenie archeofitów występujących w Polsce. Rozpr. Habil. Uniw. Jagiell. 29: 1–213.
19. Zając A., Zając M., Tokarska-Guzik B. 1998. Kenophytes in the flora of Poland: list, status and origin. Phytocoenosis 10 (N.S.) Suppl. Cartogr. Geobot. 9: 107–116.
20. Zając M., Zając A. 1992. A tentative list of segetal and ruderal apophytes in Poland. Zesz. Nauk. Uniw. Jagiell., Pr. Bot. 24: 7–23.
21. Zarzycki K., Trzcińska-Tacik H., Różański W., Szeląg Z., Wołek J., Korzeniak U. 2002. Ecological indicator values of vascular plants of Poland. In: Biodiversity of Poland 2. Mirek Z. (eds.), W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, s. 1–183.