The population of *Malva alcea* at the medieval settlement: from distribution to the reproduction of individuals

Zbigniew CELKA, Maria DRAPIKOWSKA, Marlena LEMBICZ, Lidia KUBIAK & Piotr SZKUDLARZ

Abstract: *Malva alcea* is an old cultivated plant and its today's presence is related to the remains of the medieval settlements and anthropogenic settlements. In some regions of Central Europe it shows tendencies to spread from places of its former cultivation.

The article focuses on the distribution of *Malva alcea* individuals and on their reproduction at one of the medieval settlements in Western Poland. In 2000-2004, 63 specimens were found at this site. The majority of individuals grow on southern slopes and the top of the cone. In the highest section of the cone, there are multishoot perennials, whereas in the section bordering on the meadow, the dominant group are rosettes of lower leaves. The highest reproduction level was recorded in the fourth year of the research when the highest number of generative shoots was seen (10.79). In 2003, the average number of 321 fruits was recorded, while in 2004 it was 297 fruits. What is more, significant changes in seeds' size were recorded during the three years of examination. The largest seeds were observed during the first year of the research (10.47), the smallest ones in the final year (9.70). On the basis of the four-year long observation of *Malva alcea* carried out in the field, we believe that the plant's life strategy is not different from other perennial plants, i.e. with time the extent of reproduction increases. In the case of this species, the annual production of generative shoots and the large quantity of seeds producing young specimens ensure the survival of the population at the medieval settlement as well as its consequent spreading.

Key words: *Malva alcea*, earthwork, distribution, population, reproduction, variation, biometry

Introduction

The settlements are remains of defensive strongholds, surrounded by ground-wooden ramparts with a stockade and a moat (moats). Such structures were built in places difficult to access: on hills, at river junctions, on islands and among swamps. The oldest strongholds were built in the Neolithic period. A significant increase in the number of constructed strongholds in the Slavonic area took part in the early Middle Ages (7^{th}-8^{th} century) and lasted until the 15^{th} century. Strongholds were the centres of administrative, military, legal and fiscal authorities. Today, the estimated number of strongholds in Poland is more than 2,000.

In gardens situated by the strongholds, numerous cultivated plants were planted. Many of them have survived until today at settlements or in their direct vicinity. They are known as the relics of cultivated plants. Some of them include: *Allium scorodoprasum*, *Origanum vulgare*, *Lavatera thuringiaca, Leonurus cardiaca* and *Malva alcea*. Examination of such relics solves a lot of taxonomical and phytogeographical problems and broadens our knowledge of cultivated plants (Celka 2005). So far, among others, the distribution, site conditions, usable properties, and geographic and historical status of *Malva alcea* have been studied (e.g., Celka 1999; Celka & Drapikowska 2008). Currently, the subject of research is the existence of the relics of cultivated plants in the places of their former cultivation - by and at settlements. In this work, the first results of the research are presented, which was carried out to estimate the population size, distribution of individuals and their reproduction on the model structure – a medieval settlement.

Material and methods

Species studied

Malva alcea is a perennial reproducing through seeds. It is also possible for it to reproduce vegetatively through the division of the primary root, which, as it grows old, dies from the inside. The dense range of *Malva alcea* covers Central, partly Southern and Western Europe and Southern Scandinavia (Hultén & Fries 1986). Currently, its presence is strictly related to the remains of medieval settlements. Apart from such settlements, it can be found on the verges of forests and thickets, among ruderal vegetation, in dry and warm places, roadsides and boundary strips. In some parts of its range, it shows tendencies for dispersing from its former places of cultivation (Walas 1959; Celka 1999).

Field study

In 2000, for the study of the population of *Malva alcea,* a fixed area was marked at the medieval settlement in Daleszyn, at station 1 (Western Poland; N51°56`00.4``, E17°00`05.1``). The fortified settlement in Daleszyn was established and used in the 13th/14th century. Today, its remains cover the area of about 0.25 ha and are covered with xerothermic vegetation. Among the eighty-five recorded vascular plants, the following, among others, were observed: *Asparagus officinalis, Fragaria viridis, Euphorbia cypriarissias, Galium verum*, *Turritus glabra* and *Veronica spicata*. The moat surrounding the structure is used as a hay meadow. Such plants as e.g. *Alopecurus pratensis*, *Anthoxanthum odoratum, Cirsium oleraceum* and *Ranunculus acer* grow there.

On a fixed area, with the use of wooden poles, sixty-two mallow individuals were marked, of which thirty were young specimens which had not flowered yet, located in the lower part of the structure. In 2001-2002, thirty seeds were collected from each individual and the following measures were taken: length of a seed (trait 1), length of a thilum (2), width of a seed (3), width of a seed without a hilum (4), width of a hilum (5), and seed size (6). The seed size was determined as a ratio of the seed length and two widths (Olejniczak & Lembicz 2007). In 2000-2004, the specimens' reproduction was assessed using the total number of shoots (vegetative and generative, trait 7), fructifying shoots (8) and the number of fruits (9). In 2001, a part of marked individuals in the lower part of the fortified settlement was damaged together with poles.

Statistical analyses

The comparative analysis was carried out of the size of individuals' seeds in 2000-2002, and of the number of shoots and fruits – in 2001-2004. Variation analysis – ANOVA was carried out, and the results were illustrated with diagrams (Morrison 1990). To identify the relationship between the analysed traits, the Canonical Correlation Analysis CCA was used (Braak 1995). The results were tested with the Monte Carlo permutation tests. It amounted to CA=0.06303. The level of significance was at 0.05. All analyses were performed by STATISTICA 7.1 for Windows and CANOCO version 4 (Braak & Smilauer 1998).

Results

Distribution

The majority of *Malva alcea* individuals grow on the sun-exposed southern slopes (35 individuals) and the top of the cone (19 individuals). In the south-western part of the structure, there are eight individuals, and on the northern side no *Malva alcea* grows (Fig. 1). Several dozen mallow individuals were observed on the hay meadow surrounding the structure in the form of never flowering rosettes of ground leaves. In the top part of the cone, there are multishoot, oldest individuals, and in the part bordering on the meadow – younger, individuals with few shoots.

Reproduction

Shoots and fruits**.** Statistically relevant differences were observed in the production of the general number of shoots, generative shoots and fruits (Tab. 1 and 3). *M. alcea* produced the most of generative shoots in the fourth year of the studies, whereas of seeds – in the third year. Other statistically relevant differences between individuals were observed in the extent of reproduction (Tab. 1-3, Fig. 2). In the years in question, on most shoots, fruits developed. In each fruit there were 15-19 seeds recorded.

Tab. 1. The F statistics for the analysed traits in terms of differences between individuals in 2001-2002. F values given in boldface are statistically important at level p<0.01

Trait	Traits` description	F coefficient
1	length of a seed	**107.6**
2	length of a thilum	**520.7**
3	width of a seed	**69.6**
4	width of a seed without a hilum	1.3
5	width of a hilum	**77.5**
6	seed size	**47.4**
7	number of shoots	**10.76**
8	fructifying shoots	**11.71**
9	number of fruits	**21.46**

Tab. 2. Descriptive statistics for traits 1-6 in 2001 and 2002

Trait	Traits` description	Mean	Min.	Max.	St. Deviation
2001					
1	length of a seed	2.26	2.21	2.33	0.03
2	length of a thilum	0.27	0.23	0.30	0.02
3	width of a seed	1.93	1.89	1.96	0.02
4	width of a seed without a hilum	2.14	2.12	2.22	0.02
5	width of a hilum	1.73	1.68	1.76	0.02
6	seed size	10.47	10.05	11.49	0.30
2002					
1	length of a seed	2.19	2.16	2.22	0.02
2	length of a thilum	0.21	0.20	0.23	0.01
3	width of a seed	1.91	1.88	1.95	0.02
4	width of a seed without a hilum	2.08	2.06	2.12	0.02
5	width of a hilum	1.74	1.68	1.79	0.02
6	seed size	9.70	9.26	10.64	0.32

Tab. 3. Descriptive statistics for traits 7-9 in 2001-2004

Trait	Traits` description	Mean	Min.	Max.	St. Deviation
2001					
7	number of shoots	6.35	1.00	23.00	4.56
8	fructifying shoots	5.67	1.00	23.00	4.34
9	number of fruits	85.10	3.00	324.00	65.78
2002					
7	number of shoots	4.80	1.00	21.00	3.064
8	fructifying shoots	4.75	1.00	21.00	3.10
9	number of fruits	72.79	7.00	345.00	62.80
2003					
7	number of shoots	7.48	1.00	33.00	5.91
8	fructifying shoots	7.23	1.00	33.00	5.94
9	number of fruits	321.70	1.00	2220.00	374.35
2004					
7	number of shoots	10.80	1.00	36.00	8.29
8	fructifying shoots	10.80	1.00	36.00	8.29
9	number of fruits	297.67	5.00	880.00	256.79

The seed size. Relevant statistical differences in the size of seeds produced by the individuals were recorded in the subsequent years of research. The biggest seed size was observed in the first year of studies, and the smallest in the third year (Tab. 1, 3, Fig. 2).

Traits of the seed size vs. the number of shoots and fruits. On the basis of the canonical correlation analysis it was stated that there is a strong positive relationship between trait no. 4 (a seed's width without a hilum) and trait no. 8 (number of fructifying shoots), as well as between traits no. 1, 3 and 6 (a seed's length, width and size) and trait no. 7 (number of shoots). The number of fruits does not depend on other analysed traits (Fig. 3).

Discussion

The taxonomical and phytosociological studies as well as those focusing on the genetic variation of *Malvaceae* representatives, including *Malva alcea,* have been conducted all over the world in different scientific centres (Alverson et al. 1999; Brandes 2000, 2006; Celka et al. 2006a, 2006b; El Naggar 2004; Inamdar & Chohan 1969; Tate et al. 2005). We started the studies on the ecology of *Malva alcea* population with the assumption that recognition of the current population state, and most of all of the reproduction of its representatives and their distribution, is indispensable if we want to explain (1) the persistence of the population at the settlement and (2) dispersion of individuals to new habitats.

The population of *Malva alcea* at the settlement under study is made up of two groups of individuals: multishoot, several-year-old, and juvenile (one- or two-year-old), without shoots, in the form of rosettes of lower leaves. The first group permanently occupies the top part of the settlement and the second one colonizes the meadow neighbouring on the settlement. The meadow is probably colonized through seeds of the individuals growing in the top part of the settlement. The dispersion of single mallow individuals from their place of cultivation to neighbouring ruderal and seminatural habitats was also observed in Poland, the Czech Republic, Germany and Ukraine (among others, Bauch 1937; Celka & Drapikowska 2008).

During their lifetime, *Malva alcea* individuals increase the number of shoots and almost every shoot becomes a generative shoot. It is a characteristic life strategy of perennials (Falińska 2004). It allows an individual to maintain the place it occupies for a very long time. Each individual increases its area; consequently they form patches within the population. It prevents the possibility of development of new individuals from seeds. This is probably why the young individuals of *Malva alcea* grow on the settlement fringes. They usually take the form of low rosettes and rarely propagate generatively. This may also be the result of meadow mowing.

Assuming that the seed size is the measure of investment a plant makes for generative reproduction, *Malva alcea* produces a large number of relatively small seeds. An individual may produce up to 5,500 seeds a year (the studied specimens produced 1,630 seeds on average every year). When comparing the traits of seeds from Central Europe (Celka et al. 2006b) with the data obtained from the site in question, the extent of variability of the traits studied in the population from Daleszyn is bigger.

Summing up, the *Malva alcea* population occupies the settlement permanently, and young individuals colonize new habitats. The settlement if a special island for *Malva alcea*, where it creates multishoot individuals that propagate generatively. Probably *Malva alcea* creates a bank of seeds which can be used when a space is available after an individual dies. However this issue requires further studies.

Acknowledgments

Scientific work partially financed from the resources earmarked for science in years 2005-2008 as the Research Project no. 2 P04G 050 29.

References

Alverson W. S., Whitlock B. A., Nyffeler R., Bayer C. & Baum D. A. 1999. Phylogeny of the core Malvales: evidence from ndhF sequence data. American Journal of Botany, 86 (10): 1474-1486.

Bauch R. 1937. Vorzeitliche und frühzeitliche Kulturrelikte in der Pflanzenwelt Mecklenburgs. Beih Botan Centralbl B 57: 77-138.

Braak ter C. J. F. 1995. Ordination. In: R. H. G. Jongman, C. J. F. ter Braak & O. F. R. van Tongeren (eds.). Data analysis in community and landscape ecology, pp. 109-115. Cambridge University Press, Cambridge,

Braak ter C. J. F. & Smilauer P. 1998. CANOCO reference manual and user's guide to Canoco for Windows: software for canonical community ordination (version 4). Microcomputer Power, Ithaca, USA.

Brandes D. 2000. *Lavatera thuringiaca* L. und ihre Vergesellschaftung im Harzvorland (Deutschland). Braunschweiger Naturkundliche Schriften 6(1): 219-225

Brandes D. 2006. Zur Ökologie und Vergesellschaftung von *Althaea officinalis* L. im Binnenland Mitteleuropas. In: Althaea officinalis im Binnenland Mitteleuropas, pp. 1- 8. Http://www.ruderal-vegetation.de/

Celka Z. 1999. Rośliny naczyniowe grodzisk Wielkopolski. Prace Zakładu Taksonomii Roślin UAM w Poznaniu, 9: 1-159. Bogucki Wyd. Naukowe, Poznań.

Celka Z. 2005. Relikty dawnych upraw we współczesnej florze Polski. W: Wasylikowa K., Lityńska-Zając M., Bieniek A. (red.). Roślinne ślady człowieka. Botanical Guidebooks, 28: 281-296.

Celka Z. & Drapikowska M. 2008. Relics of cultivation in Central Europe: *Malva alcea* L. as an example. Veget. Hist. Archaeobot. http://www.springerlink.com/content/h031j13318032725

Celka Z., Drapikowska M., Buczkowska K., Bączkiewicz A. & Marciniak J. 2006a. Morphological variability of *Malva alcea* L. populations from Poland. In: Kočárek P., Plášek V. & Malachová K. (eds.). Environmental changes and biological assessment. III. Scripta Facultatis Rerum Naturalium Universitatis Ostraviensis, 163: 159-165.

Celka Z., Szkudlarz P. & Biereżnoj U. 2006b. Morphological variation of hairs in *Malva alcea* L. (Malvaceae). Biodiv. Res. Conserv. 3-4: 258-261.

El Naggar S. M. 2004. Pollen Morphology of Egyptian Malvaceae: An Assessment of Taxonomic Value. Turk. J. Bot., 28: 227-240.

Falińska K. 2004. Ekologia roślin. 512 pp. Wyd. Nauk. PWN, Warszawa.

Hultén E. & Fries M. 1986. Atlas of North European vascular plants. North of the Tropic of Cancer. I-III. xvi+1172 pp. Koeltz Scientific Books, Königstein.

Inamdar J. A. & Chohan A. J. 1969. Epidermal Structure and Stomatal development in some Malvaceae and Bombacaceae. Oxford Journal - Annals of Botany, 33: 865-878.

Morrison D. F. 1990. Multivariate statistic analysis. PWN, Warszawa.

Olejniczak P. & Lembicz M. 2007. Age-specific response of the grass *Puccinellia distans* to the presence of a fungal endophyte. Oecologia, 152(3): 485-494.

Tate J. A., Aguilar J. F., Wagstaff S. J., La Duke J. C., Bodo Slotta T. A. & Simpson B. B. 2005. Phylogenetic relationships within the tribe Malveae (Malvaceae, subfamily Malvoideae) as inferred from ITS sequence data. American Journal of Botany, 92 (4): 584-602.

Walas J. 1959. *Malvaceae,* Ślazowate. W: Szafer W., Pawłowski B. (red.). Flora polska. Rośliny naczyniowe Polski i ziem ościennych, 8:278-301. PWN, Warszawa.

Zbigniew Celka, Marlena Lembicz, Piotr Szkudlarz
Department of Plant Taxonomy, Faculty of Biology, Adam Mickiewicz University, Umultowska 89, 61-614 Poznań, Poland,
e-mail: zcelka@amu.edu.pl

Maria Drapikowska
Department of Ecology and Environmental Protection, University of Life Sciences in Poznań, Piątkowska 94, 61-691 Poznań, Poland

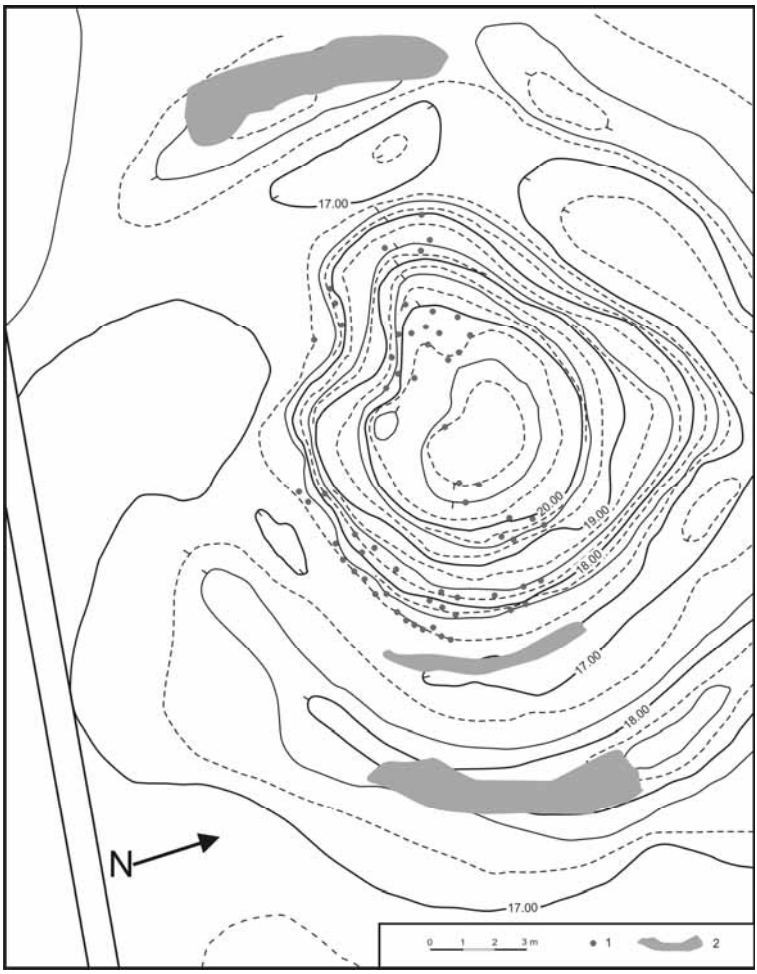

Fig. 1. Distribution of *Malva alcea* individuals in the fortified settlement in Daleszyn site 1.

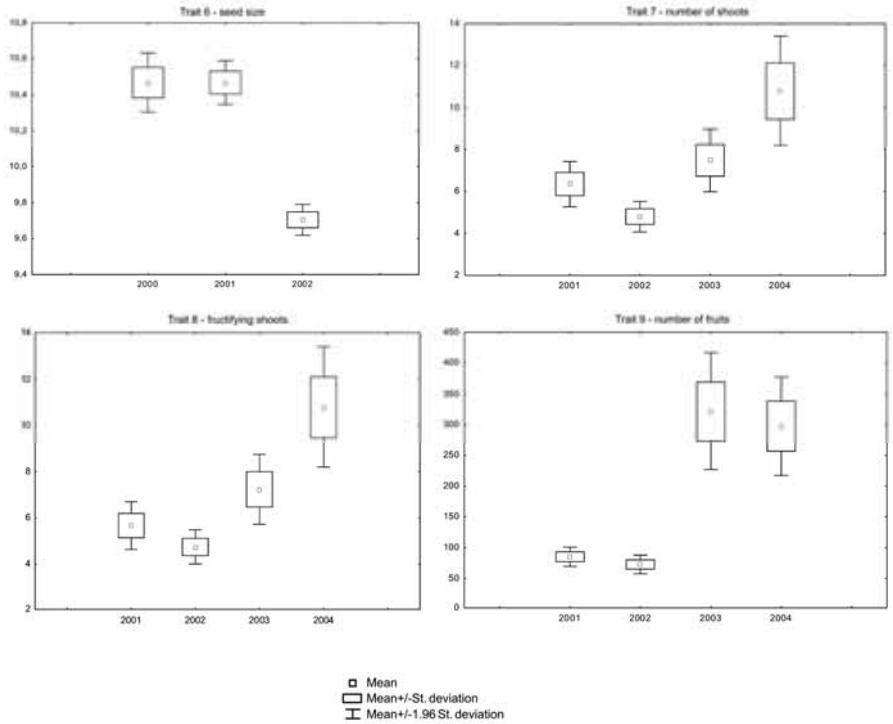

Fig. 2. Box plots for comparing populations of *Malva alcea* according to 4 traits.

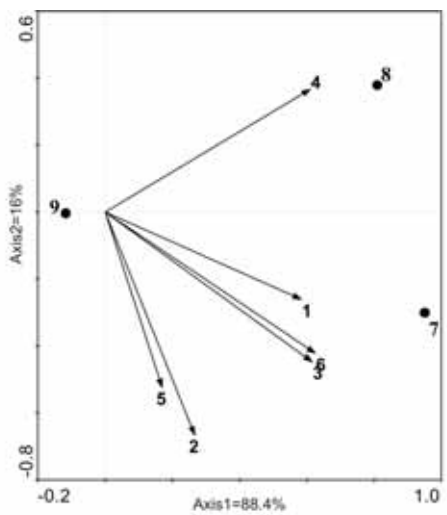

Fig. 3. Graphic picture of the canonical correlation analysis (CCA) of seed size-related traits (arrows, traits 1-6) and traits related to the number of shoots and fruits (points, traits 7-9).