

LAVATERA THURINGIACA L. — A RELICT OF FORMER CULTIVATION ON AN HISTORIC EARTHWORK IN POLAND: DISTRIBUTION AND REPRODUCTION OF INDIVIDUALS

Key words: *Lavatera thuringiaca*, Malvaceae, *relict of cultivation*, *earthwork*, *variation*, *biometry*

Abstract. *Lavatera thuringiaca* L. (*Malvaceae*) is considered to be a relict of medieval cultivation, connected in its contemporary distribution with the remnants of former settlements and anthropogenic habitats. The paper presents the distribution of *L. thuringiaca* individuals on the historic earthwork in Western Poland (Kórnik locality 2a) and variation in the selected individual characteristics. In the years 2001–2004, a total of 323 specimens were recorded. All the specimens were growing on the earthwork slope with southern exposure. The cessation of agricultural use of the central part of the object made it possible for *L. thuringiaca* to colonize the area. The highest reproduction rate was found for the specimens in the second year of the study, as at that time the biggest number of generative roots was recorded. In 2002, the highest mean number of fruits (289) was observed. In the following years this number was smaller, in 2003 amounting to 149 and in 2004 to 141 specimens. Significant changes were also found in seed size during the four years of observations. The biggest seeds were observed in the first year of analyses (5.18), while the smallest in the last year (4.94). In our opinion, on the basis of the 4-year in-situ observations of *L. thuringiaca*, the life strategy of this species is not different from that of other perennial plants. Annual production of generative shoots and a high number of seeds ensure the persistence of the population of this species on the earthwork and the possibility of its spread under advantageous conditions.

Introduction

Early medieval Slavic settlement in Central Europe was connected with the construction of characteristic fortifications — fortified towns. They served important functions in the administrative, legislative and military structures of their states. Their contemporary remnants, called earthworks [Polish «grodzisko»], located in isolated sites, are habitats for many interesting plant species. Studies on the vegetation cover of these historic earthworks and on species cultivated in the Middle Ages were conducted for many years by, among others, Celka (1999, 2004), Russow (2002) and Kamiński (2006).

Lavatera thuringiaca L. is one of the species grown in the Middle Ages, currently considered a relict of former

cultivation. It was used as a medicinal plant, in the production of pigments, as an ornamental plant and a food crop, as well as raw material in the production of ropes and strings (Celka, 2000). The persistence of *L. thuringiaca* in sites of medieval settlement was a justification for the initiation of studies on the biology of individuals and populations of this species. It is the expectation of the authors that an analysis of the distribution patterns of individuals on the earthworks, the manner of their reproduction and the number of offspring will facilitate the explanation for the persistence of the population of this taxon in these medieval sites in space. Our investigations supplement the presently conducted analyses on *L. thuringiaca* and other species of the family *Malvaceae* carried out in different research centers worldwide. These refer to phytosociological studies (Brandes, 2000, 2006), taxonomic analyses (Ray, 2005, 2008), morphological diversification (Celka et al., 2006; Shaheen et al., 2009a, 2009b, 2009c, 2010) and genetic variation (e.g. Alverson et al., 1999, Tate et al., 2005; Garcia et al., 2009).

Materials and methods

SPECIES STUDIED

Lavatera thuringiaca L. (*Malvaceae*) is found in a wide belt extending from the Adriatic Sea to central Siberia. The northern limit of its range extends roughly along 55° north latitude. Localities of this species separated from the compact range are scattered in central Europe and southern Scandinavia. The southern limit of its range is restricted by the shorelines of the Black Sea, the Caspian Sea and Lake Aral, and the Caucasus (Hultén, Fries, 1986). This species is found most frequently in thermophilous grassland communities with *Festuco-Brometea* and thermophilous ruderal communities with *Onopordion acanthii* (Brandes, 2000; Zarzycki et al., 2002). *Lavatera thuringiaca* is considered a rare species in Poland (Zajac, Zajac, 2001) and in the Wielkopolska region (Żukowski et al., 2001).



Fig. 1. The location of the studied locality in Poland

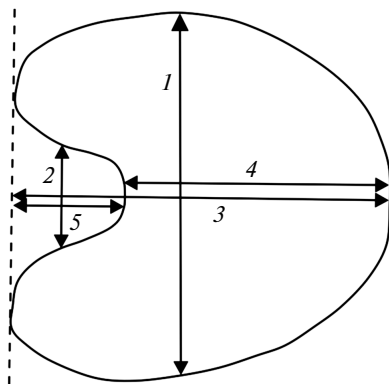


Fig. 2. *Lavatera thuringiaca* seed with traits subject to examination. Explanations: 1 — seed length, 2 — chalaza length, 3 — seed width, 4 — seed width without chalaza, 5 — chalaza width

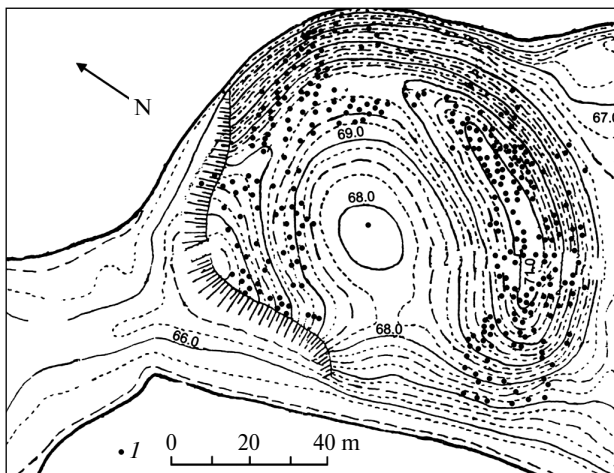


Fig. 3. Distribution of *Lavatera thuringiaca* individuals (I) in the fortified settlement in Kórnik site 2a

Lavatera thuringiaca exhibits characteristics of root (rhizophytes) and root-stem perennials (rhizocaulophytes). It forms a large root with numerous lateral roots, which as a result of dying out of the plant centre with ageing may lead to the vegetative plant division (Łukasiewicz, 1962).

OBSERVATION IN THE FIELD

In 2001, a permanent plot for the studies on *L. thuringiaca* was designated on the grounds of a model medieval earthwork in Kórnik, in site 2a (western Poland; N52°13'37.2" E17°06'04.8"; Fig. 1). The earthwork is situated about 23 km to the south-east of Poznań, in the vicinity of an inlet between lakes Bnińskie and Kórnickie, on a peninsula. The whole archeological complex consists of three parts: a conical earthwork (Kórnik, site 1), the already mentioned concave earthwork (Kórnik, site 2a), and the adjacent settlement (Kórnik, site 2b). In this area, colonization proceeded over two periods: from the 6th to 5th century B.C., in the period of the so-called Lusatian Culture, and in the early Middle Ages — from the 10th to 13th century A.D. (Žak, 1975; Fogel, 2007).

In total, there were 170 vascular plant species recorded on the peninsula. For a long time the inner area of the concave earthwork (Kórnik, site 2a) was under cultivation. It was not until 2003 that all human activity has been suspended. The earthwork's embankments are overgrown mainly by *Phragmites australis* (Cav.) Trin. ex Steud., in some places with the high participation of *L. thuringiaca*. Among xerothermic plants there are such species as *Asparagus officinalis* L., *Astragalus cicer* L. and *Verbascum lychnitis* L. The group of weeds is represented by *Avena fatua* L., *Datura stramonium* L. and *Melandrium noctiflorum* (L.) Fr. (*Elisanthe noctiflora* (L.) Rupr., *Silene noctiflora* L.). In a meadow situated between the earthworks we may find, among others, *Carex nemorosa*, *Eleocharis uniglumis* (Link) Schult., *E. palustris* (L.) Roem. & Schult., *Triglochin palustris* L., *T. maritima* L., *Caltha palustris* L., and *Ranunculus acris* L. On a pathway beside the earthwork grows the halophytic grass, *Puccinellia distans* (Jacq.) Parl.. Apart from *L. thuringiaca*, *Allium scorodoprasum* L. is also present in relatively high numbers.

MEASUREMENTS

In 2001 in the study plot, 60 individuals of *Lavatera* were identified. Thirty of them were juveniles, with only 1–3 stems, the remaining individuals were mature plants with numerous stems. In 2001–2004, 30 seeds were collected and the following measurements were taken: seed length, chalaza length, seed width, and seed width with-

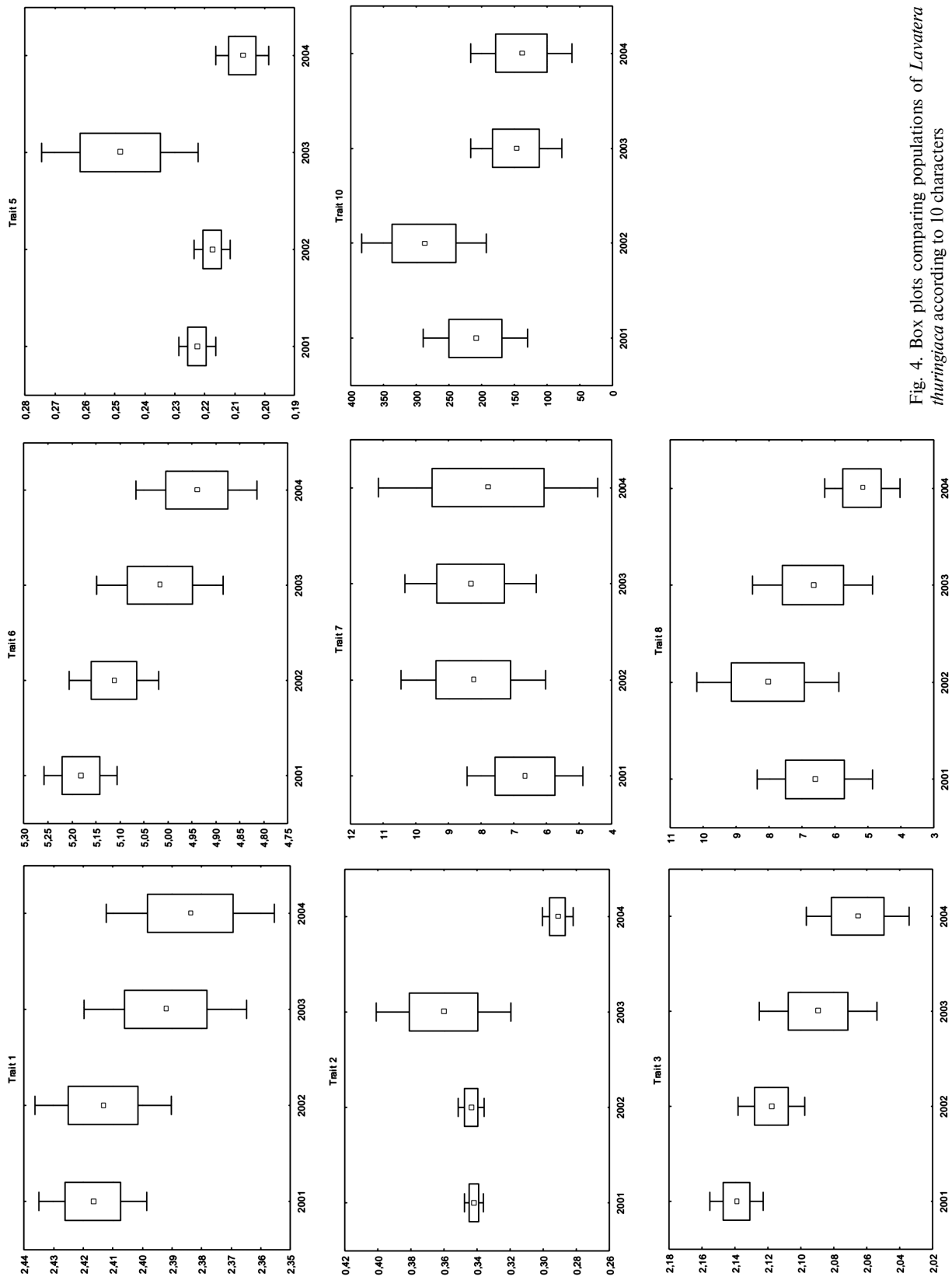


Fig. 4. Box plots comparing populations of *Lavatera thuringiaca* according to 10 characters

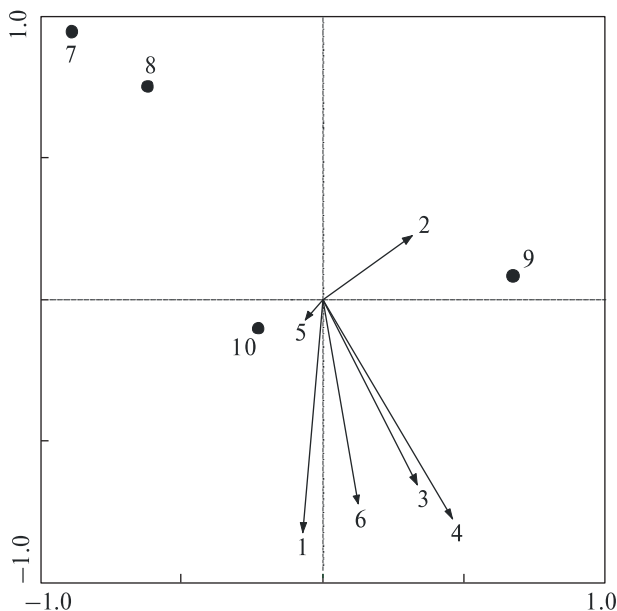


Fig. 5. Graphic picture of the canonical correlation analysis (CCA) of seed size-related traits (arrows, traits 1–6) and traits related to the number of shoots, flowers and fruits (points, traits 7–10)

out chalaza (Fig. 2). In 2000–2004 the recorded parameters included also the observed developmental stages of an individual (generative and vegetative), the number of flowering and fruiting shoots and the number of flowers and fruits.

STATISTICAL ANALYSES

The results of measurements were used in the comparative analysis of individuals in 2001–2004. An analysis of vari-

Analysis of variance (ANOVA) of *Lavatera* populations for 10 traits. F values given in boldface are statistically important level $p < 0.01$

Trait	F
1 – seed length	1.63
2 – chalaza length	7.41
3 – seed width	5.48
4 – seed width without chalaza	11.35
5 – chalaza width	5.55
6 – seed size	3.59
7 – number of shoots	0.30
8 – number of fruiting shoots	1.7
9 – number of flowers	13.59
10 – numebr of fruits	2.78

ance (ANOVA) was carried out and the results were illustrated with diagrams. To identify the relationship between the analysed features, the Canonical Correlation Analysis (CCA) was used. All analyses were performed by STATISTICA 7.1 for Windows and CANOCO version 4.

Results

DISTRIBUTION

Most individuals of *Lavatera thuringiaca* occurred on insolated southern slopes of the studied earthwork. In turn, *L. thuringiaca* has not been found in the central part of the earthwork, i.e. in the cultivated depression. In 2003, when this area ceased to be used agriculturally, the first single specimens of *Lavatera* appeared (Fig. 3). A total of 323 specimens were recorded on the earthwork. They were mostly large plants, several years old and composed of many shoots.

VARIATION IN SELECTED TRAITS

On the basis of the analysis of variance, the coefficient F was calculated and the level of statistical significance for traits 1–5 was established (Table). Statistically significant differences were found between the years of the study. Box-and-whisker diagrams show the average values of traits in particular years. In the years 2003 and 2004 the mean values of the following traits were lower than those in the years 2001 and 2002: seed length (trait 1), seed and chalaza width (3 and 4), seed size (6) and the number of flowers (9) and fruits (10) (Fig. 4).

On the basis of canonical correlation analysis it has been found that there is a strong positive relationship between trait no. 10 and traits no. 1 and 5, and between trait 9 and traits 2, 3 and 4. The number of shoots and the number of fructifying shoots (traits 7 and 8) do not depend on other investigated traits. The results were analysed with the Monte Carlo permutation tests. Their value amounted to $CA=0.06303$. The level of significance was established at 0.05 (Fig. 5).

Discussion

Our investigations show that the persistence of the population of *Lavatera thuringiaca* on the studied historic earthworks is possible due to (1) the ability of individuals to ensure relatively high reproduction rates (expressed by both the number of generative shoots and the size of seeds produced by these shoots) and (2) the presence in the population of individuals varying in terms of their age, with the predominance of large plants, forming many shoots and being several years old.

Individuals of *L. thuringiaca* increase the number of shoots throughout their lives and almost each shoot becomes a generative shoot. It is a characteristic life strategy for perennial plants (Falińska, 2004). This makes it possible for an individual to occupy a once colonized site over a period of many years. The plants increase their area of occupancy, which results in their occurrence in the population in the form of phytocenoses. Young individuals are composed of 2–3 shoots, but also start to reproduce. Earthworks were not mowed and for this reason specimens found only in the form of leaf rosettes were not observed, while it was the case in the population of another relict of former cultivation, i.e. *Malva alcea* L., growing on the earthwork in Daleszyn (see Celka et al., 2008). The cessation of agricultural use of the earthwork depression in Kórnik site 2a in 2003 resulted in the appearance of juvenile specimens of *L. thuringiaca*.

The seed size is treated as an indicator of an adaptation strategy of plants to their living conditions. The seed size is an indirect measure of a plant's investment in generative reproduction. *Lavatera thuringiaca* produces a large number of relatively small seeds. A single *Lavatera* plant may produce up to 41000 seeds per year (the individuals in question produced on average 3200 seeds per year).

The distribution of *L. thuringiaca* individuals on the fortified structure in question matches the biological features of the species and displays the cluster pattern. On sun-exposed southern slopes, *Lavatera* was observed also in other fortified settlements in Poland (Ceynowa-Giełdon, Kamiński, 2004; Towpasz, Kotańska, 2005). Moreover, spreading of individuals from places of the species cultivation to neighbouring ruderal and semi-natural sites has been observed both in Poland and Ukraine (Celka, 2000; Kagalo et al., 2004; Towpasz, 2006; Shevera et al., 2010).

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LAVATERA THURINGIACA L. — РЕЛИКТ КОЛИШНЬОЇ КУЛЬТУРИ НА ІСТОРИЧНИХ ГОРОДИЩАХ У ПОЛЬЩІ: ПОШИРЕННЯ ТА ВІДТВОРЕННЯ ОСОБИН

Вид *Lavatera thuringiaca* L. (*Malvaceae*) вважається середньовічним реліктом культури, пов'язаним із сучасними залишками колишніх поселень і антропогенних оселищ. У статті подано відомості про поширення *L. thuringiaca* в районі історичного землеробства в Західній Польщі (Курнік, 2а) та варіювання окремих ознак. Протягом 2001—2004 рр. виявлено 323 місцезнаходження; усі особини росли на схилах південної експозиції. Припинення сільськогосподарського використання центральної частини досліджуваної території дозволило *L. thuringiaca* колонізувати її. Найвищий коефіцієнт відтворення був відзначений в особин на другий рік досліджен-

ня, оскільки саме тоді зафіксовано найбільшу кількість генеративних пагонів. У 2002 р. спостерігалася висока кількість плодів (289). У наступних роках це число зменшилося і у 2003 р. знизилося до 149, а в 2004 — до 141. Значні зміни виявлені також у розмірах насіння протягом чотирьох років спостережень. Велике насіння відзначено в перший рік аналізу (5,18), тоді як менше — в останній рік (4,94). На нашу думку, що базується на чотирирічних спостереженнях *in-situ* *L. thuringiaca*, життєва стратегія виду не відрізнялася від інших багаторічних рослин. Річне поновлення генеративних пагонів і висока насіннева продуктивність забезпечили збереження популяції цього виду на оброблюваних землях і можливість його поширення за сприятливих умов.

Ключові слова: *Lavatera thuringiaca*, *Malvaceae*, релікт культивування, землеробство, міллівість, біометрія.

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Lavatera thuringiaca L. (*Malvaceae*) считается средневековым реликтом культивирования, связанным с современным распределением остатков бывших поселений и антропогенных местообитаний. В статье приведены данные о распространении *L. thuringiaca* в районе исторического земледелия в Западной Польше (Курник, 2а) и вариировании отдельных признаков. В течении 2001—2004 годов было отмечено 323 местонахождения; все особи росли на склонах южной экспозиции. Прекращение сельскохозяйственного использования центральной части исследованной территории позволило *L. thuringiaca* колонизировать ее. Наивысший коэффициент возобновления был отмечен у особей на второй год исследования, поскольку в это время зафиксировано наибольшее число генеративных побегов. В 2002 г. наблюдалось высокое количество плодов (289). В последующие годы это число уменьшилось и в 2003 г. снизилось до 149, а в 2004 — 141. Существенные изменения наблюдались также в размерах семян в течение четырех лет. Большие семена отмечены в первый год анализа (5,18), тогда как меньшие — в последний год (4,94). По нашему мнению, базирующемуся на четырехлетних наблюдениях *in-situ* *L. thuringiaca*, жизненная стратегия вида не отличалась от других многолетних растений. Годовые возобновления генеративных побегов и высокая семенная продуктивность обеспечили сохранение популяций этого вида на обрабатываемых землях и возможность его распространения в благоприятных условиях.

Ключевые слова: *Lavatera thuringiaca*, *Malvaceae*, релікт культивування, земледіліє, змієнчівість, біометрія.