

## Acquisition and ecological characterization of *Lactuca serriola* L. germplasm collected in the Czech Republic, Germany, the Netherlands and United Kingdom

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### Abstract

Expeditions were conducted in the Czech Republic, Germany, the Netherlands and United Kingdom in 2001 (partly 1998) to study *Lactuca serriola* L. (prickly lettuce, compass plant) geographic distribution, ecology, habitat characteristics and occurrence of diseases and pests on this species. During these missions the seed material of *L. serriola* L. was collected in an east–west transect of these four countries. The European transect where seeds were collected and field observations were made represents a relatively large area between 2°34'50" W–17°32'46" E and 47°40'42"–54°04'19" N. The seed material was used for regeneration, inclusion in the national genetic resources collections of individual countries and for research purposes in follow-up studies. During the missions, 50 locations with occurrence of *L. serriola* L. were visited (16 in Czech Republic and Germany, 10 in UK and 8 in the Netherlands). Individual seed lots of sixteen different plants were collected at each location (*L. serriola* L. population). Thus, in total 800 seed samples were collected. In Czech Republic and Germany *L. serriola* L. f. *serriola* dominated in all observed populations, in the Netherlands both f. *serriola* and f. *integrifolia* occurred in pure or mixed stands, whereas in the United Kingdom *L. serriola* L. f. *integrifolia* (S.F. Gray) S.D. Prince et R.N. Carter was dominant. *L. serriola* L. was recorded at various altitudes (–4 to 410 m), different habitats (ditches, along roads, fields and field margins, ruderal places, pavements and parking sites, fallow fields), individual populations varied substantially in size (20 to >1000 plants), area covered (25–10,000 m<sup>2</sup>), and the structure and character of associated plant communities. Natural infections by downy mildew (*Bremia lactucae* Regel) and powdery mildew (*Golovinomyces cichoracearum* (DC.) V.P. Gelyuta) were observed in some populations. *B. lactucae* Regel was recorded only in Czech Republic, *G. cichoracearum* (DC.) V.P. Gelyuta was more common in continental Europe. General and specific aspects of *L. serriola* L. geographic distribution and ecology are discussed.

## Introduction

*Lactuca serriola* L. (prickly lettuce, compass plant) is a winter or summer annual, a meridional-temperate, west-euroasiatic species, although it has a synanthropic world-wide distribution nowadays (Lebeda et al. 2004b). The taxon displays large morphological, geographic and genetic variation, and ranges over a wide spectrum of different habitats (Feráková 1977; Lebeda et al. 2001, 2004b). There are two forms within *L. serriola* L., namely *L. serriola* L. f. *serriola* and *L. serriola* L. f. *integrifolia* (S.F. Gray) S.D. Prince et R. N. Carter (Lebeda et al. 2004b). Recently *L. serriola* L. has spread throughout Europe as an invasive weed (Brant et al. 2000; Lebeda et al. 2004b). It is considered as a progenitor of cultivated lettuce (*Lactuca sativa* L.) (De Vries 1997).

Crop genetic diversity is the principal element of agricultural systems and without it, no evolutionary change of these systems to varying biotic and abiotic factors would be possible (Laghetti and Hammer 2004). Progenitors of cultivated crops are of a great importance for disease resistance research and practical breeding exploitation owing to their broad genetic variability (Lenné and Wood 1991). These wild relatives of globally important crops provide new sources of resistance to diseases and pests, abiotic factors, as well as genes responsible for physiological and quality characters. Genetic resources of wild *Lactuca* L. spp., including *L. serriola* L. (Lebeda et al. 2004a) have been used in commercial lettuce breeding for more than 60 years, especially as sources of race-specific resistance genes against lettuce downy mildew (*Bremia lactucae* Regel) (Lebeda et al. 2002; Reinink 1999).

However, currently there is limited knowledge about the complex variation of *L. serriola* L. germplasm originating from natural populations collected from various geographical areas and ecological conditions. Plant material and information obtained during collecting expeditions contributes to the enrichment of knowledge on the complex variability of *L. serriola* L. and enhances the possibility of utilization through the study of biodiversity, ecobiology, clarification of the taxonomic status, the structure and dynamics of natural populations, genetic variation and broadening of *Lactuca* L. germplasm in genebank collections (Lebeda et al. 2001).

The aim of the current work was to study the ecogeographic distribution of *L. serriola* L. in four European countries and to characterize the plants and the populations in their natural habitats. The collected seed material was used for characterization and evaluation purposes in follow-up studies and was included in the national germplasm collections (Czech Republic, Germany, the Netherlands and UK; for details see addresses of authors) for potential exploitation in lettuce breeding.

## Material and methods

Achievement of the aims of the present study required seed samples from individual plants from different *L. serriola* L. populations covering an east–west transect of the European distribution area, and availability of accurate collecting data of the populations. Collecting missions were undertaken in the Czech Republic (16 populations), Germany (16 populations), the Netherlands (5 populations; 3 populations, maintained as CGN genebank accessions, were sampled from August to September 1998 in the Netherlands) and the United Kingdom (10 populations) from August to October 2001 to obtain a total of 50 populations representing the target geographic area (Figure 1 and Table 1).

Seed of 16 plants were collected separately for each population. Passport data were recorded following the collecting protocol developed for the project, including name of collecting organization and collector(s), information on seed sample (sample number, collecting date, botanical name and population size), collecting site (country, province, district, location, latitude, longitude, altitude, exposure), environmental conditions (soil texture, habitat and dominant plant species), developmental stages and morphological variation of plants. Names of dominant plant species of communities in which *L. serriola* L. occurred were unified according to Kubát et al. (2002). The occurrence of downy (*Bremia lactucae* Regel) and powdery (*Golovinomyces cichoracearum* (DC.) V.P. Gelyuta) mildews was also recorded. The degree of infection (DI) for *B. lactucae* Regel was evaluated using a scale 0–3 (Petrželová and Lebeda 2004), and for *G. cichoracearum* (DC.) V.P. Gelyuta with a scale 0–4 (Lebeda 1994). The collection sites of *L. serriola* L. seed samples are presented in Figure 1.

Table 1. Frequency (%) of selected population and habitat characteristics of *Lactuca serriola* L. collected in four European countries.\*

Eco-geographic data	Country			
	CZ	D	NL	UK
<i>Altitude</i> [m a.s.l.]				
≤0			50.00	20.00
1–100		25.00	50.00	70.00
101–200	6.25	18.75		
201–300	62.50	37.50		
301–400	25.00	12.50		
>400	6.25	6.25		
Not recorded				10.00
<i>Population size</i> (no. of plants)				
≤50	56.25	56.25	50.00	40.00
51–150	37.50	31.25	37.50	40.00
151–300			12.50	
>300	6.25	12.50		10.00
Not recorded				10.00
<i>Population area</i> [m <sup>2</sup> ]				
≤50	37.50	18.75	12.50	30.00
51–150	31.25	25.00	12.50	10.00
151–300	6.25		25.00	30.00
301–500		18.75	50.00	
501–800		12.50		
801–1000	12.50	12.50		
>1000	12.50	12.50		20.00
Not recorded				10.00
<i>Landform</i>				
Basin			100	10.00
Lowland	50.00			
Plain	12.50	81.25		60.00
River valley		12.50		10.00
Hilly	37.50	6.25		20.00
<i>Soil type</i>				
Clay		12.50	25.00	20.00
Clay loam		37.50		
Loam	37.50			30.00
Loamy sand	25.00	25.00		
Sand	12.50		62.50	
Sandy loam		12.50		10.00
Silt				
Silt loam		6.25		10.00
Silty clay				10.00
Others	25.00	6.25	12.50	
Not recorded				20.00
<i>Site habitat</i>				
Roadside, crossing	18.75	37.50	25.00	10.00
Field margin	31.25	25.00		40.00
Branch bank	12.50			
Dump	25.00			
Anthropogenic	6.25	12.50	12.50	20.00
Ruderal		18.75	62.50	30.00
Others	6.25	6.25		

\* – More detailed geographic and ecological data are available from the first author.

CZ – Czech Republic; D – Germany; NL – The Netherlands; UK – United Kingdom.



Figure 1. Collection sites of *Lactuca serriola* in the Czech Republic (CZ), Germany (D), the Netherlands (NL) and United Kingdom (UK).

## Results and discussion

### Collection site data characterization

#### Czech Republic

Seeds samples were collected from 13 to 29 August 2001 from 16 localities (Figure 1). All seed samples were determined as form *serriola*. Population sizes varied between 20 and 320 plants, covering areas of 25–1250 m<sup>2</sup>. The geographical characteristics were: 49°06'59"–50°33'32" N, 14°14'10"–17°32'46"E; altitude: 177–405 m. The site aspect varied

and plant populations were found growing on southern-facing (8 locations) and all round (4 loc.) exposures. Seeds were collected from plants occurring from lowland (8 loc.) to hills (8 loc.), the soil type was determined as loam (5 loc.), loam-sand (4 loc.), stony (5 loc.) and anthropogenic soil (2). Plants were recorded growing along roadsides (3 loc.), field margins (6 loc.) and on dumps of building material (7 loc.) (Table 1). The dominant plant species at the sites were *Tripleurospermum inodorum* (L.) Schultz-Bip., *Arrhenatherum elatius* (L.) J. Presl et C. Presl, *Urtica dioica* L., *Chenopodium album* L.,

*Artemisia vulgaris* L. Most of the plants were at the full flowering and fruiting stage. With regard to diseases, only one locality was without any disease, while at other sites *G. cichoracearum* (DC.) V.P. Gelyuta exhibited an infection degree (DI) = 1 at 10 locations and for *B. lactucae* Regel an DI = 1 was recorded at 15 locations.

#### Germany

Seeds samples were collected between 15 August and 5 October 2001. In total 196 seed samples were collected from 16 localities (Figure 1). Initially 14 populations were characterized as form *serriola* and 2 were represented by mixtures of both forms (f. *serriola* and f. *integrifolia*). However, after regeneration, plants of 11 populations had leaves of the *serriola* form, while 5 populations had mixtures of both forms. The population sizes ranged from 15 to >400 plants, covering areas of 20–12000 m<sup>2</sup>. Geographical characteristics: 47°40'42"–54°04' 19" N, 6°18'34"–13°21' 12" E; altitude: 15–410 m. Plants were found on sites with south (5 loc.) and south-west (3 loc.) aspects. Seeds were collected from plants growing in valleys (2 loc.), plains (13 loc.) and hills (1 loc.). The soil types were loam (8 loc.), clay (4 loc.), sand (3 loc.) and silt (1 loc.). Plants were recorded mostly along road sides and field margins (13 loc.) (Table 1). The dominant associated plant species were *Urtica dioica* L. *Artemisia* L. sp., *Daucus carota* L., *Plantago* L. sp. Plants were at the full flowering and fruiting stage. From the viewpoint of diseases, only *G. cichoracearum* (DC.) V.P. Gelyuta (7 loc.) was found.

#### The Netherlands

Seeds samples were collected from 22 August to 9 September 2001, with the exception of 3 samples that were collected in 1998. In total, 129 seed samples were collected from 8 localities (Figure 1). Two populations were characterized as form *integrifolia*, 1 population was form *serriola*, and 5 contained both forms. Population sizes represented 30–300 plants, covering areas between 50 and 500 m<sup>2</sup>. Geographical characteristics: 50°50'42"–52° 29'19" N, 03°53'38"–06°06'59" E, altitude: –4 to 50 m. The exposure could not be recorded because of the flat nature of the collecting areas. The landform for all sites was characterized as a basin. Soil types were determined as sand (5 loc.), clay (2 loc.) and basalt blocks (1 loc.).

Plants were mostly observed in ruderal and building sites (6 loc.) (Table 1). The dominant associated plant species were *Conyza canadensis* (L.) Cronquist, *Tripleurospermum inodorum* (L.) Schultz-Bip., *Chenopodium album* L.. Plants were at the seed set stage. *G. cichoracearum* (DC.) V.P. Gelyuta was found at 4 localities, while *B. lactucae* Regel was not observed.

#### United Kingdom

Seeds samples were collected from 23 August to 9 September 2001. A total of 160 seed samples were collected from 10 localities (Figure 1). The leaf form of plants was not documented, however during regeneration both forms of *L. serriola* L. were observed, but form *integrifolia* dominated. Population size varied between 23–1000 plants, covering areas from 6 to 10000 m<sup>2</sup>. Geographical characteristics: 51°22'12"–52°42'00" N, 2°34'50" W–0°08' 52" E; altitude: 11–96 m. Plants were found mostly at sites with all round aspects. Seeds were collected from plants growing at different landscapes, ranging from plains (4 loc.) to hills (2 loc.). Soil types were identified as loam (5 loc.) and clay (3 loc.), data were not recorded from 2 localities. Plants were found in field margins (4 loc.) and ruderal places (6 loc.) (Table 1). The dominant associated plant species were not documented. Most of the plants were at the seed set stage. For diseases occurrence, 'mildew' was recorded at 1 locality (not specified on species level) and Diptera larvae at four localities.

#### Geographic distribution of *Lactuca serriola* L. forms

In agreement with previous observations (Lebeda et al. 2001), only *L. serriola* L. f. *serriola* was recorded in the populations from the Czech Republic. Plants with entire non-lobed leaves of form *integrifolia* occurred in approximately one third of German populations (5 out of 16), in terms of individuals, however, only 9% of all plants collected in Germany exhibited this leaf form. Detailed data on the distribution of both forms in Germany were not previously available (Rothmaler et al. 1999). Among the Dutch populations, two were characterized as form *integrifolia*, one as f. *serriola*, and five as mixtures of both forms, whereas after regeneration we found both forms represented more or less equally. From the Dutch

literature (Frietema de Vries et al. 1994) it is evident that the distribution of both forms in the Netherlands had not been described previously. In the United Kingdom, populations of *L. serriola* L. f. *serriola* were not documented for leaf form during collecting, however during regeneration 98% of plants were determined as f. *integrifolia*. These findings support the general consensus on the occurrence of *L. serriola* L. forms in Europe. *L. serriola* L. f. *serriola* is distributed throughout the greater part of Europe (Doležalová et al. 2001; Lebeda et al. 2001, 2004b), while the rarer f. *integrifolia* is prevalent in south-western parts of Continental Europe and southeastern and central England (Lebeda et al. 2001, 2004b). On the other hand Prince and Carter (1977) recorded this form frequently in south-eastern England and further field observation in years 1993, 1995 and 1998 (Lebeda, unpubl. results) confirmed the occurrence of plants with this leaf form in central England (e.g. Warwickshire) as being the most frequent. However, there is no detailed information about the distribution of the forms in the flora of the British Isles (Stace 1997). Records of *L. serriola* f. *integrifolia* (S.F. Gray) S.D. Prince et R.N. Carter were also published for the Netherlands (Van der Ham 1981) and Germany (Hegi 1987), however its occurrence in Germany is somewhat rare (Lebeda et al. 2004b). In recent years form *integrifolia* has been quite frequently observed in southern France and Italy (Lebeda et al. 2001, 2004b), and sporadic records are known from Slovakia and Turkey (Lebeda et al. 2004b). Mixed populations of *L. serriola* L. f. *serriola* and *L. serriola* L. f. *integrifolia* (S.F. Gray) S.D. Prince et R.N. Carter were found in Germany and in the Netherlands (recent observations). This may indicate the previous concept (Lebeda et al. 2001) on the probable origin of mixed populations due to migration of both forms between individual populations within and/or between countries.

#### *Ecology of Lactuca serriola* L.

In Europe it is evident that the population sizes of *L. serriola* L. are generally increasing (Lebeda et al. 2001; Sagarin and Gaines 2002). Our observations showed that the largest population was represented by approximately 1000 plants of *L. serriola* L. f. *integrifolia* (S.F. Gray) S.D. Prince

et R.N. Carter, observed in Chesterton, UK. This is rather an exception. In other countries the largest populations consisted of 300 to >400 plants. The smallest populations were represented by 15–25 plants. Generally, populations of *L. serriola* L. with different leaf forms covered more or less the same range regarding the number of plants (Table 1). The largest populations were recorded in open communities along field margins and roads. Recent observations in the Czech Republic showed that large and very dense populations (e.g. covering an area larger than 10,000 m<sup>2</sup> and comprising more than 1000 plants), so called ‘Lactuca fields’ (Petrželová and Lebeda 2004), are increasing in occurrence in arable areas (Lebeda 2004, unpubl.). This phenomenon evidently supports our findings that *L. serriola* is to be considered an ‘r’ strategist and a pioneer species (Mejías 1994) of natural plant communities persisting at localities for 2 or 3 years and in the course of the succession is replaced with other plant species (Weaver and Downs 2003).

Most of the project collecting sites represented ruderal habitats (19 loc.), roadsides (15 loc.) and field margins (10 loc.) (Table 1), which supports the theory that *L. serriola* L. disperses along transport corridors (Jehlík 1998; Lebeda et al. 2004b) and urban habitats (Doležalová et al. 2001; Lebeda et al. 2001). *L. serriola* L. grows mostly in open, unshaded places and in sunny exposures (Weaver and Downs 2003). The present study showed that 44% of the locations exhibited a southern exposure. From the viewpoint of substratum, *L. serriola* L. is generally thought to prefer fertile and carbonate-rich soils (Feráková 1977), although others consider the species to prefer dry soils or to tolerate a wide range of substrata (Weaver and Downs 2003). In the present study, plants were observed mostly on loams and clay soils (26 loc., 52%), sandy soils (10 loc., 20%) and stony (6 loc., 12%) substrata, supporting the suggestion of a wider tolerance for different substrata (Table 1).

*L. serriola* L. is a pioneer of open habitats, commonly occurs in disturbed areas and habitats (roadsides and railroads, farmyards and dockyards, town suburbs, vacant lots and new city developments/construction, ruins, ruderal communities) and as a weedy species (Lebeda et al. 2001; Weaver and Downs 2003). It is usually found growing in plant communities of winter annual and/or biennial

weed species (*Capsella bursa-pastoris* (L.) Med., *Cichorium intybus* L., *Coryza canadensis* (L.) Cronquist, *Lamium amplexicaule* L., *Lepidium* L. spp., *Plantago media* L., *Polygonum aviculare* L., *Senecio vulgaris* L., *Sonchus oleraceus* L., *Bromus tectorum* L.) invading disturbed habitats (Weaver and Downs 2003), and frequently is accompanied by species considered as the first colonizers *Artemisia vulgaris* L., *Chenopodium album* L., *Tripleurospermum inodorum* (L.) Schultz-Bip. *L. serriola* L. is very common in ruderal vegetation of the following plant associations: *Onopordion*, *Daucum-Melilotion*, *Sisymbrium officinalis*, *Arctium lappae*, *Convolvulo-Agropyron* and *Balloto nigrae-Robinion* (Grulich 2004). In the present study, the habitats, plant species and communities mentioned above were observed most frequently in the Czech Republic, Germany and the Netherlands. The dominant plant species were not recorded in UK.

#### *Downy and powdery mildew occurrence*

Recording the natural occurrence of diseases was mainly focused on downy and powdery mildews. Lettuce downy mildew (*Bremia lactucae* Regel) is distributed worldwide and known to infect more than 200 species of Asteraceae from more than 40 genera (Lebeda et al. 2002). However, from the approximately 100 *Lactuca* L. species described (Lebeda et al. 2004b), only 14 *Lactuca* L. spp. are known as natural hosts of *B. lactucae* Regel, among them *L. serriola* L. (Lebeda et al. 2002). No detailed results are available on the geographic distribution of *B. lactucae* Regel on wild *Lactuca* L. spp. in Europe (Lebeda et al. 2001). In this study, *B. lactucae* Regel was recorded at 15 localities (i.e. more than 90%) in the Czech Republic, but not observed in other countries. This is in good agreement with research of the natural occurrence of *B. lactucae* Regel in the Czech Republic (Lebeda and Petrželová 2004; Petrželová and Lebeda 2004) and with observations in other European countries (Lebeda et al. 2001). Lettuce powdery mildew (*Golovinomyces cichoracearum* (DC.) V.P. Gelyuta) showed occurrence at 21 locations, predominantly in the Czech Republic (60% loc.), Germany (45% loc.) and the Netherlands (50% loc.). The infected plants showed mostly a low or medium degree of infection (DI = 1–2). Field observations on the occurrence of *G. cichoracearum* (DC.) V.P. Gelyuta

(*Erysiphe cichoracearum* DC.) on *L. serriola* L. plants in the four involved countries have been reported previously (Braun 1995; Lebeda 1985). However, to date no detailed studies on the distribution and degree of infection of this pathogen have been performed.

By the collection activities described within this paper, a large part of the European distribution area of *Lactuca serriola* L. was sampled. The data compiled during the acquisition trips contribute additional and valuable information to the knowledge on the geographic distribution of the two forms of prickly lettuce, f. *serriola* and f. *integrifolia*, on their ecology and on the occurrence of two mildew diseases. From the viewpoint of the conservation of *L. serriola* L. genetic diversity, the project expeditions were one of the most comprehensive collecting activities carried out through the collaboration of several European institutions. The material was included in the national genebanks of the countries involved, will soon be documented in the International *Lactuca* Database (ILDB) (Stavěliková et al. 2002) and will be further studied morphologically, for disease resistances and by molecular markers, deepening the insights into this species gained here; the respective publications are in preparation.

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