

The Biology of Canadian Weeds. 146. *Lapsana communis* L.

Ardath Francis¹, Stephen J. Darbyshire¹, David R. Clements², and Antonio DiTommaso³

¹Agriculture and Agri-Food Canada, Eastern Cereal and Oilseed Research Centre, Wm. Saunders Bldg. #49, Ottawa, Ontario, Canada K1A 0C6 (e-mail: ardath.francis@agr.gc.ca); ²Biology Department, Trinity Western University, 7600 Glover Road, Langley, British Columbia, Canada V2Y 1Y1; and ³Department of Crop and Soil Sciences, 903 Bradfield Hall, Cornell University, Ithaca, NY 14853 USA. Received 17 August 2010, accepted 20 December 2010.

Francis, A., Darbyshire, S. J., Clements, D. R. and DiTommaso, A. 2011. **The Biology of Canadian Weeds. 146. *Lapsana communis* L.** Can. J. Plant Sci. **91**: 553–569. Nipplewort, *Lapsana communis*, is an annual weed of the Asteraceae native to Europe and western Asia, first detected in northeastern and Pacific northwestern regions of North America in the 19th century. It appears to have been introduced as a contaminant of imported garden material and seeds, but may also have been deliberately introduced as a medicinal herb. After a century of remaining close to its original points of introduction in gardens and ruderal habitats, it spread to neighbouring areas, and now occurs across southern Canada and in many areas of the United States. Possible reasons for this range expansion include forest clearance and changing crop management practices as was observed in Europe, where this plant has become an important weed in grain, forage and vegetable crops. In Ontario, *L. communis* has recently emerged as a weed in wheat (*Triticum aestivum*), corn (*Zea mays*) and soybean (*Glycine max*) fields. Various herbicides have been effective on *L. communis* in corn, but control has been less effective in winter wheat, where the herbicides MCPA and 2,4-D used alone have provided little or no control. Control in soybean has yet to be assessed. In Europe both mechanical methods and herbicides have been effective in controlling the weed, but *L. communis* has recently developed tolerance to MCPA. It is unclear whether this weed will continue to spread or will remain a localized or relatively minor crop pest in Canada.

Key words: *Lapsana communis*, lapsane commune, nipplewort, LAPCO, weed biology

Francis, A., Darbyshire, S. J., Clements, D. R. et DiTommaso, A. 2011. **La biologie des mauvaises herbes au Canada. 146. *Lapsana communis* L.** Can. J. Plant Sci. **91**: 553–569. La lapsane commune, *Lapsana communis*, est une annuelle de la famille des Astéracées indigène en Europe et dans l'ouest de l'Asie. En Amérique du Nord, la plante a été identifiée pour la première fois dans le nord-est et dans la partie nord-ouest du Pacifique au XIX^e siècle. Elle semble avoir été introduite comme contaminant avec le matériel de jardinage ou des graines, mais il se peut aussi qu'on l'ait délibérément apportée comme herbe médicinale. Après être restée près d'un siècle à proximité des points d'introduction originaux, dans les jardins et les habitats rudéraux, la plante s'est étendue aux régions voisines, si bien qu'on la retrouve maintenant partout dans le sud du Canada et dans maintes régions des États-Unis. Les explications possibles à cette expansion comprennent le déboisement et la modification des pratiques agricoles, comme on l'a observé en Europe, où cette espèce est devenue une adventice importante dans les cultures céréalières, fourragères et maraîchères. En Ontario, *L. communis* est depuis peu considérée comme une adventice du blé (*Triticum aestivum*), du maïs (*Zea mays*) et du soja (*Glycine max*). Divers herbicides donnent de bon résultats dans les cultures de maïs, mais la lutte s'avère plus ardue dans les champs de blé d'hiver, où l'usage du MCPA et du 2,4-D sans autre herbicide est inefficace ou presque. On n'a pas encore évalué les moyens de lutte dans les champs de soja. En Europe, le désherbage mécanique et chimique permet de combattre cette mauvaise herbe, mais *L. communis* a récemment acquis la tolérance au MCPA. On ignore si cette adventice continuera de ce propager ou demeurera une mauvaise herbe d'importance relativement mineure pour les cultures au Canada.

Mots clés: *Lapsana communis*, lapsane commune, nipplewort, LAPCO, biologie des mauvaises herbes

1. Name and Generic Status

Lapsana communis L. — Synonym: *Lampsana communis* auct. Common names: **nipplewort** (Darbyshire et al. 2000), nipple-wort, swine's cress (Darbyshire 2003), dock-cress (UK); **lapsane commune** (Darbyshire et al. 2000), graveline, herbe aux mamelles (Darbyshire 2003), lampsane commune. European and Mediterranean Plant Protection Organization (Bayer) code: LAPCO.

Asteraceae (Compositae): aster family – Asteracées (Composées).

The genus *Lapsana* is a member of the Cichorieae (formerly Lactuceae) tribe (Reveal 1997; Kilian et al. 2009). It consists of the single variable species *Lapsana communis* L., native to Europe and west Asia. The genus formerly included nine species, five of which are now treated either as variants or as taxonomically distinct

subspecies of *L. communis*. Based on cladistic analysis of morphological characters, four East Asian species have been transferred to the genus *Lapsanastrum* (Pak and Bremer 1995).

2. Description and Account of Variation

(a) *Species Description* — The following description applies to the type subspecies, and is based on floras (e.g., Provancher 1862; Gray 1884, 1889; Hegi 1929; Sell 1976, 1981; Stace 1991; Bogler 2006) and on personal observations of Canadian populations by the authors. Measurements are given as the usual range with extremes in parentheses. The whole mature plant, the involucre, the achenes and two- and four-leaf seedlings are illustrated in Fig. 1, A–D.

Annual or winter annual with over-wintering rosette; taproot with fibrous to thickened rootlets; stem (6) 30–125 cm tall, cylindrical, slender to robust, often reddish-green, slightly ridged, glabrous or usually with white hairs that are sometimes glandular, branching above the middle; leaves alternate, thin and pliant, upper surfaces glabrate to sparsely hairy, lower surfaces with scattered hairs mostly along the veins, margins usually hairy, 1–15 (–30) cm long, 1–7 (–10) cm wide, usually crenulate to dentate, apex of the teeth or lobes with a small gland; basal leaves long-petiolate, ovate to suborbiculate to lyrate-pinnatifid, with a large terminal lobe separated by a narrow constricted neck from smaller lateral lobes, the lateral lobes often vestigial; upper leaves sometimes entire, shortly petiolate to sessile, narrowly-ovate to lanceolate, gradually decreasing in size apically; capitula (flowering heads) 5–25 (–100+), in a more or less loose corymbose inflorescence; peduncles slender, smooth, usually more than twice as long as the involucre, slightly expanded distally, without bracts; involucre 5–10 mm long, 3–4 mm wide; calyculi (scale-like bractlets resembling a calyx) 0.5–1 (–2) mm long; phyllaries uniseriate, linear-lanceolate, (4–) 6–8 (–10), keeled toward the base with a prominent expanded usually yellowish mid-vein; receptacle flat, smooth, glabrous; ligules (spreading limbs of ray florets) 8–15, up to 1.5 times as long as the involucre, with very fine longitudinally striped cuticle patterns (Baagøe 1977), pale to deep yellow, apex blunt, notched into 5 shallow teeth; anthers fused in cylindrical tube, brown, apical lobes not tailed; style slender, pubescent on the upper part, stigma spreading; cypselae (achenes, often referred to as “seeds”) dimorphic, outer much longer than inner, (3–) 3.5–4 mm long, tan to golden brown, slightly dorsiventrally flattened, curved, 18–20-ribbed, glabrous, gradually tapered at the proximal end, terminating in a ring-like bulge at the distal end (Fig. 1C); pappus absent. Cotyledons round or spoon-shaped (Fig. 1D).

Chromosome counts of $n = 7$ and $2n = 12, 14, 16$ have been reported. Canadian counts of $2n = 14$ are from Haida Gwaii (Queen Charlotte Islands), BC (Taylor and Mulligan 1968), and Montreal, QC (Morton 1981). Other counts of $2n = 14$ are reported from Austria

(Kiehn et al. 1991), California, USA (Stebbins et al. 1952), the Ukraine (Stebbins et al. 1952), the United Kingdom (Edmonds et al. 1974; Morton 1977), Portugal (Fernandez and Queirós 1971), the Slovak Republic (Váchova and Májovský 1977; Uhrikova 1978), and Sweden (Lövkvist and Hultgård 1999). Mejias (1986) reported a count of $n = 7$ from Spain. Counts of $2n = 16$ have been reported from Poland (Mizianty et al. 1981), southeast Spain (Luque and Díaz Lifante 1991) and Bulgaria (Kuzmanov and Georgieva 1977; Jurukova-Grancharova 1995).

An early report of $2n = 12$ (Marchal 1920) was treated as doubtful by Stebbins et al. (1952) whose counts were all of $2n = 14$. However, Jovtchev et al. (2007) reported $2n = 12$ for material from the German IPK genebank. Pak and Choi (1994) determined a somatic chromosome number of $2n = 14$ for *L. communis*, and identified the karyotype as consisting of 3 pairs of metacentric, 3 pairs of submetacentric and 1 pair of subtelocentric chromosomes. Pak and Bremer (1995) found only $2n = 14$ in material from the United Kingdom, Sweden, the Netherlands and the United States of America, and concluded that if the deviating numbers of $2n = 12$ and $2n = 16$ were to be confirmed, they would regard them as derived, and therefore suggested that $x = 7$. Jovtchev et al. (2007) found a negative correlation between endopolyploidy and temperature in *L. communis*, which switched from non-endopolyploid at 22°C to being endopolyploid when grown at 14°C.

(b) *Distinguishing Features* — Superficially, *Lapsana communis* resembles other composites with yellow ray flowers such as dandelion (*Taraxacum officinale* Web. ex Wigg.), but has very different stems and leaves, particularly distinctive lyrate lobed lower leaves (Fig. 1A), and notable absence of a pappus on achenes (Fig. 1C). It has been confused with sow-thistles (*Sonchus* spp.) or prickly lettuce (*Lactuca serriola* L.), but it lacks the spiny leaves and pappus on achenes found on these species (Cowbrough 2005). It can also be confused with wall lettuce [*Lactuca muralis* (L.) Fresn., = *Mycelis muralis* (L.) Dumort.] with many similarities in morphology and habitat, but in this species the lyrate lower leaves are more prominently pinnate, the terminal lobe triangular or 3-lobed, the lateral lobes are distinctly angular and less dissimilar in size, the capitula have only five-ray florets (as compared with 8–15 in *L. communis*) and the achenes have a prominent pappus of hair-like bristles (illustrated in Douglas et al. 1998). Knörzer (1971) stated that the spindle-shaped, slightly-curved, many-ribbed achenes of *L. communis* could not be confused with those of any other composites.

(c) *Intra-specific Variation* — Several subspecies have been recognized, although only the type, subsp. *communis*, is known in most of Europe (e.g., Hegi 1929; Hanf 1970; Sell 1981; Berkefeld 1988) and as an introduction to North America (Bogler 2006). Although

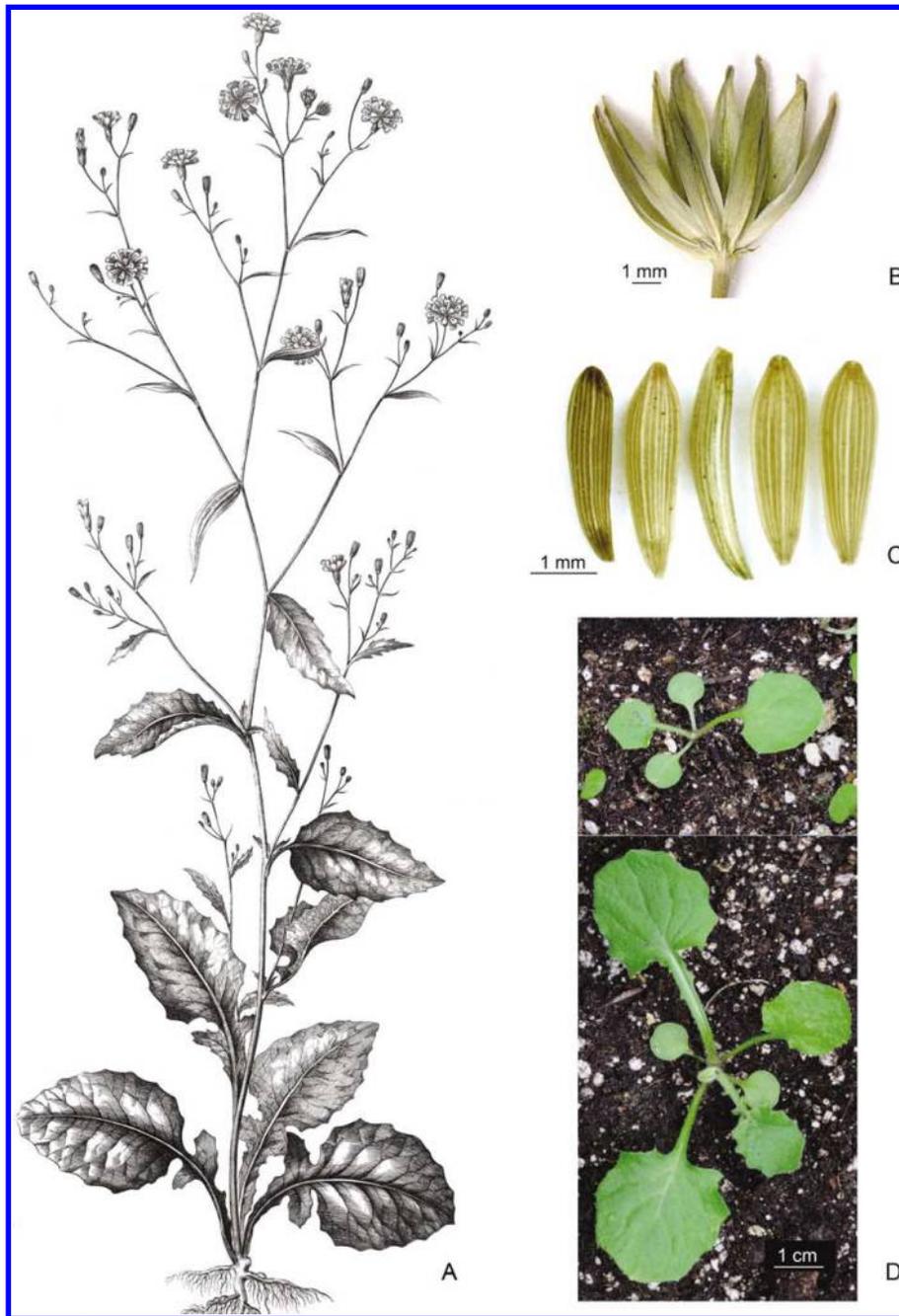


Fig. 1. *Lapsana communis*. A. Drawing of flowering plant adapted from “Flora londinensis” by W. Curtis (1775–1798). B. Involucre after seed dispersal showing the small bract-like outer phyllaries and the eight longer inner phyllaries with the mid-vein keeled towards their base. C. Achenes; two at left in abaxial view, centre achene in lateral view, two at right in adaxial view. D. Seedlings at the two (above) and four (below) leaf stages.

plants from North Africa are usually included with the typical subspecies, those plants with larger involucre are sometimes differentiated as subsp. *macrocarpa* (Cosson) Arcangeli (Sell 1981). Subspecies *adenophora* (Boiss.) Rech. f. and subsp. *intermedia* (M. Bieb.) Hayek are mainly confined to southeastern Europe, although

the latter has occasionally appeared elsewhere in Europe as an introduction (Sell 1981; Clapham et al. 1987; Butcher 1999); subsp. *alpina* (Boiss. & Balansa) P. D. Sell is largely confined to the mountains of Crimea; subsp. *pisidica* (Boiss. & Heldr.) Rech. f. has been doubtfully recorded in mainland southeast Europe and extends

from the eastern Aegean islands through Turkey into west Asia; and, subsp. *grandiflora* (M. Bieb.) P. D. Sell occurs in the Caucasus and in eastern and north-eastern Anatolia. Sell (1981) has provided a key to the subspecies of *Lapsana communis*, in which most are distinguished from the typical subspecies by ligules more than twice as long as the involucre, and by individual differences such as numerous stems, glaucous leaves, and a perennial habit (subsp. *alpina*), an annual to perennial habit (subsp. *adenophora*, *pisidica*, *intermedia*, and *grandiflora*), dense crispate glandular hairs on the lower stem (subsp. *pisidica*), or ovate undivided leaves and very large ligules (subsp. *grandiflora*).

Within the typical subspecies, Berkefeld (1988) noted differences in morphology which he treated as distinct ecotypes or races. Plants growing in fields matured more quickly, branched more profusely, flowered slightly earlier and for longer, and produced achenes much larger than those growing in woodlands, but remained shorter than their woodland counterparts. The latter were not only taller, but less branched, with longer internodes, looser flower heads, shorter lateral shoots, and were less aggressively weedy. These differences appear to be phenotypic responses to environmental conditions and are not taxonomically significant.

(d) *Illustrations* — The whole plant (Fig. 1A), an empty involucre (Fig. 1B), achenes (Fig. 1C) and seedlings (Fig. 1D) are illustrated. An excellent colour illustration can be found in Thomé (1905). Other illustrations can be found in Hegi (1929), Muenscher (1955), Blamey and Grey-Wilson (1989), Douglas et al. (1998), and Bogler (2006).

3. Economic Importance and Environmental Impact

(a) *Detrimental* — Early reports from North America (See Sections 5c and 6) treated *L. communis* as a weed of gardens, ruderal sites and waste places but did not cite crop areas, apart from an isolated report from Quebec (Provancher 1862); nor has it been recognized as a weed of crops in more recent provincial and state floras of North America (e.g., Douglas et al. 1988; Zinck 1998; Bogler 2006), although specimens in Canadian herbaria have occasionally been collected from cleared fields and pastures. In southern Ontario it has recently become more prevalent in field corn (*Zea mays* L.), soybean [*Glycine max* (L.) Merr.] and winter wheat (*Triticum aestivum* L.), particularly under reduced tillage systems (Cowbrough 2005). It is also a species of concern in natural environments, such as Garry oak (*Quercus garryana* Hook.) ecosystems in British Columbia where it now occurs widely (Fuchs 2001; Lilley 2007). In the United States, its recent appearance in Texas was as a weed in a landscaped area (O'Kennon et al. 1999).

In Europe the species appears to have spread with the expansion of agriculture (see Section 6) and has long been reported occurring around dwellings and in

gardens (e.g., Miller 1752, 1768; Hegi 1929) and as an easily controlled weed on arable land (Morse and Palmer 1925). However, after centuries of attracting little attention as a weed, it has recently become more weedy and problematic, spreading in a number of cropping systems, including fodder crops, cereals, vegetables, orchards and vineyards, particularly in the eastern and northern parts of its range (Weber and Gut 2005). The species has become an important weed in cereal crops throughout northern Europe including Denmark (Jensen 1991), the United Kingdom (Marshall 1989; Bond et al. 2007), Estonia (Vesik 2001; Reintam and Koster 2000), Finland (Raatikainen and Raatikainen 1979; Salonen and Ervio 1988; Salonen 1993; Hyvönen et al. 2003; Haukkaipää et al. 2005; Hyvönen 2007), France (Barralis et al. 1988), Norway (Semb and Skuterud 1996; Skuterud et al. 1998; Berge et al. 2008), Poland (Hocho 1990; Wojcik 1998; Snarska 2004), and Sweden (Hallgren 1996).

In the United Kingdom (Froud-Williams and Chancellor 1987), *L. communis* ranked 16th among the 25 most frequent broadleaved weeds in "winter oilseed rape" (canola, *Brassica napus* L.) fields that had either survived herbicide treatment or had not been sprayed. Its total occurrence in the 450 fields surveyed was 3%, divided nearly equally between the margins, headlands, and field areas; and was also among a group of species associated with canola, but either totally or virtually absent from cereals. *Lapsana communis* was among the 16 most common weed species in spring cereal and vegetable field plots in southern and central Finland (Ervio et al. 1994). In Denmark, *L. communis* was among those weeds requiring control in a variety of spring- and autumn-sown crops including cereals, canola, sugarbeet (*Beta vulgaris* L.) and vegetables (Jensen 1991). More than 1000 field trials were conducted in a variety of spring- and autumn-sown crops over a period of almost two decades and showed that *L. communis* remained moderately competitive in both crop types, with an average ranking among the most common weed species of 5th in autumn-sown crops and of 10th in spring-sown crops, and with average fresh weights of 6 and 3 g per plant, respectively (Jensen 1991). It has been reported in Danish crops of potato (*Solanum tuberosum* L.), pea (*Pisum sativum* L.), carrot (*Daucus carota* L.), parsnip (*Pastinaca sativa* L.), celery (*Apium graveolens* L.) and onions (*Allium cepa* L.) (Brendstrup and Koster 1998), and has also been among the major weeds of pasture seed crops, such as timothy (*Phleum pratense* L.), Kentucky blue grass (*Poa pratensis* L.), red fescue (*Festuca rubra* L.), meadow fescue (*F. pratensis* Huds.), and red clover (*Trifolium pratense* L.) (Aamissepp 1982).

In Poland, increased infestation by several weeds, including *L. communis*, was noted in winter rye (*Secale cereale* L.) fields under conservation tillage systems (Kraska and Pays 2007; see also Section 12). In Turkey it is among the dominant weeds of commercial hazelnut

(*Corylus avellana* L.) orchards (Mennan et al. 2006). In the Russian Federation of the former USSR, *L. communis* was among important weeds of fodder beet (Kameneva et al. 1987). In Sweden, it has been among weeds requiring control in meadow fescue seed crops (Pettersson 1984). Weed surveys in fields, winter wheat, winter and spring barley (*Hordeum vulgare* L.), and one-year fallow, along a north-south European climate gradient at locations in Italy, Hungary, Germany and Sweden found *L. communis* to be among the typical weed species of the more northern climate zones (Glemnitz et al. 2000).

In the United Kingdom it has been reported as a contaminant in local and imported forage grass seeds, with a gradual increase from ca. 6% to ca. 13% of seed samples (origin not specified) tested between 1927 and 1957 (Bond et al. 2007). Gooch (1963) reported up to 12.3% contamination of grass seed commodities produced in the United Kingdom and up to 29% of grass seed produced in Sweden and Denmark, noting that *L. communis* was relatively more frequent than other weed seeds in Italian ryegrass (*Lolium multiflorum* Lam.) seed stocks.

(b) *Beneficial* — The common name “nipplewort” was apparently based on the use of the plant’s milky latex to soothe cracking and inflammation of the breasts of nursing mothers, a use reported by the 16th century German Camerarius for the plant known as “papillaris” in Prussia, and “docke cresses” in England (Gerard 1633). Pratt (1855) and Hedrick (1919) reported that young spring leaves were eaten in Turkey as a salad herb, and that leaves were eaten boiled by the “peasantry” in England as well as being used medicinally in villages, observations that fit Gerard’s (1633) reference to the plant as a “pothorb”. Such references to culinary uses may belong primarily to the past (Polunin 1969; Plants for a Future 2010), although the species is among wild Asteraceae believed to have potential as a vegetable in Romania (Munteanu and Sirbu 2008).

Fontanel et al. (1998b) suggested that the large quantity of triterpene alcohols in *L. communis* could explain its healing properties. The volatile oil has inflammatory and antiseptic properties with potential for exploitation in the treatment of dermatological diseases (Stanciu et al. 2007; see also Section 7c). In Tennessee, *L. communis* was among local plant species studied as potential sources of oil and other industrial raw materials (Carr and Bagby 1987; see also Section 7c). An earlier U.S. study (White et al. 1971) concluded that, although the seed oil contained crepenynic acid, used in protective coatings, resins and other products, the small achenes were not well retained on plants and the crop potential was poor. The species is among 16 native plants tested as bioindicators for the presence of ambient ozone in Central and Eastern Europe, its leaves showing ozone injury symptoms of brown stipple and

chlorosis (Manning et al. 2002; Manning and Godzic 2004).

(c) *Legislation* — The species is not listed as noxious or invasive in weed legislation in either Canada or the United States.

4. Geographic Distribution

This introduced species is reported from all Canadian provinces, although no specimen from Prince Edward Island, where it had been reported as present (see Section 6), was located during this study (Fig. 2). It is local and may be ephemeral in the three Prairie Provinces. In the United States, it has now been reported from 38 states, including those in New England, where its populations are concentrated, all Pacific states, Hawaii (two islands: Maui and Hawaii), and the Alaskan Panhandle (Bogler 2006; USDA, NRCS 2009).

In its native range, it occurs in Europe east to Russia, Ukraine, the Caucasus and West Asia, southwest to Northwest Africa, scattered through southern Scandinavia, Finland, Russia and parts of Central Asia. It has been introduced to Canada, the United States of America, Argentina, Chile, Tasmania and New Zealand (Holm et al. 1979; Hultén and Fries 1986). It has been recently recorded in the Balearic Islands (Orell Casanova 1985), the Vladivostok area of eastern Siberia (Nechaeva 1992), and in Korea (Park 1999).

5. Habitat

(a) *Climatic Requirements* — If its distribution is compared with plant hardiness zone maps for Europe and North America, *L. communis* is found in temperate climate zones of both hemispheres in areas with warm summers and moderate rainfall, where neither summer drought nor the early severe frosts and harsh winters of continental climate zones are common. In North America it is found mainly in Zones 5–7, but extends into the moderate climate of Zone 8 in the Pacific region. It is bounded roughly by eastern maritime Canada and New England in the east, through southeastern Quebec, southern Ontario and south central United States west to the eastern Pacific states and north into British Columbia, average minimum temperatures corresponding roughly to those cited below for the same zones in Europe. In Europe, it has adapted to the short, but long-day summers of the Nordic region as far north as southern Norway, Sweden and Finland, an area whose climate has been moderated by the Gulf Stream, placing it within Hardiness Zone 5 in Finland to Hardiness Zone 8 in coastal Norway, with average minimum temperatures of -23 to -29°C and of -12 to -7°C respectively. Elsewhere in Europe it is found primarily in Zones 6–8, bounded by west-central Europe from the Baltic to the western Black Sea and northern Greece in the east through northern Italy and north central Spain to France and the United Kingdom,

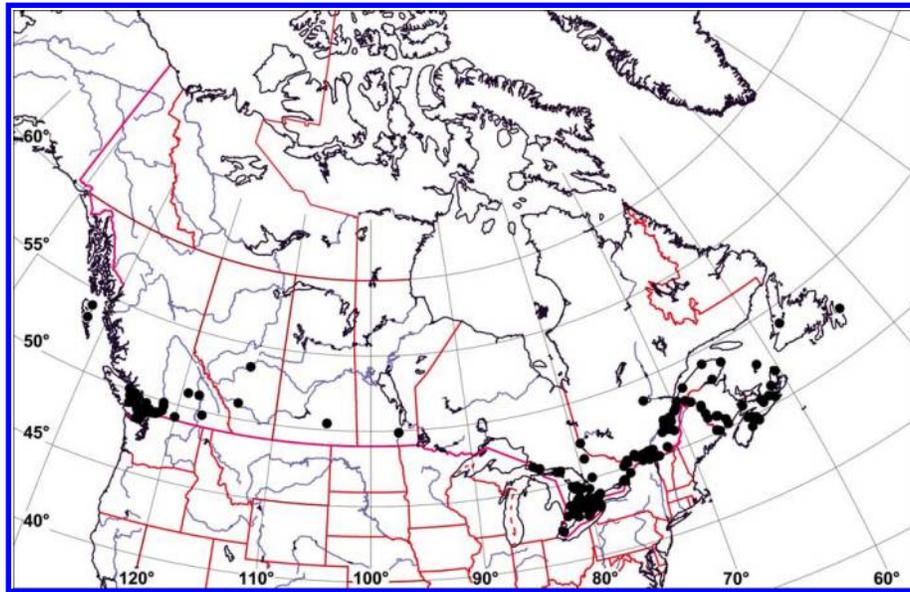


Fig. 2. Distribution of *Lapsana communis* in Canada, based on 670 herbarium specimens from ACAD (22), ALTA (4), CAN (50), DAO (95), HAM (21), LKHD (13), MAN (2), MT (80), NSPM (12), OAC(36), QFA (103), QK (23), QUE (39), SASK (11), TRTE (30), UAC (4), UBC (41), UNB (14), UWO (14), V(43), and WAT (13). Herbarium abbreviations follow Holmgren et al. (1990).

minimum temperatures averaging -23 to -7°C . It is generally found inland from the sub-Atlantic and sub-Mediterranean climate zones, in low-lying areas such as the Rhone valley, or in warm temperate sites at 900–1700 m altitude (Waldis 1984). It is not generally adapted to maritime habitats (Plants for a Future 2010), although it is present as a crop weed in coastal regions of the Gulf of Bothnia in Finland (Riesinger and Hyvönen 2006) and on the Black Sea Coast in Turkey (Mennan et al. 2006).

In Belgium, Godefroid et al. (2006) investigated microclimate and plant species composition variation within clearcuts of an old beech (*Fagus sylvatica* L.) forest, with a focus on gradients of air temperature and humidity, soil temperature and light intensity correlated with distance to the forest margin. Among these species, *L. communis* never occurred in sites above 35% humidity, but was otherwise among the small number of species studied that did not show a significant change in expected occurrence in response to the microclimatic parameters considered. In response to moderate light intensity, for example, change in estimated percentage cover values was $<0.03\%$.

(b) *Substratum* — In Canada, *L. communis* has been collected from rocky, gravelly, calcareous and sandy areas, clay and rich loam soils, brackish tidal marshes, and, rarely, on gypsum, shale and silica soil (herbarium specimen labels). The species grows best on nutrient-rich damp loamy and clay soils which are fairly rich in nitrogen (Hanf 1970); especially neutral and basic alkaline soils (Plants for a Future 2010). In Finland, *L.*

communis was reported to grow best in mineral or organic rather than in clay soils (Ervio et al. 1994). In the United Kingdom and northern Europe it is reported as adapted to “slightly acid to calcareous soils” (Blamey and Grey-Wilson 1989). In hazelnut orchards in Turkey, *L. communis* is present on a mixed soil consisting of 42% sand, 15% silt, 41% clay, 2.1% organic matter, and pH 6.4 (Mennan et al. 2006). It was among plants showing a relatively low tolerance of copper-contaminated soil in Denmark, providing a minimum of 4% and a maximum of 12% cover in the study area, and mostly present near the border of the study area (Strandberg et al. 2006). In the Czech Republic, *L. communis* was among species of ruderal habitats whose populations increased in forest reserves where grazing by deer (*Cervus* spp.) and mouflon (*Ovis musimon* Pallas) had depleted many native forest species, created soil disturbance, and increased the organic composition of the soil (Chytrý and Danihelka 1993).

(c) *Communities in Which the Species Occurs* — Information on flora associated with *L. communis* in Canada reported below is derived primarily from specimen labels in Canadian herbaria. In eastern Canada, *L. communis* has been found most frequently in lowland areas and along rivers and streams, often on the margins of deciduous forest zones in association with sugar maple (*Acer saccharum* Marsh.), oak (*Quercus* spp.), poplar (*Populus* spp.), eastern white cedar (*Thuja occidentalis* L.) and various shrubs and wild flowers such as currant (*Ribes* spp.), rose (*Rosa* spp.), climbing nightshade (*Solanum dulcamara* L.), Canada goldenrod

(*Solidago canadensis* L.) and wild lettuce (*Lactuca* spp.). In British Columbia, it has been found in lowland, steppe and montane zones, mainly in the southeastern part of the province (Douglas et al. 1998) where it has been collected from Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco], arbutus (*Arbutus menziesii* Pursh), Garry oak and other forested zones as well as from roadsides and around shrubs and in gardens in urban areas. It is reported as a frequent non-native species in Garry oak meadow communities in British Columbia (Fuchs 2001; Lilley 2007). In the United States, it has been reported occurring in gardens, hedges, orchards, deciduous woodland trails, streambanks, roadsides and waste areas at 50–1900 m (Muenscher 1955; Voss 1996; Bogler 2006), but there is little published information on the associated flora.

In Europe, the earliest archaeological remains of *L. communis* achenes were found in association with seeds of *Rumex* spp. and *Poa* spp. (Knörzer 1971; see Section 6). Its presence as a weed of gardens, hedgerows, and various ruderal and waste sites has been noted in many parts of Europe (e.g., Miller 1768; Hegi 1929; Hanf 1970). In the United Kingdom, it has been prevalent in damp open woods, hedgerows, on walls, in cereal and root crops, in gardens; on waste and disturbed ground; and at altitudes up to 450 m (Salisbury 1961; Hanf 1970; Stace 1991). In Poland, *L. communis* is found in cereal fields in the southeastern foothills in association with four-seeded vetch [*Vicia terasperma* (L.) Schreb.] and common hemp-nettle (*Galeopsis tetrahit* L.) (Wojcik 1998), and is frequent in ruderal habitats along with a variety of chenopods, grasses, crucifers, members of the pink family and composites, as well as infesting cultivated fields (Korniak and Kalwasinska 2001). In hazelnut orchards in Turkey, *Lapsana communis* occurs with such species as bracken, *Pteridium aquilinum* (L.) Kuh., lamb's-quarters, *Chenopodium album* L., Himalayan blackberry, *Rubus armeniacus* Focke (reported as *R. discolor* Weihe & Nees), mugwort, *Artemisia vulgaris* L., dog nettle, *Urtica urens* L., Bermuda grass, *Cynodon dactylon* (L.) Pers., black grass, *Alopecurus myosuroides* Huds., green foxtail, *Setaria viridis* (L.) P. Beauv., and annual blue grass, *Poa annua* L. (Mennan et al. 2006).

6. History

In Canada, *L. communis* was first collected from Quebec (probably Quebec City) as early as 1833 (Hooker 1840) and later Provancher (1862) mentioned it as a weed at St. Joachim. A few years later (1871), it was collected in Owen Sound, ON. Between 1883 and 1905 it was collected from numerous locations in southern Quebec, Ontario and British Columbia as well as at one location each in New Brunswick (1883) and Nova Scotia (1890) (herbarium specimens). From the 1950s it was collected widely around those same areas at an increasing number of locations, and distribution maps in recent floras (Zinck 1998; Hinds 2000) indicate a spread from previously isolated locations. It was reportedly collected

from roadsides in Charlottetown, PE, in 1914, but there are no recent reports from that province (Catling et al. 1985). In other provinces, a collection was made from eastern Newfoundland in 1958, and isolated collections have been made from city gardens, as in Winnipeg, MB (1943), in Edmonton, AB (1971), in Regina, SK (1972) (where it is reported to have arrived with transported garden plants from BC), in St. John's, NL (1978), and most recently in 2009 in a garden in Calgary, AB. There is no indication of a spread in those provinces with climates outside of its typical zones. In Regina, for example, it was collected again from the same garden in 1982, suggesting that the plant could be persistent in a sheltered location, but was not spreading. No additional sites have been reported for Newfoundland (Rouleau and Lamoureux 1992).

In the United States *L. communis* was recorded by Gray (1884, 1889) and by Britton (1901) as present in New England and on the Columbia River as well as in Canada. From New England it began to spread to the midwest, appearing in Michigan in the early 20th century, where its population began to increase dramatically in the 1970s (Voss 1996). It was recently collected in Georgia, possibly having spread from Tennessee or North Carolina (Stiles and Howel 1998); has spread to Texas (O'Kennon et al. 1999); and has been spreading in North Carolina, where it is treated as an introduced but not invasive "exotic" (Pointdexter 2006). It was first collected on Maui in 1916 at the Haleakala Crater and was first collected on the Big Island (Hawaii) in 1981 (Wagner et al. 2005).

Hultén and Fries (1986) suggested that *L. communis* is probably indigenous to central and southeastern Europe, spreading with the migration of farming communities. Seeds of *L. communis* have been found with those of grasses and chenopods at sites in the fertile loess soils of the Rhineland dating from the Ceramic period of the fifth millennium BC to the Bronze age around 1250 BC (Knörzer 1971). It is believed that most of these plants grew originally in the same vegetation zones including forest margins and hedges surrounding fields as is still the case in the Rhineland, where they have rarely been found in weed-crop complexes (Knörzer 1971; Groenman-van Waateringe 1979). At seven neolithic sites in other parts of Germany where *L. communis* was present, only two sites showed any evidence of a weed-cereal crop complex (Knörzer 1971). The later spread of *L. communis* into crop areas has been attributed in part to changes in cultivation practices leading to transfer of seed, such as forest clearance and transport of sod from heath, peat, meadows, field edges, etc. as fertilizer for areas where soils were nutrient-depleted (Groenman-van Waateringe 1979). Further spread throughout Europe and to other continents could have followed the introduction of cereal and forage crops and their contaminants as well as of garden plants and their associated weeds (See Sections 3a and 5c).

7. Growth and Development

(a) *Morphology* — The numerous yellow flowers are attractive to small insect pollinators. As with most annuals, the species is highly variable in stem height, achene size and other features (see end of Section 2c), for example, under adverse conditions plants may grow to only 6–10 cm and produce 2–3 capitula (Canadian herbarium specimens). Ennos and Fitter (1992) recorded a 12% allocation of resources to root anchorage (as measured in dry matter), with approximately half of this devoted to the taproot and the other half to fibrous roots, and a further 8% of the dry matter of *L. communis* was invested in absorption roots.

(b) *Perennation* — *Lapsana communis* reproduces only by seed. Late germinating seedlings sometimes overwinter as rosettes.

(c) *Physiological Data* — *Lapsana communis* uses the C₃ photosynthetic pathway typical of its family. Like lettuce (*Lactuca* spp.) and other members of its tribe, *L. communis* possesses lactiferous canals (i.e., milky latex) in both the subterranean and aerial parts (Kilian et al. 2009). Like all but a few members of its tribe, the species lacks endodermal oil ducts in the roots, while dedoublement of the endodermis without formation of ducts has been reported (Kilian et al. 2009). Oil has been extracted from achenes and aerial parts, and a number of chemical compounds from different parts of the plant have been identified. *Lapsana communis* is among members of the tribe containing 15–75% crepenynic acid, its achenes having 50% of this fatty acid in the oil (White et al. 1971; Hegnauer 1977). In a Tennessee study of aerial plant parts, *L. communis* gave the highest yield of oil (6.1%) of 51 species analysed, and also yielded 12.1% ash, moderate amounts of polyphenol (5.5%) and protein (9.3%), and contained a very low level of hydrocarbons (Carr and Bagby 1987). In France, Fontanel et al. (1998a) isolated caffeic, chlorogenic, 3,5-O-dicaffeoylquinic, caftaric and chicoric acid (the major phenylpropanoic constituent in the species) from aerial parts of the plant, as well as the flavonoids, isoquercitrin, luteolin and luteolin-7-O- β -glucuronide. Although the high oil content detected in the Tennessee study was not confirmed by Fontanel et al. (1998b), they extracted 2.01% oil, consisting of 43.2% nonsaponifiable matter, a 42.5% mix of nonsaponifiable matter and triterpene alcohols, and 18.4% triterpene alcohols; fatty acids consisting of myristic, palmitic, 10, 13- or 11, 14-octadecadienoic, α -linolenic, stearic and arachidic acids; and triterpene alcohols consisting of three unidentified compounds and of taraxerol, β -amyrin, germanicol, α -amyrin, lupeol, cycloartenol and ψ -taraxasterol. Five guaianolide glycosides were identified in extracts of the latex from young stems of *L. communis*: two previously known sesquiterpene lactone glycosides, crepiside E and tectoroside, and three new compounds, lapsanoside A, B, and C (Fontanel et al. 1999). In Romania,

components of volatile oil extracted from *L. communis* plants harvested at the flowering stage consisted of limonene at a concentration of 22.5 g L⁻¹, acetophenone, nonanal, ethyl-3-hydroxymandelic acid ester, decanal, heptadecane, octadecane, dibutyl phthalate and squalen, the limonene providing protection against other potentially harmful constituents in the volatile oil (Stanciu et al. 2007). The mineral content of the achenes, as represented by the percentage of ash, was reported by Fenner (1983) as 4.1% in the embryo and 1.7% in the seed coat.

(d) *Phenology* — Germination occurs mostly in the spring following achene dispersal the previous year, but may occur in the late summer or fall of the flowering year. In Ontario, achenes of *L. communis* germinate in early spring or late autumn (Cowbrough 2005). In a greenhouse study in the United Kingdom to determine maximum seedling weight attained using only the embryo resources at a constant temperature of 20°C, *L. communis* achenes exhausted endosperm resources at 5 wk, the plants having a minimum of two leaves in addition to the cotyledons (Fenner 1983). Once the roots have developed, the rate of further growth depends on climate and soil conditions, but can occur rapidly. Larger lyrate leaves form a rosette, followed by bolting, with progressively smaller leaves forming on the upper parts of the stem. In Ontario, flowering has been observed to occur from July to September (Cowbrough 2005) and the time between germination and first capitulum production in greenhouse plants in Ottawa, ON, was about three months. In Europe, flowering can occur from May to September (Hanf 1970). In the United Kingdom, Miller (1752) observed that plants flowered in April and achenes ripened in June; whereas Smith (1829) referred to flowering as “June, July”. After achene dispersal, the lower leaves begin to rapidly senesce, but dried-up leaves and flower heads may remain on the stem until well into the fall (personal observations).

(e) *Mycorrhiza* — A vesicular-arbuscular mycorrhizal association was reported by Polish and German sources for *L. communis* in Europe (Harley and Harley 1987).

8. Reproduction

(a) *Floral Biology* — *Lapsana communis* is a protandrous (stamens mature prior to stigmas being receptive) sexually reproducing species (Jurukova-Grancharova 1995), pollinated by insects or often self-pollinated, and during the second or pistillate phase of anthesis, the stigma branches diverge widely in such a way that automatic self-pollination is regularly effected if insect visitors have not removed the pollen during the first phase of anthesis (Knuth 1908). Pollinators are attracted by the nectar produced from the start of anthesis by collar-like nectaries around the base of the style and on top of the inferior ovary (Wist and Davis 2006).

The small capitula will remain open to pollinators during bright or sunny weather, but will close in late afternoon or altogether if the weather is unfavourable (Knuth 1908).

The ability to self-pollinate was confirmed in a recent Russian study of achene formation under different flowering regimes. There was no evidence of apomictic reproduction in *L. communis* following emasculation of capitula, but non-emasculated capitula could produce high seed set even when blooming in isolation, indicating that the species was among facultatively allogamous species (Kashin et al. 2007).

The style projects 1.5–2 mm from the anther-cylinder, which in turn exceeds the corolla tube of the disc florets by 2–3 mm (Knuth 1908). The anthers are tetrasporangiate, the mature pollen is 3-celled, and the pollen grains are yellow, polyhedral, and average 31 µm in diameter (Knuth 1908; Jurukova-Grancharova 1995). Transmission and scanning electron microscopy of the pollen grains has shown them to be echinolphate in structure, with sections including both ridge and lacunar areas (Skvarla et al. 1977).

Although Müller (1883) suggested that flowers of *L. communis* attracted few insect visitors and were primarily self-pollinated, florets have a pollen-presentation mechanism involving stamens with sensitive (or “irritable”) filaments, which contract in response to touch (of filaments or anther tube) by flower visitors. A general description of the pollen-presentation mechanism in the family is given by Proctor and Yeo (1973). The mechanism, clearly an adaptation for insect pollination, is seen in many (but not all) members of the Asteraceae (Small 1917a, b). Small (1917a) described the touch response he observed in *Lapsana communis* as a marked lateral movement towards the touch accompanied by pollen being expressed at the top of the anther tube.

In Europe, flowers have been observed to attract relatively small pollinators including the following: the syrphid flies *Melanostoma mellinum* L., *Syrirta pipiens* L., *Eristalis arbustorum* L., *E. nemorum* L., *E. sepulcralis* L. and *Ascia podagrica* Fabr. (Diptera: Syrphidae); house-flies (Diptera: Muscidae); butterflies (Lepidoptera); and several bees, *Lasioglossum leucozonicum* Schr., *L. morio* Fabr. and *L. smeatmanellum* (Kirby) (Hymenoptera: Halictidae) (Knuth 1908; Drabble and Drabble 1927). A dagger fly, *Empis pennipes* L. (Diptera: Empididae), a cabbage butterfly *Pieris rapae* L. (Lepidoptera: Pieridae) and unidentified syrphid flies were photographed visiting flowers in Belgium (Lindsay 2005).

The embryo develops according to the Asterad-type (i.e., a blending of terminal and basal cells following longitudinal division of the two initial embryonic cells) (Jurukova-Grancharova 1995).

(b) *Seed Production and Dispersal* — In Ontario, a plant may produce from 400 to 800 achenes (Cowbrough 2005). In the United Kingdom, the figure given was

somewhat higher at 1000 achenes per plant, with a suggestion that in ruderal habitats the actual number of achenes produced can be much higher (Bond et al. 2007). Achenes are relatively small, but size and number may vary considerably, depending upon conditions as noted by Berkefeld (1988) (see Section 2c). In a study of achenes collected from a variety of open and closed habitats in the United Kingdom, Fenner (1983) found an average weight of 1.07 mg, with an embryo weight of 0.6 mg. Guitián and Garrido (2006) determined an average weight of 0.44 mg for achenes collected from a deciduous woodland in northwestern Spain; whereas Jankowska-Blaszczuk and Daws (2007) determined a mean weight of 0.86 mg for achenes collected from a deciduous forest in Poland.

The absence of a bristly pappus ensures that achenes of *L. communis*, although relatively small and light, will not be carried long distances by wind, as is the case for many Asteraceae, such as dandelion, and there is no evidence of dispersal by birds or mammals. As noted in Sections 3a and 6, dispersal of *L. communis* has been very slow and gradual from forest margins and ruderal areas to neighbouring cultivated areas, although long-distance dispersal has occurred in the course of transfer of soil associated with sod and garden material. The species has also been documented as a contaminant of cereal and other grass seeds (see Section 3a). In a study of understorey plants in a managed temperate forest in Denmark (Svenning and Skov 2002), *L. communis* was present mainly in open areas with a minimal spread to neighbouring plots, and, like other poor dispersers, showed a stronger tendency to clumping at the 100-m scale compared with more effective dispersers.

(c) *Seed Banks, Seed Viability and Germination* — There are no published Canadian studies on *L. communis* achene behaviour. All observations on the seed bank and long-term viability of its achenes have come from Europe. The botanist Philip Miller (1752) noticed that the seed bank of *L. communis* was depleted after only 2–3 yr of emergence in English gardens. A 5-yr study of seedling emergence in the United Kingdom (Roberts and Neilson 1981) confirmed that the majority of achenes germinated in the first 2–3 yr, although a small percentage remained viable up to 5 yr. In France, changes in the soil seed bank were monitored over a 4-yr period on plots sown initially with *L. communis* and other weeds at known densities and with subsequent shedding prevented (Chadoeuf et al. 1984). *Lapsana communis* was among species that disappeared rapidly from the seed bank, the decrease being greatest in the first year. In a 5-yr study of weed seeds sown by hand in single-crop fields of winter wheat and spring barley (Barralis et al. 1988), *L. communis* showed a very high rate of annual decline in the seed bank, about 80% per year, with emergence representing an average of 15% of the annual seed bank. In both French studies, viability of buried seeds remained relatively high. In Sweden,

viability among buried seeds did not decrease significantly over a 2-yr study period, although the long-term survival rate of *L. communis* was, at less than 5 yr, the lowest among the species studied (Milberg and Andersson 1997).

In the state of Massachusetts, USA, 99% of *L. communis* achenes planted immediately post-harvest germinated within 7 d at 20–30°C in light and dark conditions; with pre-chilling, however, achenes became dormant (Lincoln 1983). In the United Kingdom, *L. communis* was among species exhibiting relatively rapid germination after dry storage for 12 mo at 5°C, although some achenes also germinated well immediately after collection (Grime et al. 1981). Seed dormancy studies of *L. communis* from November 1994 to April 1997 in Sweden showed inconsistent dormancy changes: in 1995, germination was lowest during the first spring after planting, but, from July onwards, was complete in full light and almost so after short light exposure, but was almost nil in the dark (Milberg and Andersson 1997). In Poland, *L. communis* was among 27 temperate deciduous forest species investigated for the effect of the red-far red light (R:FR) ratio on the percent germination of their seeds (Jankowska-Blaszczuk and Daws 2007). *Lapsana communis* was among the small-seeded species with a moderately high light requirement achieving less than 20% germination at low R:FR, and 100% at the highest R:FR level. The authors also found that requirements of small-seeded species for light was reflected in a greater persistence in the soil seed bank, although this generalization is not consistent with the above-cited results of studies elsewhere, perhaps because results were averaged over a number of species.

(d) *Vegetative Reproduction* — *Lapsana communis* does not reproduce vegetatively.

9. Hybrids

No cases of inter-specific hybridization involving *L. communis* were found.

10. Population Dynamics

No published statistics on population spread or structure of *L. communis* in Canada were found. The species is still most widespread in the areas where it was first reported in eastern Canada and British Columbia, with only a limited spread from ruderal habitats to crops (see Section 3a). In the United States, *L. communis* appears to have spread only slowly from its original garden and ruderal habitats, with occasional introductions to isolated locations in new areas (see Sections 3a and 6). However, in Michigan, an initially inconspicuous population began to increase dramatically in size in the 1970s into newly disturbed areas along trails and roads in deciduous woods, in gardens, hedges and various waste places (Voss 1996). In Hawaii, it populates mainly higher elevations on Maui and Hawaii, and it is not always competitive in communities with more aggressive

plants, but moves into new areas after fire and other disturbances (Starr and Starr 2008; F. Starr, personal communication May 2010).

In untreated sample plots in 255 fields assessed in Finland, *L. communis* was among dicot weeds producing the highest biomass in spring cereals, ranking 7th with a frequency of 55% and an average dry weight of 21 kg ha⁻¹ which comprised 6–7% of the total average weed biomass (Salonen and Ervio 1988). In a comparison of weed populations in hedges and field margins and at various distances into crop fields in the United Kingdom, *L. communis* was among those plants found in both hedges and fields: higher percent cover occurred in the hedges and on the margins than in the field, suggesting a spread into fields via seed banks progressively established at different distances (Marshall 1989). Wilson and Aebischer (1995) observed a similar pattern for *L. communis* in British cereal fields, and emphasized the progressive reduction in seed bank density further from the edge of the field. In Poland, the species appears to have spread from ruderal habitats to cultivated fields (Korniak and Kalwasinska 2001); and occurred in 35% of cereal crop fields (Snarska 2004). A forest survey in Denmark showed little response to microclimatic parameters such as orientation, soil type, drainage, altitude or stand age; the species rarely spread beyond the open areas it occupied in the forest (Svenning and Skov 2002). In a study following the succession of plants in abandoned agricultural fields in the United Kingdom, *L. communis* was displaced by later successional species after several decades (Brenchley and Adam 1915). As noted in Section 6, *L. communis* populations in Europe have tended to remain in typical habitats of forest and field margins for centuries, rarely moving into or establishing within cleared fields until changes in field management practices led to changes in population dynamics.

11. Response to Herbicides and Other Chemicals

In southern Ontario, control of *L. communis* has been difficult, especially if plants were past the early seedling or rosette stage. However, based on single field trials in corn and winter wheat, suggestions for control of this weed using post-emergent herbicides applied at recommended rates have been provided (Cowbrough 2005). Applications of the following herbicides at the 12-leaf stage or above provided 94–99% control in field corn: atrazine (1010–1490 g a.i. ha⁻¹), atrazine/2,4-D (936–1404 g a.i. ha⁻¹; 1.5:1), bromoxynil + atrazine (280–340+1010–1490 g a.i. ha⁻¹), dicamba (600 g a.e. ha⁻¹), dicamba/atrazine (1480–1800 g a.i. ha⁻¹; 1:2), and diflufenzopyr/dicamba (200 g a.i. ha⁻¹; 1:2.6); and 60–83% control was provided by mesotrione (100 g a.i. ha⁻¹), primisulfuron/dicamba (166 g a.i. ha⁻¹; 1:5.3), and prosulfuron + dicamba (10 g a.i. ha⁻¹+140 g a.e. ha⁻¹) (Cowbrough 2005). In winter wheat, clopyralid (200 g a.e. ha⁻¹), dicamba/MCPA/mecoprop (400–600 g a.e. ha⁻¹; 1:4.4:1) and dichlorprop/2,4-D (1017 g a.i.

ha⁻¹; 1:1:1) provided 69–75% control, whereas thifensulfuron-methyl/tribenuron-methyl (15 g a.i. ha⁻¹; 2:1), bromoxynil (280–340 g a.i. ha⁻¹), dicamba (110–139 g a.e. ha⁻¹), bromoxynil/MCPA (560 g a.e. ha⁻¹; 1:1), MCPA (350–850 g a.e. ha⁻¹) and 2,4-D (350–550 g a.e. ha⁻¹) were progressively less effective, down to 0% control for the latter, all applied at the nine-leaf stage or older (Cowbrough 2005). No field studies on the control of this weed in soybeans have been published.

In Sweden, *L. communis* was among weeds that increased in frequency in spring cereals during 1951–1990, suggesting that the herbicide mixture used to control weeds during this period (300 g L⁻¹ dichlorprop+130 g L⁻¹ MCPA+58 g L⁻¹ ioxynil+38 g L⁻¹ bromoxynil) had become less effective over time (Hallgren 1996). In the United Kingdom, pyridate applied at post-emergence at rates of 1000 and 1500 g a.i. ha⁻¹ was effective against a broad spectrum of weeds in small grains and corn and selectively controlled *L. communis* in wheat and barley (Diskus et al. 1976). In Germany, metsulfuron-methyl, a herbicide with low toxicity to wildlife and rapid absorption via the roots and leaves of weeds, provided 100% control of *L. communis* in winter cereals at an application rate of 8 g a.i. ha⁻¹ (Drobny 1984). In Russia, *L. communis* was among weeds treated at the two- to four-leaf stage that were controlled by application of either 1200 g lenacil+6 L phenmedipham ha⁻¹ by broadcasting, or 600 g lenacil+3 L phenmedipham ha⁻¹ by banded placement (Kameneva et al. 1987).

In Finland, forage seed crops sprayed once with bromoxynil+dichlorprop+ioxynil+MCPA or with MCPA+mecoprop+clpyralid in spring, or twice when the crop grass had 1 or 2 nodes, reduced the numbers and weight of weeds, including *L. communis*, but the effect was relatively small with the single application, and the meadow fescue crop required two applications of MCPA+mecoprop+clpyralid for effective weed control (Ervio 1982). The effectiveness of imidazolinones (IMIs), a group of herbicides inhibiting acetolactate synthase (ALS) activity in IMI-resistant canola, was tested at several locations, using imazamox (Haukkapää et al. 2005). Imazamox was very effective against the most troublesome weeds, but was largely ineffective against *L. communis*. In spring wheat fields where *L. communis* had a moderately high frequency and biomass (see Section 10), control by MPCA sprayed at 1200 g a.i. ha⁻¹ was poor (9%), confirming that this species was among several that had become tolerant to MCPA, whereas dichlorprop+MCPA provided 49% control and mecoprop+MCPA 90%, the MCPA mixtures applied at an average rate of 2500–4000 g a.i. ha⁻¹ (Salonen and Ervio 1988).

In Denmark, the herbicide aclonifen, applied pre- or post-emergence on clay or sandy soils, or post-emergence on organic soils was found to provide effective control of *L. communis* and other weeds in a number of vegetable garden crops (Brendstrup and Koster 1998).

In peas, aclonifen could be used alone or in tank mixtures or sequential treatments with bentazon, and in potatoes, in tank mixtures or sequential treatments with metribuzin. In Norway, greenhouse pot experiments were carried out to study the effect of herbicide doses and application times on the production of weed seeds in a reduced tillage system (Semb and Skuterud 1996). The weeds were sprayed once with glyphosate at 360 and 720 g ha⁻¹ and glufosinate at 200 and 400 g ha⁻¹ at the developmental stages of full flowering, and at 10 d or 20 d later. The number of viable seeds of all species studied was reduced by 90–100% with applications at full flowering, whereas later spraying had little effect on the weight or number of viable seeds. The greatest impact on the number of achenes of *L. communis* was obtained at the highest dose of glufosinate. Field experiments (1990–1991) in commercially grown cereal fields and fields sown with spring rape were performed at the two- to four-leaf stage using a low dose spray mixture of ioxynil + dichlorprop + MCPA at rates of 53, 223 and 75 g a.i. ha⁻¹, respectively (Skuterud et al. 1998). Spraying took place at different times of the day. *Lapsana communis* was among the least susceptible to this herbicide mixture when sprayed in the evening, when the number of plants and dry weight was considered. Spraying reduced the weight of this species more than the number of plants. It was suggested that the greater efficacy of applying herbicides in the morning might be attributed to a lower risk of rain and strong wind during this time of day.

In Turkish hazelnut orchards, mechanical control using either rotary hoeing or mowing combined with post-emergent herbicides glyphosate (2400 g a.i. ha⁻¹) or paraquat (1000 g a.i. ha⁻¹) provided 100% control of *L. communis*; rotary hoeing combined with pendimethalin at 1320 g+fluazifop-*p*-butyl at 120 g a.i. ha⁻¹ provided 60–65% control, less than control achieved by rotary hoeing alone; and mowing combined with pendimethalin at 1320 g + fluazifop-*p*-butyl at 120 g a.i. ha⁻¹ provided 70% control, slightly greater than mowing alone (Mennan et al. 2006).

12. Response to Other Human Manipulation

Control of *L. communis* was achieved in the United Kingdom through prevention of achene dispersal and destruction of young plants by hoeing and tillage (Morse and Palmer 1925). In Norway, Fiveland (1974) found that competition from *L. communis* and other weeds in swede [*Brassica napobrassica* (L.) Mill.] and carrot crops could begin to affect yields after 28 d, and to significantly affect yields after 42 d, but yields increased significantly after periods of hand-weeding every 14 d after planting up to 42 d, after which the crops themselves provided effective weed control. In Germany, the use of herbicides to control *L. communis* and other weeds in canola could be replaced by the use of fast-growing cultivars and thorough seedbed preparation, with rolling (to reduce the detrimental

herbivory from snails), early sowing, and cultivation to control volunteer cereals (Klischowski and Beyer 1989). In Turkey, cover crops of Italian ryegrass, hairy vetch (*Vicia villosa* Roth) and red clover combined with mechanical control methods (rotary hoeing and mowing) were tested in hazelnut orchards for their weed control efficacy (Mennan et al. 2006). Residues from all three cover crops suppressed *L. communis*, reducing the weed biomass significantly at 20 d after desiccation of the cover crops. The level of weed control by mechanical means alone was inadequate, with at least double the plant density and several times the residual dry weight compared with combinations including various herbicides (see Section 11). In a comparative study in winter rye plots in Poland (Kraska and Pays 2007), where herbicides were seldom used because the dense canopy of rye plants was expected to suppress weed growth, both conventional tillage involving stubble cultivation (8–10 cm depth) plus pre-plant ploughing (18–20 cm depth), and conservation tillage involving rigid-tine cultivation (18 cm depth) were tested for effectiveness in control of weeds over a period of 6 yr. Whereas *L. communis* and several other species were completely suppressed, and other weed species were suppressed by 50–88% under the conventional tillage regime, weed density and biomass were found to be almost double under the conservation tillage regime.

In a study of biodiversity of arable weeds in Finland, *L. communis* was among the majority of weeds that increased in frequency of occurrence between the 1960s (when intensive cropping measures, including herbicide use and frequent ploughing, had been applied) and the 1990s (when many fields had been converted to organic production characterized by omission of herbicides and mineral fertilizers, reduced tillage, and more diverse crop rotations). For example, *Lapsana communis* increased in frequency from 41.6 to 57.3% (Hyvönen 2007). The density of most weeds in the study decreased (that of *L. communis* from 18 to 15.5 plants m⁻²), attributed by Hyvönen (2007) in part to the greater plant diversity and number of total individuals in a given area. Comparing production systems in Finland, the relative abundance of *L. communis* in organic fields was considerably lower (1.5% in May–June, 1.8% in July–August) than in conventional cereal (3.2%, 5.2%) and dairy farms (7.9%, 8.6%) where traditional management practices were used, suggesting that it differentially benefited within the weed flora from herbicide use and high nitrogen input (Hyvönen et al. 2003).

13. Response to Herbivory, Disease and Higher Plant Parasites

(a) Herbivory

(i) *Mammals, including both domestic and wild animals* — *Lapsana communis* is said to be eaten by all domestic animals except goats (Fogelfors 1984). In reports of weed contamination of pasture seed crops, the weeds, including *L. communis*, reduced the percentage of more

nutritious pasture plants such as red clover, red fescue or timothy (Pettersson 1984; Aamissepp 1982, 1984; Nortoft 1985; Bond et al. 2007). However, there is no suggestion that the weeds themselves were not eaten or were harmful to animals.

(ii) *Birds and other vertebrates* — No information located.

(iii) *Insects* — An absence of reports of insect herbivory of *L. communis* in North America suggests that this species may not be particularly vulnerable to insect attack, as is the case in New Zealand where it has suffered virtually no herbivory compared with the native plants (Bossdorf et al. 2005). A survey of pre-dispersal predation in herbaceous Asteraceae in the United Kingdom and New Zealand found no *L. communis* capitula infested by insects (Fenner and Lee 2001). In Quebec, where this introduced plant has been known for longer than elsewhere in Canada, no evidence of significant chemical defence compounds was found in local populations of the species (Almeida-Cortez et al. 1999; Almeida-Cortez and Shipley 2002). The lettuce root aphid, *Pemphigus bursarius* (L.) (Homoptera: Aphididae), which attacks roots of *L. communis* in Europe, has been reported on lettuce and other plants in Quebec, but *L. communis* was not reported on the list of host plants compiled by Alleyne and Morrison (1977).

In the United Kingdom, the lettuce root aphid overwinters in the egg stage on black poplar (*Populus nigra* L.), and colonizes hosts among the Asteraceae in the following summer. Large colonies have been found on the roots of *L. communis* reflecting its status as a highly susceptible host; among 64 plants examined between July 1956 and February 1957, 43.7% of roots were infested by a total of 617 aphids, or 22 aphids per infested plant (Dunn 1959). It was subsequently found that a proportion of the aphid species that alternate between host plants had lost the sexual phase of the life-cycle. These remained in the soil and overwintered as asexual apterae after the aestival host plant had died in the autumn, and *L. communis* was among the host species likely to be colonized in the spring (Phillips et al. 1999). When clones of *P. bursarius* were cultured first on *L. communis* as a “home” host and subsequently on two “away” hosts, *Lactuca* and *Matricaria*, no clones survived on *Lactuca* and only a few on *Matricaria*, and populations of this aphid on *L. communis* appeared to be a mixture of cyclical and obligate parthenogens and were more genetically heterogenous than populations on other hosts (Miller et al. 2005). In Sweden, *L. communis* is among summer hosts of the lettuce root aphid (Ramert 1977).

A number of phytophagous insects have also been reported on *L. communis* in the United Kingdom including the leaf miners *Chromatomyia syngenesiae* Hardy, *Ophiomyia cunctata* Hendel, and *Phytomyza*

marginella Fallén (Diptera: Agromyzidae); the aphid *Hyperomyzus lamprosanus* Börner (Homoptera: Aphididae) on leaves and shoots; and the moth *Phalonidia gilvicomana* Zeller (Lepidoptera: Tortricidae) on achenes (Filter and Peat 1994).

A British study showed a relationship between small capitulum size and reduced pre-dispersal achene predation among species of Asteraceae (Fenner et al. 2002). Among the 20 species examined *L. communis* had the smallest capitula and showed no insect predation.

(iv) *Other invertebrates* — *Lapsana communis* was found to have a high degree of palatability to slugs in Washington State (Cates and Orians 1975). The authors found both *Ariolimax columbianus* Gould and *Aarion ater* L., a European slug, feeding on *L. communis*.

(b) Diseases

(i) *Fungi* — In Canada, the rust fungus *Puccinia lapsanae* Fuckel has been reported on *L. communis* in British Columbia and Ontario, and the leaf spot fungus *Ramularia lapsanae* (Desm.) Sacc. in British Columbia (Connors 1967; Ginns 1986). The rust fungus has been reported from three states in the USA, Minnesota (McCain et al. 1990), Oregon, and Wisconsin (Farr and Rossman 2010). The only fungi reported on *L. communis* in New Zealand are *P. lapsanae* and *R. lapsanae*, and the former has also been reported from Chile (Farr and Rossman 2010), suggesting that these monophagous pathogens were introduced along with the host species. The above and numerous other fungal pathogens have been reported from various parts of Europe (Fitter and Peat 1994; Farr and Rossman 2010), among them the oligophagous *Podospaera fusca* (Fr.) U. Braun & Shishkoff, infecting leaves and stems with powdery mildew, and *Botrytis cinerea* Pers., infecting stems, leaves and achenes with grey rot or blight; but the majority of the 56 species reported from the United Kingdom are generalists and saprophytic on rotting or dead stems and leaves. In eastern Europe, *L. communis* was among Asteraceae harbouring the lettuce downy mildew fungus, *Bremia lactucae* Regel, but there was no interspecific transmissibility of *B. lactucae* isolates from the host species to *Lactuca sativa* cultivars (Lebeda and Syrovatko 1988). Lindsay (2005) photographed infection by *Podospaera fusca* and *Puccinia lapsanae* on leaves of *L. communis* in Belgium

(ii) *Bacteria* — No information located.

(iii) *Viruses* — No information located.

(c) *Higher Plant Parasites* — No information located.

ACKNOWLEDGEMENTS

We thank Rob Nurse, weed scientist, AAFC, Harrow, ON for valuable assistance on weed control; Forest Frost, plant biologist, Hawaii, for information on *Lapsana communis* populations in Hawaii; and the

curators of the following Canadian herbaria for making specimens available for study: ACAD, ALTA, CAN, DAO, HAM, LKHD, MAN, MT, NSPM, OAC, QFA, QK, QUE, SASK, TRTE, UAC, UBC, UNB, UWO, V and WAT.

Aamissepp, A. 1982. Weed control in pasture seed crops. Engfroavl. 1982: 211–219.

Aamissepp, A. 1984. Weed control in grassland seed crops. Svensk Frotidning 53: 3, 31–32, 42.

Alleyne, E. H. and Morrison, F. O. 1977. The lettuce root aphid, *Pemphigus bursarius* (L.) (Homoptera: Aphidoidea) in Quebec, Canada. Ann. Entomol. Soc. Que. 22: 171–180.

Almeida-Cortez, J. S. and Shipley, W. 2002. No significant relationship exists between seedling relative growth rate under nutrient limitation and potential tissue toxicity. Funct. Ecol. 16: 122–127.

Almeida-Cortez, J. S., Shipley, W. and Arnason, J. T. 1999. Do plant species with high relative growth rates have poorer chemical defences? Funct. Ecol. 13: 819–827.

Baagøe, J. 1977. Microcharacters in the ligules of the Compositae. Pages 120–138 in V. H. Heywood, J. B. Harborne, and B. L. Turner, eds. The biology and chemistry of the Compositae, Vol. 1., Academic Press, London, UK.

Barralis, G., Chadoeuf, R. and Longchamp, J. P. 1988. Longevité des semences de mauvaises herbes annuelles dans un sol cultivé. Weed Res. 28: 407–418.

Berge, T. W., Aastveit, A. H. and Fykse, H. 2008. Evaluation of an algorithm for automatic detection of broad-leaved weeds in spring cereals. Precis. Agric. 9: 391–405.

Berkefeld, K. 1988. Investigations about ecotype formation in *Galium aparine* L. (Rubiaceae) and *Lapsana communis* L. (Compositae). Flora (Jena) 181: 111–130. [in German, English abstract].

Blamey, M. and Grey-Wilson, C. 1989. The illustrated flora of Britain and northern Europe. Hodder & Stoughton, London, UK. 544 pp.

Bogler, D. J. 2006. *Lapsana* Linnaeus. Page 257 in Flora of North America north of Mexico. Vol. 19. Magnoliophyta: Asteridae, part 6: Asteraceae, part 1. Oxford University Press, New York, NY.

Bond, W., Davies, G. and Turner, R. 2007. The biology and non-chemical control of nipplewort (*Lapsana communis* L.). Henry Doubleday Research Association, Ryton Organic Gardens, Coventry, UK. 3 pp. [Online] Available: <http://www.getsetgrow.org.uk/organicweeds/downloads/lapsana%20communis.pdf> [2010 May 13].

Bossdorf, O., Auge, H., Lafuma, L., Rogers, W. E., Siemann, E. and Prati, D. 2005. Phenotypic and genetic differentiation between native and introduced plant populations. Oecologia 144: 1–11.

Brenchley, W. E. and Adam, H. 1915. Recolonisation of cultivated land allowed to revert to natural conditions. J. Ecol. 3: 193–210.

Brendstrup, I. and Koster, I. 1998. FENIX (aclonifen) – a novel herbicide for use in potato, pea, carrot, parsnip, celery, parsley root and set onions. DJF Rapport, Markbrug 2: 133–140. [in Danish, English abstract].

Britton, N. L. 1901. Manual of the flora of the northern states and Canada. Henry Holt and Company, New York, NY. 1080 pp.

- Buttler, H. 1999.** A first record of *Lapsana communis* L. subspecies *intermedia* (Bieb.) Hayek for Germany, with an overview of the genus. *Florist. Rundbr.* **33**: 3–7.
- Carr, M. E. and Bagby, M. O. 1987.** Tennessee plant species screened for renewable energy sources. *Econ. Bot.* **41**: 78–85.
- Cates, R. G. and Orians, G. H. 1975.** Successional status and the palatability of plants to generalized herbivores. *Ecology* **56**: 410–418.
- Catling, P. M., Erskine, D. S. and MacLaren, R. B. 1985.** The plants of Prince Edward Island with new records, nomenclatural changes and corrections and deletions. Research Branch, Agriculture Canada, Ottawa, ON. Publ. 1798, 272 pp.
- Chadoeuf, R., Barralis, G. and Lonchamp, J. P. 1984.** Evolution du potentiel semencier de mauvaises herbes annuelles dans un sol cultivé. VIIème Colloque International sur l'Ecologie, la Biologie et la Systématique des Mauvaises Herbes (Paris). pp. 63–70.
- Chytry, M. and Danihelka, J. 1993.** Long-term changes in the field layer of oak and oak-hornbeam forests under the impact of deer and mouflon. *Folia Geobot. Phytotax. Praha* **28**: 225–245.
- Clapham, A. R., Tutin, T. G. and Moore, D. M. 1987.** Flora of the British Isles. 3rd ed. Cambridge University Press, Cambridge, UK. 688 pp.
- Connors, I. L. 1967.** An annotated index of plant diseases in Canada. Canada Dep. Agric. Res. Branch, Ottawa, ON. Publ. 1251, 381 pp.
- Cowbrough, M. 2005.** Nipplewort (*Lapsana communis* L.), Ontario Ministry of Agriculture, Food and Rural Affairs. [Online] Available: <http://www.omafra.gov.on.ca/english/crops/field/weeds/nipplewort.htm> [2010 May 13].
- Darbyshire, S. J. 2003.** Inventory of Canadian agricultural weeds. Agriculture and Agri-Food Canada, Ottawa. [Online] Available: <http://dsp-psd.pwgsc.gc.ca/Collection/A42-100-2003E.pdf> [2010 May 13].
- Darbyshire, S. J., Favreau, M. and Murray, M. 2000.** Common and scientific names of weeds in Canada/Noms populaires et scientifiques des plantes nuisibles du Canada. Agriculture and Agri-Food Canada/Agriculture et Agroalimentaire Canada, Ottawa, ON. Publ. 1397, 132 pp.
- Diskus, A., Schonbeck, R., Auer, E. and Kloimstein, E. 1976.** CL 11 344 – a new selective herbicide for use in cereals and maize. Proc. 1976 British Crop Protection Conference – Weeds **2**: 717–722.
- Douglas, G. W., Straley, G. B., Meidinger, D. and Pojar, J. (eds.) 1998.** Illustrated flora of British Columbia. Vol. 1: Gymnosperms and dicotyledons (Aceraceae through Asteraceae). British Columbia Ministry of Environment, Lands and Parks, and British Columbia Ministry of Forests, Victoria, BC. 436 pp.
- Drabble, E. and Drabble, H. 1927.** Some flowers and their dipteran visitors. *New Phytol.* **26**: 115–123.
- Drobný, H. G. 1984.** DPX – T 6376 – a new herbicide for cereals. *Z. Pflanzenkr. Pflanzenschutz Sonderheft* **10**: 305–309. [In German, English abstract].
- Dunn, J. A. 1959.** The biology of lettuce root aphid. *Ann. Appl. Biol.* **47**: 475–491.
- Edmonds, J. M., Sell, P. D. and Walters, S. M. 1974.** Some British chromosome counts in the Compositae subfamily Cichorioideae. *Watsonia* **10**: 159–161.
- Ennos, A. R. and Fitter, A. H. 1992.** Comparative functional morphology of the anchorage systems of annual dicots. *Funct. Ecol.* **6**: 71–78.
- Ervio, L. R. 1982.** Repeated weed control in seed crops in spring. *Engfroavl.* **1982**: 205–210.
- Ervio, R., Hyvarinen, S., Ervio, L. R. and Salonen, J. 1994.** Soil properties affecting weed distribution in spring cereal and vegetable fields. *Agric. Sci. Finl.* **3**: 497–504.
- Farr, D. F. and Rossman, A. Y. 2010.** Fungal databases, Systematic Mycology and Microbiology Laboratory, ARS, USDA. [Online] Available: <http://nt.ars-grin.gov/fungaldata-bases/> [2010 May 13].
- Fenner, M. 1983.** Relationships between seed weight, ash content and seedling growth in twenty-four species of Compositae. *New Phytol.* **95**: 697–706.
- Fenner, M. and Lee, W. G. 2001.** Lack of pre-dispersal seed predation in introduced Asteraceae in New Zealand. *N. Z. J. Ecol.* **25**: 95–99.
- Fenner, M., Cresswell, J. E., Hurley, R. A. and Baldwin, T. 2002.** Relationship between capitulum size and pre-dispersal seed predation by insect larvae in common Asteraceae. *Oecologia* **130**: 72–77.
- Fernandez, A. and Queirós, M. 1971.** Contribution à la connaissance cytotoxonomique des Spermatophyta du Portugal. II. Compositae. *Bol. Soc. Broteriana, sér. 2*, **45**: 5–121.
- Fitter, A. H. and Peat, H. J. 1994.** The ecological flora database. *J. Ecol.* **82**: 415–425. *Lapsana communis*. [Online] Available: <http://www.ecoflora.co.uk> [2010 Nov. 26].
- Fiveland, T. J. 1974.** The competition between swedes or carrots and annual weeds. *Meld. Nor. Landbrukshogsk* **53**: 21. 15 pp.
- Fogelfors, H. 1984.** Useful weeds? Part 12. *Lantmannen* **105**: 14, 49.
- Fontanel, D., Galtier, C., Debauzy, J.-C., Gueiffier, A. and Viel, C. 1999.** Sesquiterpene lactone glycosides from *Lapsana communis* L. subsp. *communis*. *Phytochemistry* **51**: 999–1004.
- Fontanel, D., Galtier, C., Viel, C. and Gueiffier, A. 1998a.** Caffeoyl quinic and tartaric acids and flavonoids from *Lapsana communis* subsp. *communis* (Asteraceae). *Zeitschr. Naturforsch. Sect. C, Biosc.* **53**: 1090–1092.
- Fontanel, D., Kargol, M., Gueiffier, A. and Viel, C. 1998b.** Triterpene alcohols and fatty acids in lipids and nonsaponifiable matter of *Lapsana communis* L. subspecies *communis* (Asteraceae). *J. Am. Oil Chem. Soc.* **75**: 1457–1459.
- Froud-Williams, R. J. and Chancellor, R. J. 1987.** A survey of weeds of oilseed rape in central southern England. *Weed Res. (Oxford)* **27**: 187–194.
- Fuchs, M. A. 2001.** Towards a recovery strategy for Garry oak and associated ecosystems in Canada: Ecological assessment and literature review. Environment Canada, Canadian Wildlife Service, Pacific and Yukon Region. Technical Report GBEI/EC-00-030. 106 pp.
- Gerard, J. 1633.** The herball or general historie of plantes. The complete 1633 edition as revised from the 1597 edition. Very much enlarged and amended by Thomas Johnson. 1975 facsimile, Dover Publications Inc., New York, NY. 1630 pp.
- Giñas, J. H. 1986.** Compendium of plant disease and decay fungi in Canada 1960–1980. *Agric. Can. Res. Branch Publ.* 1813. 416 pp.
- Glemnitz, M., Czimmer, G., Radics, L. and Hoffman, J. 2000.** Weed flora composition along a north-south climate gradient in Europe. *Acta Agron. Ovar.* **42**: 155–169.
- Godefroid, S., Rucquoi, S. and Koedam, N. 2006.** Spatial variability of summer microclimates and plant species response along transects within clearcuts in a beech forest. *Plant Ecol.* **185**: 107–121.

- Gooch, S. M. S. 1963.** The occurrence of weed seeds in samples tested by the official seed testing station, 1960–1. I. Grass seed of United Kingdom origin. II. Grass seed of Scandinavian origin. *J. Nat. Inst. Agric. Bot.* **9**: 353–371.
- Gray, A. 1884.** Synoptical flora of North America. Vol. I – part II.: Caprifoliaceae – Compositae. Ivison, Blakeman, Taylor, and Company, New York, NY. 473 pp.
- Gray, A. 1889.** Manual of the botany of the northern United States, ed. 6, revised and extended westward by S. Watson and others. American Book Company, New York, NY. 760 pp.
- Grime, J. P., Mason, G., Curtis, A. V., Rodman, J., Band, S. R., Mowforth, M. A. G., Neal, A. M. and Shaw, S. 1981.** A comparative study of germination characteristics in a local flora. *J. Ecol.* **69**: 1017–1059.
- Groenman-van Waateringe, W. 1979.** The origin of crop weed communities composed of summer annuals. *Vegetatio* **41**: 57–59.
- Gutián, J. and Garrido, J. L. 2006.** Is early flowering in myrmecochorous plants an adaptation for ant dispersal. *Plant Spec. Biol.* **21**: 165–171.
- Hallgren, E. 1996.** Do the weed flora and effect of a herbicide change with time? Proc. of the 2nd International Weed Control Congress, Copenhagen, Denmark, 25–28 June. **1–4**: 1355–1368.
- Hanf, M. 1970.** Weeds and their seedlings. BASF UK Ltd., Ipswich, UK. 345 pp.
- Harley, J. L. and Harley, E. L. 1987.** A check-list of mycorrhiza in the British flora. *New Phytol. (Suppl.)* **105**: 1–102.
- Haukkipää, A. L., Junnila, S., Eriksson, C., Tulisalo, U. and Seppänen, M. 2005.** Efficacy of imazamox in imadazolinone-resistant spring oilseed rape in Finland. *Agric. Food Sci.* **14**: 377–388.
- Hedrick, U. P. (ed.) 1919.** Sturtevant's notes on edible plants. J. B. Lyon Co., Albany, NY. 686 pp.
- Hegi, G. 1929.** *Illustrierte Flora von Mittel-Europa*. Vol. 6, Part 2. J. F. Lehmanns Verlag, München. 1388 pp. [in German].
- Hegnauer, R. 1977.** The chemistry of the Compositae. Pages 284–324 in V. H. Heywood, J. B. Harborne, and B. L. Turner, eds. *The biology and chemistry of the Compositae*, Vol. 1., Academic Press, London, UK.
- Hinds, H. R. 2000.** *Flora of New Brunswick*. 2nd ed. Department of Biology, University of New Brunswick, Fredericton, NB. 695 pp.
- Hocho, T. 1990.** Segetal weed communities in the Osošina Valley in the Beskid Wyspowy: Part II. The weediness of cereals, *Zeszyty Naukowe Akademii Rolniczej im. H. Kollataja w Krakowie, Rolictwo*. **29**: 77–91. [In Polish, English abstract].
- Holm, L., Pancho, J. V., Herberger, J. P. and Plucknett, D. L. 1979.** A geographical atlas of world weeds. John Wiley & Sons, New York, NY. 391 pp.
- Holmgren, P. K., Holmgren, N. H. and Barnett, L. C. (Eds.) 1990.** *Index herbariorum*. Part 1: The herbaria of the world. 8th ed. New York Botanical Garden, New York, NY. 693 pp.
- Hooker, W. J. 1840.** *Flora Boreali-Americana; or the botany of the northern parts of British America: compiled principally from the plants collected by Dr. Richardson and Mr. Drummond on the late northern expeditions, under the command of Captain Sir John Franklin, R. N. to which are added (by permission of the Horticultural Society of London)* those of Mr. Douglas, from north-west America, and of other naturalists. Vol. 1. Henry G. Bohn, London, UK. 351 pp.
- Hultén, E. and Fries, M. 1986.** *Atlas of North European vascular plants*. Part I – III, maps and commentaries. Koeltz Scientific Books, Königstein, Germany. 1172 pp.
- Hyvönen, T. 2007.** Can conversion to organic farming restore the species composition of arable weed communities? *Biol. Cons.* **137**: 382–390.
- Hyvönen, T., Ketoja, E., Salonen, J., Jalli, H. and Tiainen, J. 2003.** Weed species diversity and community composition in organic and conventional cropping of spring cereals. *Agric. Ecosyst. Environ.* **97**: 131–149.
- Jankowska-Blaszczuk, M. and Daws, M. I. 2007.** Impact of red: far red ratios on germination of temperate forest herbs in relation to shade tolerance, seed mass and persistence in the soil. *Funct. Ecol.* **21**: 1055–1062.
- Jensen, P. K. 1991.** Weed size hierarchies in Denmark. *Weed Res. (Oxford)* **31**: 1–7.
- Jovtchev, G., Barow, M., Meister, A. and Schubert, I. 2007.** Impact of environmental and endogenous factors on endopolyploidization in angiosperms. *Environ. Exp. Bot.* **60**: 404–411.
- Jurukova-Grancharova, P. 1995.** An embryological study of *Lapsana communis* L. (Asteraceae). Proceedings of a jubilee symposium marking 100 years from the birthday of the Academician Boris Stepanov (1894–1979), Sofia, Bulgaria, 2–3 June 1994. pp. 101–104.
- Kameneva, E. A., Kuznetsov, N. I. and Popkov, V. V. 1987.** Herbicides – banded applications. *Zashch. Rast.* **3**: 25–26.
- Kashin, A. S., Berezutsky, M. A., Kochanova, I. S., Dobryncheva, N. V. and Poljanskaja, M. V. 2007.** Peculiarities of seed production in populations of Asteraceae species under impact of anthropogenic factors. *Bot. Zhurn.* **92**: 1408–1427. [in Russian, English summary].
- Kiehn, M., Vitek, E., Hellmayr, E., Walter, J., Tschenett, J., Justin, C. and Mann, M. 1991.** Beiträge zur Flora von Österreich: Chromosomenzählungen. *Verh. Zool.-Bot. Ges. Österreich* **128**: 19–39.
- Kilian, N., Gemeinholzer, B. and Lack, H. W. 2009.** Cichorieae. Pages 343–383 in V.A. Funk, A. Susanna, T. Stuessy, and R. Bayer, eds. *Systematics, evolution and biogeography of the Compositae*. IAPT, Vienna, Austria.
- Klischowski, B. and Beyer, H. 1989.** Some considerations on weed control in winter rape. *Gesunde Pflanzen* **41**: 311–313.
- Knörzer, K. H. 1971.** Urgeschichtliche unkräuter im Rheinland: ein Beitrag zur entstehungsgeschichte der segetalgesellschaften. *Vegetatio* **23**: 89–111. [in German, English summary].
- Knuth, P. 1908.** *Handbook of flower pollination*. Translation of 1898 original. Vol. 2. Clarendon Press, Oxford, UK. 703 pp.
- Korniak, T. and Kalwasinska, G. 2001.** Interrelations between segetal and ruderal flora in the Olsztyn Lake District. *Acta Agrobot.* **54**: 1, 137–151.
- Kraska, P. and Pays, E. 2007.** Weed phytocenosis in winter rye canopy developed after six years of ploughing or conservation tillage. European Weed Research Society, 14th EWRS Symposium, Hamar, Norway, 2007 Jun. 17–21. p. 215.
- Kuzmanov, B. and Georgieva, S. 1977.** In A. Löve, ed. *IOPB chromosome number reports LVII*. *Taxon* **26**: 443–452.
- Lebeda, A. and Syrovatko, P. 1988.** Specificity of *Bremia lactucae* isolates from *Lactuca sativa* and some Asteraceae plants. *Acta Phytopath. Entomol. Hung.* **23**: 39–48.
- Lilley, P. L. 2007.** Determinants of native and exotic plant species diversity and composition in remnant oak savannas on

southeastern Vancouver Island. M.Sc. thesis. University of British Columbia, Vancouver, BC. vi+108 pp.

Lincoln, W. C., Jr. 1983. Laboratory germination methods of some native herbaceous plant species – preliminary findings. *Newsl. Assoc. Offic. Seed Analysts* **57**: 29–31.

Lindsay, J. K. 2005. *Lapsana communis*. Photographs at Commanster site in Belgium. [Online] Available: <http://www.commanster.eu/commanster/Plants/Flowers/SpFlowers/Lapsana.communis.html> [2010 May 13].

Lövkvist, B. and Hultgård, U. M. 1999. Chromosome numbers in south Swedish vascular plants. *Opera Bot.* **137**: 1–42.

Luque, T. and Díaz Lifante, Z. 1991. Chromosome numbers of plants collected during Iter Mediterraneum I in the SE of Spain. *Bocconea* **1**: 303–342.

Manning, W. J. and Godzik, B. 2004. Bioindicator plants for ambient ozone in Eastern Europe. *Environ. Pollut.* **130**: 33–39.

Manning, W. J., Godzik, B. and Musselman, R. 2002. Potential bioindicator plant species for ambient ozone in forested mountain areas of central Europe. *Environ. Pollut.* **119**: 283–290.

Marchal, E. 1920. Recherches sur les variations numériques des chromosomes dans la série végétale. *Mém. Acad. R. Belg. Cl. Sci. (8°) Sér. 2, 4: no. 3.* 108 pp.

Marshall, E. J. P. 1989. Distribution patterns of plants associated with arable field edges. *J. Appl. Ecol.* **26**: 247–257.

McCain, J. W., Hennen, J. F. and Ono, Y. 1990. New host species and state distribution records for North American rust fungi (Uredinales). *Mycotaxon* **39**: 281–300.

Mejías, J. A. 1986. Números cromosómicos para la flora Española, 471–478. *Lagascalia* **14**: 289–292.

Mennan, H., Ngouajio, M., Isik, D. and Kaya, E. 2006. Effects of alternative management systems on weed populations in hazelnut (*Corylus avellana* L.). *Crop Prot.* **25**: 835–841.

Milberg, P. and Andersson, L. 1997. Seasonal variation in dormancy and light sensitivity in buried seeds of eight annual weed species. *Can. J. Bot.* **75**: 1998–2004.

Miller, N. J., Kift, N. B. and Tatchell, G. M. 2005. Host-associated populations in the lettuce root aphid, *Pemphigus bursarius* L.). *Heredity* **94**: 556–564.

Miller, P. 1752. The gardeners' dictionary containing the methods of cultivating and improving the kitchen, flower, fruit and pleasure garden. 6th ed. John and James Rivington, London, UK.

Miller, P. 1768. The gardeners' dictionary containing the best and newest methods of cultivating and improving the kitchen, fruit, flower garden and nursery; as also for performing the practical parts of agriculture: . . . , 8th ed. John and Francis Rivington, London, UK.

Mizianty, M., Frey, L. and Mirek, Z. 1981. Contribution to the knowledge of the chromosome numbers of Polish vascular plants. *Frag. Florist. Geobot.* **27**: 19–30.

Morse, R. and Palmer, R. 1925. British weeds: their identification and control. Ernest Benn Ltd., London, UK. 207 pp.

Morton, J. K. 1977. A cytological study of the Compositae (excluding *Hieracium* and *Taraxacum*) of the British Isles. *Watsonia* **11**: 211–223.

Morton, J. K. 1981. Chromosome numbers in Compositae from Canada and the U.S.A. *Bot. J. Linn. Soc.* **82**: 357–368.

Muenschel, W. C. 1955. Weeds. 2nd ed. The McMillan Co., New York, NY. xvi + 560 pp.

Müller, H. 1883. The fertilisation of flowers. Translation by D. W. Thompson. Macmillan & Co., London, UK. xii+669 pp.

Munteanu, N. and Sirbu, C. 2008. Wild species of Compositae (syn. Asteraceae) – vegetation potential in the Lasi county. *Lucrari Stiintifice, Universitatea de Stiinte Agricole Si Medicina Veterinara “Ion Ionescu de la Brad” Lasi. Seria Agronomie* **51**: 285–290.

Nechaeva, T. I. 1992. New and rare species of adventive plants in flora of Primorski Krai. *Bot. Zhurn. (St. Petersburg.)* **77**: 129–131. [in Russian].

Nortoft, B. 1985. Problems with weed seed contamination in herbage seed. *Dansk. Froavl* **68**: 134–136. [in Danish].

O’Kennon, R. J., Barkley, T. M., Diggs, G. M., Jr. and Lipscomb, B. 1999. *Lapsana communis* (Asteraceae) new for Texas and notes on invasive exotics. *Sida* **18**: 1277–1283.

Orell Casanovas, J. 1985. *Cotula australis* (Sieb.) Hook. f. and *Lapsana communis* L. in the Balearic Islands. *Collect. Bot. Barcelona* **16**: 239. [in Spanish].

Pak, J.-H. and Bremer, K. 1995. Phylogeny and reclassification of the genus *Lapsana* (Asteraceae: Lactuceae). *Taxon* **44**: 13–21.

Pak, J.-H. and Choi, K. 1994. Karyomorphology of *Lapsana* species (Compositae; Lactuceae). *Korean J. Plant Taxon.* **24**: 247–257.

Park, S. Y. 1999. Unrecorded naturalized plants in Korea (XIV). *Korean J. Plant Taxon.* **29**: 91–109.

Pettersson, C. G. 1984. Control of weed levels in seed crops. *Svensk Frotidning* **53**: 103.

Phillips, S. W., Bale, J. S. and Tatchell, A. G. M. 1999. Escaping an ecological dead-end: asexual overwintering and morph determination in the lettuce root aphid *Pemphigus bursarius* L. *Ecol. Entomol.* **24**: 336–344.

Plants For A Future 2010. Database report: *Lapsana communis* L. [Online] Available: <http://www.pfaf.org/database/plants.php?Lapsana+communis> [2010 May 13].

Pointdexter, D. B. 2006. Eight new plant distributional records to Alleghany county, North Carolina. *J. N. C. Acad. Sci.* **122**: 101–105.

Polunin, O. 1969. Flowers of Europe – a field guide. Oxford University Press, London, UK. 662 pp.

Pratt, A. 1855. The flowering plants of Great Britain. Vol. 2. Society for Promoting Christian Knowledge, London, UK. 247 pp.

Proctor, M. and Yeo, P. 1973. The pollination of flowers. William Collins Sons, London, UK. 418 pp.

Provancher, L. 1862. Flore canadienne, Vol. 1. Joseph Darveau, Québec, QC. 842 pp.

Raatikainen, M. and Raatikainen, T. 1979. Establishing and management of winter rye and the ecology of weeds in rye fields. *J. Sci. Agric. Soc. Finl.* **51**: 432–479.

Ramert, B. 1977. The lettuce root aphid (*Pemphigus bursarius*). *Biology. Observations in Skane. Vaxtskyddsnotiser* **41**: 83–87.

Reintam, E. and Koster, T. 2000. Biodiversity and nutrient cycling in natural and cultural ecosystems. *Proc. Int. Congr. European Soc. Soil Cons.* **1**: 607–619.

Reveal, J. L. 1997. Early suprageneric names in Asteraceae. *Compositae Newsl.* **30**: 29–45.

Riesinger, P. and Hyvönen, T. 2006. Weed occurrence in Finnish coastal regions: a survey of organically cropped spring cereals. *Agric. Food Sci.* **15**: 166–182.

Roberts, H. A. and Neilson, J. E. 1981. Seed survival and periodicity of seedling emergence in twelve weedy species of Compositae. *Ann. Appl. Biol.* **97**: 325–334.

- Rouleau, E. and Lamoureux, G. 1992. Atlas des plantes vasculaires de l'île de Terre-Neuve et des îles de Saint-Pierre-et-Miquelon. Fleurbec, Saint-Henri-de-Lévis, QC. 770 pp.
- Salisbury, E. 1961. Weeds and aliens. Collins, London, UK. 384 pp.
- Salonen, J. 1993. Weed infestation and factors affecting weed incidence in spring cereals in Finland – a multivariate approach. *Agric. Sci. Finl.* **2**: 525–535.
- Salonen, J. and Erviö, L.-R. 1988. Efficacy of chemical weed control in spring cereals in Finland. *Weed Res.* **28**: 231–235.
- Sell, P. D. 1976. *Lapsana*. Page 344 in T. G. Tutin, V. H. Heywood, N. A. Burges, D. M. Moore, D. H. Valentine, S. M. Walters, and D. A. Webb, eds. *Flora Europaea* vol. 4: Plantaginaceae to Compositae (and Rubiaceae). Cambridge University Press, Cambridge, UK.
- Sell, P. D. 1981. *Lapsana intermedia* Bieb. or *Lapsana communis* L. subsp. *intermedia* (Bieb.) Hayek? *Watsonia* **13**: 299–302.
- Semb, K. and Skuterud, R. 1996. Effect on the production of weed seeds in a reduced tillage system by autumn spraying: a pot experiment. *Proc. 2nd Intern. Weed Control Congress*, Copenhagen, Denmark. 1996 Jun. 25–28. Vol. 1–4: 1031–1036.
- Skuterud, R., Bjugstad, N., Tyldum, A. and Semb Tørreson, K. 1998. Effect of herbicides applied at different times of the day. *Crop Prot.* **17**: 41–46.
- Skvarla, J. J., Turner, B. L., Patel, V. C. and Tomb, A. S. 1977. Pollen morphology in the Compositae and in morphologically related families. Pages 143–249 in V. H. Heywood, J. B. Harborne, and B. L. Turner, eds. *The biology and chemistry of the Compositae*, Vol. 1. Academic Press, London, UK.
- Small, J. 1917a. Irritability of the pollen-presentation mechanism in the Compositae. *Ann. Bot.* **31**: 261–268.
- Small, J. 1917b. The origin and development of the Compositae. Chapter III. Irritability of the pollen-presentation mechanism. *New Phytol.* **16**: 253–276.
- Smith, J. E. 1829. *The English flora*. Vol. 3. 2nd ed. Longman, Rees, Orme, Brown and Green, London, UK. 512 pp.
- Snarska, K. 2004. Monitoring of weed infestation – an ecological factor for weed control in cereals. *Prog. Plant Prot.* **44**: 1099–1101.
- Stace, C. 1991. *New flora of the British Isles*. Cambridge University Press, Cambridge, UK. 1226 pp.
- Stanciu, G., Lupsor, S. and Arcuş, M. 2007. GC-MS characterization of the volatile oil from *Lapsana communis* L. *Ovidius Univ. Ann. Chem.* **18**: 72–75.
- Starr, F. and Starr, K. 2008. *Plants of Hawaii*. [Online] Available: <http://www.hear.org/starr/> [2010 May 13].
- Stebbins, G. L., Jenkins, J. A. and Walters, M. S. 1952. Chromosomes and phylogeny in the Compositae, Tribe Cichorieae. *Univ. Calif. Publ. Bot.* **26**: 401–428.
- Stiles, B. J. and Howel, C. L. 1998. Floristic survey of Rabun County, Georgia, Part II. *Castanea* **63**: 154–160.
- Strandberg, B., Axelsen, J. A., Bruus Pedersen, M., Jensen, J. and Attrill, M. J. 2006. Effect of a copper gradient on plant community structure. *Environ. Toxicol. Chem.* **25**: 743–753.
- Svenning, J.-C. and Skov, F. 2002. Mesoscale distribution of understorey plants in temperate forest (Kalø, Denmark): the importance of environment and dispersal. *Plant Ecol.* **160**: 169–185.
- Taylor, R. L. and Mulligan, G. A. 1968. *Flora of the Queen Charlotte Islands*, Part 2: Cytological aspects of the vascular plants. *Can. Dep. Agric. Res. Branch Monogr.* **4**, Part 2. 148 pp.
- Thomé, O. W. 1905. *Flora von Deutschland, Österreich und der Schweiz*. Ed. 2, Vol. 4. Hugo Bermühler Verlag, Berlin-Lichterfelde, Germany. 509 pp.
- Uhríkova, A. 1978. In J. Majovsky et al., eds. *Index of chromosome numbers of Slovakian flora*. Part 6. *Acta Fac. Rerum Nat. Univ. Comen. Bot.* **26**: 1–42.
- USDA, NRCS. 2009. *Lapsana communis* L. [Online] Available: <http://plants.usda.gov/> [2010 May 13].
- Váchova, M. and Májovský, J. 1977. In A. Löve, ed. *IOPB chromosome number reports LVI*. *Taxon* **26**: 257–274.
- Vesik, E. 2001. The species of weeds in spring cereals. *Trans. Eston. Agric. Soc.* **15**: 119–122.
- Voss, E. G. 1996. *Michigan flora*. Part III: Dicots (Pyrolaceae – Compositae). *Cranbrook Institute of Science Bull.* **61** and *Univ. of Michigan Herbarium. Ann Arbor, MI.* 622 pp.
- Wagner, W. L., Herbst, D. R. and Lorence, D. H. 2005. *Flora of the Hawaiian Islands* website. [Online] Available: <http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/index.htm> [2010 May 13].
- Waldis, R. 1984. Distribution patterns of weeds in Wallis. *Schweiz. Landwirtsch. Forsch.* **23**: 131–142.
- Weber, E. and Gut, D. 2005. A survey of weeds that are increasingly spreading in Europe. *Agron. Sustain. Dev.* **25**: 109–121.
- White, G. A., Willingham, B. C., Skrdla, W. H., Massey, J. H., Higgins, J. J., Calhoun, W., Davis, A. M., Dolan, D. D. and Earle, F. R. 1971. Agronomic evaluation of prospective new crop species. *Econ. Bot.* **25**: 22–43.
- Wilson, P. J. and Aebischer, N. J. 1995. The distribution of dicotyledonous arable weeds in relation to distance from the field edge. *J. Appl. Ecol.* **32**: 295–310.
- Wist, T. J. and Davis, A. R. 2006. Floral nectar production and nectary anatomy and ultrastructure of *Echinacea purpurea* (Asteraceae). *Ann. Bot.* **97**: 177–193.
- Wojcik, Z. 1998. Segetal communities of the Przemyski Foot-hills and their immediate neighbourhood. *Fragm. Florist. Geobot. Ser. Pol.* **5**: 117–164.
- Zinck, M. 1998. *Roland's Flora of Nova Scotia*. 3rd ed. Nimbus Publishing and Nova Scotia Museum, Halifax, NS. 1297 pp.