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The role of railway lines in the distribution of alien plant species in the territory of Daugavpils City (Latvia)

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Abstract. The study was performed based on an inventory of alien flora in Daugavpils City. During the field studies all the alien species were recorded applying a regular grid consisting of 344 quadrats of 500 m × 500 m. Data of the 84 quadrats that cover all railway lines in the city were analysed to identify relationships between the distribution of alien plants and the location of railway lines. First the obtained data were compared with the first flora inventory in the city, which was conducted from 1975 to 1983. Comparison of data of the previous inventory and those obtained by us showed that the number of the recorded alien taxa along railways differed: 95 and 38 taxa, respectively. Secondly, some factors affecting the distribution of alien species along railway lines were analysed. Obtained results indicate that the highest concentrations of alien plants occurred in areas where railways are crossing or are located close to the adjacent cultivated and abandoned allotments, areas of private houses or cemeteries. Railway management measures such as topsoil disturbance and application of herbicides were found to be important human-induced factors affecting the distribution of annual alien taxa. The results of geospatial and statistical analyses demonstrated that the geographical distribution of alien species in general did not coincide with railway lines. However, the distribution of three species, i.e. *Dracocephalum thymiflorum*, *Erysimum durum*, and *Lappula squarrosa*, was associated only with railway lines, demonstrating the importance of railway infrastructure elements for the expansion of these species.

Key words: alien plants, disturbed areas, urban flora, *Dracocephalum thymiflorum*, *Erysimum durum*, *Lappula squarrosa*, affecting factors.

INTRODUCTION

The main feature of urban floras is high proportion of alien species with often divergent distribution patterns (Von der Lippe & Kowarik, 2008). Roads, as the major promoter of human urbanization, can be initial habitats for plants dispersed by transportation (Hayasaka et al., 2012). Roads can also act as dispersal corridors where seeds can be spread by water as well as by birds and other animals that use roadways as travel paths (Buckley et al., 2003; Von der Lippe & Kowarik, 2007).

The consequences of expansion and integration of road networks, which accompany urbanization, and their negative impact on flora are different, e.g. floristic homogenization (Smart et al., 2006; Von der Lippe & Kowarik, 2007; Wittig & Becker, 2010) and enabling of invasion of aggressive alien species into adjacent plant communities and habitats (Ozinga et al., 2004; Rentch et al., 2005; Von der Lippe & Kowarik, 2007; Niggemann et al., 2009).

So far, a lot of research has been made concerning the distribution of alien plants in relation to motor roads (Tyser & Worley, 1992; Zwaenepoela et al., 2006; Von der Lippe & Kowarik, 2007, 2008; Flory & Clay, 2009; Kowarik & Von der Lippe, 2011; Hayasaka et al., 2012), while there are fewer such studies concerning railways (Hansen & Clevenger, 2005; Westermann et al., 2011; Penone et al., 2012). Also in Latvia studies on this particular issue are very fragmentary. From 1960 to 1975 the adventive flora of Riga and Daugavpils railways was studied in detail (Šulcs, 1972, 1976, 1977). The first complete inventory of the flora, including alien flora, in Daugavpils was carried out in 1975–1983 (Tabaka et al., 1985). Šulcs (1972) emphasizes that the introduction of alien species has increased in particular with intensive use of rail transport, starting from 1861, when the first railway line was built in Latvia from Riga to Daugavpils. Also Tabaka (1985) stated that the main factor of anthropogenic impact on the formation of the vegetation in Daugavpils is the influx and spreading of the species along the railways and motor roads.

Review of the literature focused on the studies of flora along transport corridors, e.g. Hansen & Clevenger, 2005; Westermann et al., 2011, reveals that railway with its typical abiotic factors contributes to the migration of many species. The major part of the research carried out in Latvia also provides evidence of the aforementioned regularity (Rasiņš, 1959; Šulcs, 1976, 1977).

However, recent studies (Penone et al., 2012) indicate that even though railways might be corridors for alien species, the frequency of these species seems to be much more related to other factors. These factors, reported in the literature, could be, e.g. higher levels of disturbance (Hansen & Clevenger, 2005; Pollnac et al., 2012), seed traits and certain life-history traits like seed production (Westermann et al., 2011), similarity of abiotic conditions such as type of soil and slope aspect (Gelbard & Harrison, 2003), better light (Trombulak & Frissell, 2000; Seiler, 2001; Flory & Clay, 2006) and wind conditions (Seiler, 2001; Kowarik & Von der Lippe, 2011).

Therefore, the aim of our study was to evaluate the role of railway lines in the distribution of alien species in the territory of Daugavpils City.

Our main tasks were (1) to survey Daugavpils City's railway lines and adjacent areas and to map the alien plant species present in this territory; (2) to compare data obtained through our research with data from a previously conducted inventory on the urban flora; (3) to evaluate some factors affecting the distribution of alien species along railway lines, i.e. way of propagation, territories adjacent to these lines, railway management practices, and the manner in which the railway line is used; (4) and to carry out analysis of alien species most characteristic of railway lines.

MATERIALS AND METHODS

Study area

The research area is located in Daugavpils, in the south-eastern part of Latvia (55°52′30″N, 26°32′8″E). Daugavpils, situated on the banks of the Daugava River, is the second largest city in Latvia with 92 533 inhabitants (CSB, 2012) and an area of 72.48 km^2. Daugavpils has historically developed as a crossroads for routes of goods and passenger transport. Four international railway transit corridors pass through the city. Also at national level Daugavpils is an important railway transport node (Spatial Plan of Daugavpils…, 2005).

Currently the flora of Daugavpils is considered as one of the most unique in Latvia. This is due to the large diversity of natural and semi-natural habitats as well as different anthropogenically transformed habitats, the presence of which is associated with long-standing development of the city as the industrial and transport centre of eastern Latvia.

According to a recent research, 1079 vascular plant species are known in the flora of Daugavpils, 281 or 26% of them are considered to be alien plant species (Evarts-Bunders et al., 2012). Daugavpils is the only known locality for nine alien plant species in Latvia. Five of them, i.e. *Agropyron desertorum* (Fisch. ex Link) Schult, *Cerastium dubium* (Bast.) O. Schwarz, *Reseda alba* L., *Ulmus pumila* L., and *Visnaga daucoides* P. Gaertn. were listed by Tabaka et al. (1985), and four species, i.e. *Gilia achilleaefolia* Benth., *Malva parviflora* L., *Macleaya* × *kewensis* Turrill, and *Cerasus tomentosa* (Thunb.) Wall. are known from recent studies (Romancevičа et al., 2011).

Field studies

The field studies were carried out from spring to autumn in the period 2007–2010. This research was conducted as part of a wider research programme concerning the inventory of flora in Daugavpils City and focused on all alien vascular plants. Before the beginning of the field studies, the territory of Daugavpils City was mapped in a regular grid, and quadrats of 500 m ×500 m were obtained. The grid system method is most useful as an aid to population density estimation over large areas (Reid & Thompson, 1996). The total number of quadrats was 344 (Nitcis et al., 2011), which were accordingly numbered (Fig. 1a). During the field studies an inventory of all quadrats was carried out and for each quadrat all alien species as well as habitats were recorded in their exact area. Simultaneously, the precise location of the mapped records was fixed by GPS THALES Mobilemapper CE. This allowed us to carry out further processing and analysis of field data with the GIS (geographic information system) software ArcView 9.3.1. For precise identification of species herbarium material of alien species was collected and their taxonomy was determined in the Laboratory of Systematic Botany, Daugavpils University. As a result, a list of alien species and their geographic distribution for

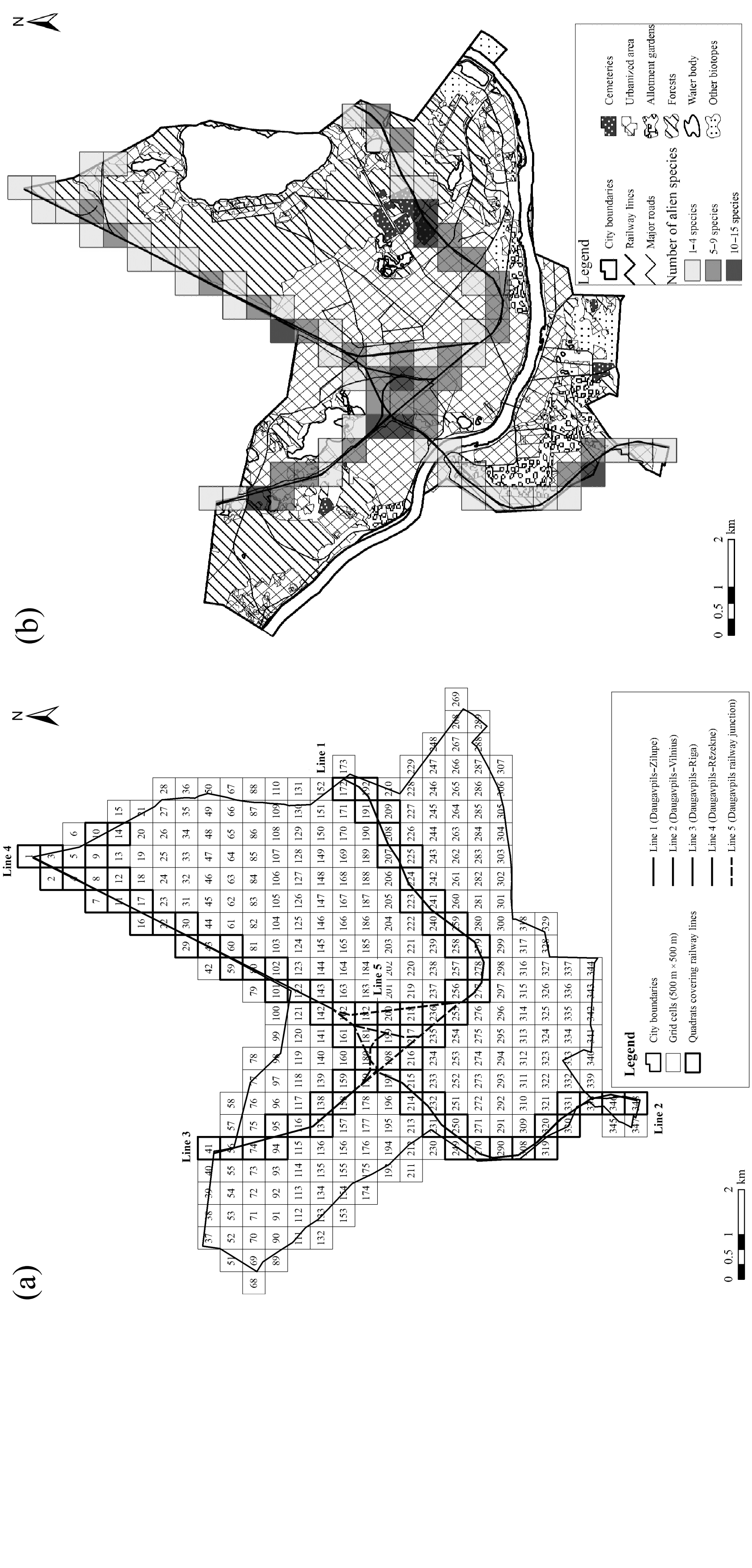

Fig. 1. The grid of numbered quadrats covering the territory of Daugavpils City and highlighted quadrats covering the railway lines where the field studies were performed (a); the pattern of quadrats coded by the number of alien species in each (b).

the whole territory of Daugavpils City was obtained. The information about the area of origin, life-history traits, and ways of propagation of the recorded alien species was obtained from the literature (Tutin et al., 1964–1980).

However, considering that the role of railways in the distribution frequency of alien species is under discussion in this paper, data of the quadrats covering railway lines were selected. Altogether 84 quadrats (Fig. 1a), i.e. 24.41% of the total number of quadrats in the city, were selected. Within these quadrats analysis of the number and distribution of alien species along the railway lines and areas adjacent to them was performed. The areas adjacent to the railway lines with a total length of 37 km comprise up to 50 m wide belts of ruderal habitats, which are strongly modified by regular management activities such as plant reaping, burning, and application of herbicides conducted by the State Joint Stock Company 'Latvijas Dzelzceļš'.

Desk-based studies

Univariate analysis of variance by One-Way ANOVA was used to establish whether railway lines were related to the number of the alien species. Railway lines were used as the influencing factors, and numbers of species as the dependent variables. Serial numbers were given to the existing railway lines located in the city (Fig. 1a): No. 1 eastward-directed line Daugavpils–Zilupe (carriage of goods), No. 2 southward-directed line Daugavpils–Vilnius (mixed passengers–goods carriage with dominance of goods carriage), No. 3 north-westward-directed line Daugavpils–Riga (mixed passengers–goods carriage with dominance of passengers carriage), No. 4 north-eastward-directed line Daugavpils–Rēzekne (mixed passengers–goods carriage with dominance of goods carriage), No. 5 Daugavpils railway junction (mixed passengers–goods carriage with dominance of goods carriage). The data were log-transformed. A Spearman's rank correlation coefficient was used to establish the closeness of relationship between railway lines and numbers of alien species (Gotelli & Ellison, 2004; Quinn & Keough, 2006). Data were analysed using the statistical software IBM SPSS Statistics 20.

The representation of the number of alien taxa per quadrat using colour coding (Mitchell, 1999) and subsequent comparison of all quadrats under study were done with GIS software ArcView 9.3.1. Classification and visualization (Fig. 1b) of field data by GIS tools allowed us to elucidate the pattern of geographical distribution of aliens in the quadrats covering railway lines and to analyse factors affecting the distribution of alien species.

The most characteristic species of railways were identified on the basis of the percentage of each species that had invaded railway quadrats of the total number of invaded quadrats in the whole city. To be regarded as a most characteristic species of railways the species had to make up at least 90% (Table 1).

The obtained results are compared with the data on the same areas from the inventory carried out in 1975–1983 (Tabaka et al., 1985).

RESULTS

In the habitats adjacent to railways, 38 alien plant species were recorded (Table 1). The natural region of origin of the major part of alien species found along the railways in Daugavpils is Europe (47%). Fewer species are from North America (26%) and Asia (23%). The remaining 4% includes species originating in cultivation and known from culture only, both accounting for 2% of the species.

According to data of the previous inventory of the flora in Daugavpils City (Tabaka et al., 1985), 95 alien plant species were found along the railways, in marshy areas along the railways, on the railway embankments, and near railways. During our inventory conducted in 2007–2010 we found 22 species listed by Tabaka et al. (1985), and identified 16 new species that were not detected during the previous inventory. However, it is necessary to point out that 73 species that were recorded by Tabaka et al. (1985) were not found in this study (Table 1).

As to the ways of propagation, the majority of alien species, i.e. 26 species recorded in the quadrats along the railway lines are spreading by seeds (see Table 1). In comparison there are only seven species that are spreading by roots whilst five species are spreading by roots and seeds.

The number of alien species found in each quadrat under study varies from 1 to 15, on average 5.1 per quadrat. The geographical distribution of quadrats characterized by higher numbers of alien species has a dispersed pattern (Fig. 1b). For instance, two quadrats, No. 223 and No. 224, are located close to cemeteries. In these quadrats 11 and 12 alien species were recorded, respectively. These values are higher in comparison to the neighbouring quadrats with no cemeteries. Quadrat No. 330, where 10 alien species were found, is located near an area of private houses or cultivated and abandoned allotments. In quadrat No. 101, which covers one of the marshalling yards in Daugavpils, 12 species were found. Other quadrats characterized by higher numbers of alien species in comparison to neighbouring quadrats, i.e. Nos 179, 197, and 199, are associated with hard disturbance of topsoil along the railway lines. In these quadrats annual alien plant species constituted 75%, 67%, and 82%, respectively, of all recorded alien taxa.

The results of univariate variance analysis indicate that the type of carriage had no significant effect on the distribution of the number of alien species: the F critical 2.3 > F actual 1.9 ($p > 0.12$) and confidence intervals of the average number of species between the railway lines overlap (Fig. 2). No statistically significant correlation was found between the type of carriage and the number of alien species either, regardless of whether carriage of goods or carriage of goods–passengers was involved.

The geographical distribution of three of the species, *Dracocephalum thymiflorum* Houtt., *Erysimum durum* J. Presl et C. Presl, and *Lappula squarrosa*, found in the ruderal habitats located along the railway is of particular interest: 100%, 100%, and 90% of all the records of these species were made near the railway (Table 1). Another 35 species along the railways made up less than 50% of the total number of species recorded in the city, indicating that railways are less important in their distribution.

Table 1. Data of the inventory of alien species in Daugavpils City

Scientific name	Family	Area of origin	Life span	Main way of propagation	No. of grid cells in which the species was recorded		Railways/ city, % (column 7/6)	Species identified	
					in Daugavpils	along railways		new in 2007–10	in 1975–83 & 2007–10
1	2	3	4	5	6	7	8	9	10
Acer negundo L.	Aceraceae	N. America	perennial	seeds	226	31	13.7	x	
Amaranthus albus L.	Amaranthaceae	N. America	annual	seeds	30	22	73.3		x
Amaranthus blitoides S. Watson	Amaranthaceae	N. America	annual	seeds	4	3	75.0		x
Amaranthus retroflexus L.	Amaranthaceae	N. America	annual	seeds	68	38	55.9	x	
Amelanchier spicata (Lam.) K. Koch	Rosaceae	N. America	perennial	seeds, roots	128	3	2.3		x
Armoracia rusticana P. Gaertn., B. Mey. et Scherb.	Cruciferae	Europe	perennial	roots	148	6	4.1		x
Artemisia austriaca Jacq.	Asteraceae	Europe, Asia	perennial	seeds	5	1	20.0	x	
Asparagus officinalis L.	Liliaceae	Europe	perennial	seeds	67	2	3.0		x
Bunias orientalis L.	Cruciferae	Europe	biennial	seeds	158	14	8.9		x
Camelina microcarpa Andrz.	Cruciferae	Europe, Asia	annual	seeds	3	2	66.7		x
Caragana arborescens Lam.	Leguminosae	Eurasia	perennial	roots	49	3	6.1	x	
Carduus nutans L.	Asteraceae	Eurasia, Africa	biennial	seeds	27	20	74.1		x
Dracocephalum thymiflorum L.	Labiatae	Europe	annual	seeds	23	23	100.0		x
Echinocystis lobata (Michx.) Torr. et A. Gray	Cucurbitaceae	N. America	annual	seeds	104	4	3.8	x	
Eragrostis minor Host.	Poaceae	Asia	annual	seeds	19	14	73.7		x
Erigeron annuus (L.) Pers.	Asteraceae	N. America	biennial	seeds	108	4	3.7	x	
Erigeron canadensis L.	Asteraceae	N. America	annual	seeds	276	63	22.8		x
Erysimum durum J. Presl et C. Presl	Cruciferae	Europe	biennial	seeds	4	4	100.0		x
Erysimum hieracifolium L.	Cruciferae	Eurasia	biennial	seeds	19	2	10.5	x	

Table 1. *Continued*

Scientific name	Family	Area of origin	Life span	Main way of propagation	No. of grid cells in which the species was recorded		Railways/ city, % (column 7/6)	Species identified	
					in Daugavpils	along railways		new in 2007–10	in 1975–83 & 2007–10
1	2	3	4	5	6	7	8	9	10
Euphorbia cyparissias L.	Euphorbiaceae	Europe	perennial	seeds, roots	32	11	34.4		x
Galinsoga parviflora Cav.	Asteraceae	N. America	annual	seeds	118	40	33.9		x
Helianthus tuberosus L.	Asteraceae	N. America	perennial	roots	133	1	0.8	x	
Impatiens parviflora DC.	Balsaminaceae	Asia	annual	seeds	89	4	4.5	x	
Lappula squarrosa (Retz.) Dumort.	Boraginaceae	Europe	biennial	seeds	10	9	90.0		x
Lepidium densiflorum Schrad.	Cruciferae	N. America	annual	seeds	85	7	8.2		x
Malus domestica Borkh.	Rosaceae	originated in cultivation	perennial	seeds	257	10	3.9	x	
Medicago × varia Martyn	Leguminosae	known from culture only	perennial	seeds	18	8	44.4		x
Populus alba L.	Salicaceae	Europe	perennial	roots, seeds	33	3	9.1	x	
Populus laurifolia Ledeb.	Salicaceae	Asia	perennial	roots, seeds	43	1	2.3	x	
Prunus cerasifera Ehrh. var. *divaricata* (Ledeb.) L. H. Bailey	Rosaceae	Eurasia	perennial	seeds, roots	33	1	3.0	x	
Rosa rugosa Thunb.	Rosaceae	Asia	perennial	roots	51	6	11.8		x
Rumex confertus Willd.	Polygonaceae	Europe	perennial	seeds	132	2	1.5		x
Salix daphnoides Vill.	Salicaceae	Europe	perennial	roots	62	1	1.6		x
Sisymbrium altissimum L.	Cruciferae	Europe	annual	seeds	24	4	16.7	x	
Sisymbrium loeselii L.	Cruciferae	Asia	annual	seeds	100	8	8.0		x
Solidago canadensis L. s.l.	Cruciferae	N. America	perennial	seeds	151	10	6.6		x
Spiraeae media F. Schmidt	Rosaceae	Eurasia	perennial	roots	15	2	13.3	x	
Syringa vulgaris L.	Oleaceae	Europe	perennial	roots	138	5	3.6	x	

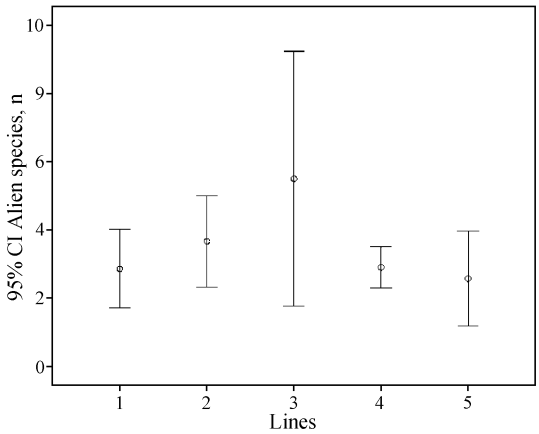

Fig. 2. Average numbers of alien species in the analysed quadrats that cover railway lines (1, 2, 3, 4, 5) at 95% confidence interval (CI). For explanation of the number of lines see Fig. 1a.

DISCUSSION

Comparison of the data on alien species of the inventories of 1975–1983 and 2007–2010

Differences between results of the two studies could be explained by the following circumstances:

(1) in the previous inventory the concepts of 'railway' and 'along the railway' were not explained precisely, possibly denoting a wider area than the area researched by the present authors. For example, *Achillea micrantha* Willd. is listed in the previous inventory, but was not found by us;

(2) the climate in Daugavpils, characterized by a relatively large range of temperatures, is more continental than in other areas of Latvia. The absolute maximum temperature + 36.4 °C and the absolute minimum temperature – 43.2 °C in the whole territory of Latvia were observed only in Daugavpils, thus the range of extreme temperatures here is 79.6 °C (Kļaviņš et al., 2008). These critical temperatures probably are among the key factors limiting the distribution of some alien species. Therefore, the occurrence of part of the species during the previous inventory was incidental (Tabaka et al., 1985). As these species were not naturalized, they were not found in the recently performed inventory. Such species are, for example *Acer pseudoplatanus* L. and *Sambucus nigra* L.;

(3) since the 1990s in Latvia herbicides have been applied twice during the vegetation period in railway lines management. This measure limits particularly the occurrence of those taxa that propagate mainly by seeds, which do not ripen before the processing with chemicals. Such species include, for example *Ambrosia artemisiifolia* L., *Echinops sphaerocephalus* L., and *Reseda lutea* L.

Factors affecting the distribution of alien species along railway lines

The distribution of alien species along railway lines in relation to ways of propagation, railway management measures, and land use in adjacent areas could be explained by the following aspects:

(1) aspect of seeds (Hansen & Clevenger, 2005; Westermann et al., 2011) – species that are spreading by seeds, for example *Erigeron canadensis* L., *Galinsoga parviflora* Cav., *Lepidium densiflorum* Schrad., and *Sisymbrium loeselli* L., are more 'mobile' due to mechanical transmission caused by the motion of trains. Moreover, the fact that railway is characterized by a relatively high wind speed induced by traffic (Seiler, 2001) is beneficial to wind-pollinated species (Penone et al., 2012) and seed transfer (Kowarik & Von der Lippe, 2011);

(2) aspect of disturbance (Hansen & Clevenger, 2005) – on the railroad tracks and the adjacent areas repairing and management works are carried out on a regular basis, therefore such areas are subject to recurrent disturbances (Trombulak & Frissell, 2000; Seiler, 2001). Consequently non-vegetated areas or those with a disturbed vegetation cover are developing (Trombulak & Frissell, 2000), which in turn creates favourable conditions for alien species to spread by seeds. We could observe such a situation in quadrats Nos 74, 179, 197, and 199 where topsoil had been disturbed within areas located directly along the railway lines due to land-use management practices. These quadrats had a relatively higher proportion of annual alien taxa than perennial species. Annual alien plant species constituted a relatively high proportion also in quadrats where harrowing along railway lines had been performed recently;

(3) aspect of land use – quadrats characterized by higher numbers of alien taxa are associated with areas where railways are crossing or passing territories of cemeteries, areas of private houses, cultivated and abandoned allotments, or where marshalling yards are located (Fig. 1b).

Our findings agree with results presented in the literature (Laiviņš & Jermacāne, 2000; Gudžinskas, 2005; Bowdler et al., 2007; Rutkovska et al., 2011) showing that cemeteries are important donor territories of alien species, e.g. of *Amelanchier spicata* (Lam.) K. Koch., *Solidago canadensis* L., etc. Hence they contribute to the number of taxa in the relevant quadrats (Nos 224 and 223).

The fact that many alien plants are distributed through ornamental plantings (Priedītis, 2012) and disposal of garden waste (Pyšek et al., 2004) explains the occurrence of some species, e.g. *Euphorbia cyparissias* L., *Solidago canadensis* L. s.l., *Asparagus officinalis* L., etc., and thus the higher number of alien taxa in quadrat No. 330.

In the territory of Daugavpils marshalling yards trains are connected and disbanded and maintenance, cleaning, and repairs of wagons are carried out. During maintenance and cleaning activities plant seeds that have stuck to the wagons can get into the marshalling area. It is most likely that this circumstance causes the presence of high numbers of alien species, i.e. in quadrat No. 101;

(4) aspect of type of carriage – no statistically significant correlation was found between the number of alien species in the quadrats covering railway lines and different types of carriage (Fig. 2). The main reason for this might be that all railway lines are managed simultaneously and the same management measures are used.

Analysis of the most characteristic species

Three most characteristic species of railways were identified.

Dracocephalum thymiflorum L. – according to Genova (2012), the distribution of *D. thymiflorum* is limited by grazing of the territory, intensive agriculture, or infrastructure development. However, our study demonstrated just the opposite: repair work and maintenance of the railway infrastructure did not limit the distribution of *D. Thymiflorum*; morever, all finds of this species were made along railways (Table 1). Also, the first herbarium of this species in Daugavpils was collected at the edge of a railway in 1965 (DAU).

Erysimum durum J. Presl et C. Presl – has rare occurrence in Latvia (Priedītis, 2012). In Daugavpils it was for the first time found only in 2009 near a railway station. Recent observations in the Check Republic show that the plant is spreading mainly along railways (Houska, 2009), whilst in our study this species was found only along railways. Although according to NOBANIS (2012) data *E. durum* is referred to as a non-invasive species in Latvia, in Daugavpils, despite the small number of records (Table 1), the species has the tendency to form large plantations and expand in the invaded area.

Lappula squarrosa (Retz.) Dumort. – in Latvia single specimens or small stands occur in dry weedy places, railway edges, sand and gravel pits, and on riverbank slopes (Priedītis, 2012). The literature review revealed that in other countries the plant is found in disturbed areas, roadsides, waste areas, cultivated fields (Frick, 1984; Royer & Dickinson, 1999), grasslands, shrublands, and forest openings in lowlands (Douglas et al., 1998). In the current study nine out of ten finds of *L. squarrosa* were recorded along railways. According to Frick (1984), the distribution of the plant can be controlled by herbicides; however, our research showed that apparently the plant is tolerant of Roundup herbicide used in the management of the railway areas.

CONCLUSIONS

The results of this research permit us to draw several important conclusions about the regularities of the factors affecting the localization of alien taxa as well as the role of railway lines in the distribution of alien plant species in the territory of Daugavpils City.

Analysis of the geographical distribution pattern of alien taxa indicates that quadrats with higher numbers of alien species generally did not coincide with railway lines. However, the distribution of three species, i.e. *D. thymiflorum*, *E. durum*, and *L. squarrosa*, was associated precisely with railway lines, demonstrating the importance of this infrastructure element for the expansion of these species.

Comparison of previous and recent inventory data on the flora in Daugavpils showed that the number of alien species recorded in 2007–2010 was 2.5 times smaller than in the inventory of 1975–1983. Most likely such a wide discrepancy can be explained by the different meaning of 'railway' and 'along the railway' concepts as used in the previous inventory and in the present study. Another explanation for the observed discrepancy is the use of herbicides for the last 15 years by the State Joint Stock Company 'Latvijas Dzelzceļš' as a railway management measure, leading to a decrease in the number of alien species that propagate by seeds.

The principal factors affecting the distribution of alien species along railway lines are the land use ways along railways and, more significantly, railway management practices and the way of the propagation of species. The manner in which the railway line is used has no significant effect on the distribution of the numbers of alien species.

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