

## Original research

# *Dittrichia graveolens* (Asteraceae), rapidly spreading along European highways, recorded in Lithuania

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### Abstract

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For a long time, railways were the main pathway for the accidental introduction of alien plant species, but now highways and other roads are becoming increasingly important in this process. Considering that *Dittrichia graveolens* is spreading rapidly along highways in Central Europe and neighbouring Poland, a targeted search was conducted in Lithuania in 2023. *Dittrichia graveolens* was recorded at two sites along the Kalvarija–Kaunas highway (Kazlų Rūda district, in the environs of Pentupiai, and Kaunas city, in the environs of Jonučiai). At both sites, the species occupied relatively compact stands consisting of several hundred individuals, suggesting that the stands were formed from locally matured seeds. The mean number of flowers per capitulum in Lithuania in 2023 was  $20.5 \pm 4.9$ , and the realised fecundity was 89.7% of the potential fecundity. It is presumed that the seeds of *Dittrichia graveolens* were accidentally introduced into Lithuania by trucks, probably attached to tyres. Currently, this species is classified as a casual alien, but its naturalisation is expected. The study revealed that the first record of *Dittrichia graveolens* in Poland was not in 2013, as previously reported, but more than 20 years earlier, in 1990, near Kraków, at the slag deposit site of the Nowa Huta Steelworks.

**Keywords:** accidental introduction, alien species, casual species, Poland, potential fecundity, realised fecundity.

## INTRODUCTION

The pathways of alien plant species introduction and their significance change depending on the shift in human economic activity and its intensity (Joly et al., 2011; Lemke et al., 2019; Keim & Cerny, 2021; Sennikov & Kozhin, 2023). For a long time, railways were the most important pathway for the accidental introduction of alien plant species, and the most important vector was the import of grain (Suominen, 1979; Özaslan et al., 2016; Benedetti & Morelli, 2017; Wrzesień & Denisow, 2017). High-

ways and other roads have played a relatively minor role in the introduction of alien plant species, but since the 1980s, their significance and impact on the spread of alien species have increased (Griese, 1996; Stecher & Buckelmüller, 2012; Follak et al., 2018a). This process has been intensified both by the rapid development of the road network in Europe and by the dramatic increase in the volume of transported commodities (Joly et al., 2011; Dekker et al., 2012; Follak et al., 2018a; Keim & Cerny, 2021).

The introduction of new alien species by road transport and the spread of previously introduced

species along roads, particularly motorways, has intensified in Central European countries over the last few decades (Šerá, 2008; Joly et al., 2011; Lemke et al., 2019; Follak et al., 2018a, b). The fastest spreading alien plant species along roadsides in Central Europe are *Dittrichia graveolens* (L.) Greuter and *Senecio inaequidens* DC. (Heger & Böhmer, 2005; Kocián, 2015, 2016; Kozłowska-Kozak et al., 2019; Szatmari & Hurdu, 2020).

*Dittrichia graveolens* (Asteraceae) is native to the Mediterranean region of Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, France, Greece, Italy, Montenegro, North Macedonia, Portugal, Serbia and Spain) and North Africa (Algeria, Libya, Morocco, Tunisia), as well as in the western part of South Asia (Afghanistan, Iran, Israel, Jordan, Lebanon, Pakistan, Syria, and Turkey). In its native range, *Dittrichia graveolens* grows in open habitats with sparse vegetation cover, usually on the banks of water bodies, in temporarily or intermittently flooded areas, on gravel deposits, and often in saline soils. The species frequently colonises anthropogenic habitats with nitrogen-rich soils, such as wastelands, roadsides and cultivated lands (Davis, 1975; Guinocet & Vilmorin, 1982; Pignatti, 1982; Brullo & Marco, 2000).

Outside its native range in Europe, *Dittrichia graveolens* was first found in Belgium in 1895, where it had been accidentally introduced with ore and wool (Verloove, 2006a, b). The species started to spread rapidly in Europe only in the second half of the 20th century and particularly fast in the first two decades of the 21st century. *Dittrichia graveolens* is now recorded Austria (Essl & Rabitsch, 2002), Belgium (Verloove, 2006b), the Czech Republic (Pyšek et al., 2012), Denmark (Pedersen, 1961), Germany (Dettmar, 1991; Radkowsch, 2003), Hungary (Takács et al., 2016), the Netherlands (Meijden, 2005), Poland (Kocián, 2015; Wróbel, Nobis, 2017; Kozłowska-Kozak et al., 2019), Romania (Szatmari & Hurdu, 2020), Slovakia (Király et al., 2014), Slovenia (Frajman & Kaligarič, 2009), Switzerland (Ciardo & Delarze, 2005), and United Kingdom (Sell & Murrell, 2006). *Dittrichia graveolens* is alien to Australia, New Zealand, South Africa and North America and is considered a hazardous invasive plant in some regions (Given, 1984; Esler, 1988; Parsons & Cuthbertson, 2001; Brownsey et al., 2013).

In Central Europe, *Dittrichia graveolens* spreads rapidly from the south and west along highways to the north and east. A decade ago, the species was still rare in Poland, but it has now spread widely along some highways (Kocián, 2015; Pliszko & Kocián, 2017; Kozłowska-Kozak et al., 2019) and by spreading north-eastwards has reached Lithuania. The aim of this study was to determine the distribution of *Dittrichia graveolens* in Lithuania, and to estimate its population size as well as its potential and realised fecundity, which is an essential factor influencing its further spread and naturalisation.

## MATERIALS AND METHODS

The search for *Dittrichia graveolens* in Lithuania was initiated after the species was observed spreading rapidly along highways in north-eastern Poland. The surveys were conducted in September and October 2023 in the southern part of Lithuania along the most important highways with the highest levels of truck traffic. A total of more than 360 km of highway edges were surveyed during this study. The surveys were performed by driving a car in both directions of the highway and observing the roadsides and the median strip separating the two traffic directions. The median strip usually comprises a mown grassland of varying width, bordered by crash barriers on one or both sides.

Herbarium specimens of *Dittrichia graveolens* were deposited at the Herbarium of the Institute of Botany of the Nature Research Centre (BILAS). Specimens from Poland stored in this Herbarium were also used for the study. The distribution map was compiled according to the geographical grid system.

The area occupied by each of the detected populations of *Dittrichia graveolens* was estimated, and the number of individuals was counted in five 0.25 m<sup>2</sup> plots evenly spaced across the site to determine the density of individuals. To estimate the height of the plants, 20 individuals were measured at both sites with an accuracy of one centimetre. In each population, 20 heads were collected in which fruits were already ripe but had not yet started shedding. The heads were analysed under a stereo microscope in the laboratory, and the number of developed and undeveloped seeds was counted.

The results of the descriptive statistics were presented as mean and standard deviation (mean  $\pm$  SD). Since the data samples were small, their differences were estimated using the non-parametric Mann-Whitney test. Data were analysed, and graphs were plotted using the PAST 4.13 software (Hammer et al., 2001).

## RESULTS

When surveying highway roadsides in 2023, the alien species *Dittrichia graveolens* was found for the first time in Lithuania. Two localities of the species were detected during the study period (Fig. 1). The first locality of the species was found in Kazlų Rūda district, in the vicinity of Pentupiai village (Appendix), at the Kalvarija–Kaunas highway (A5). The second locality of the species was detected in Kau-

nas district, near the settlement of Jonučiai, along the highway Kalvarija–Kaunas (A5).

Near Pentupiai village, *Dittrichia graveolens* was found along the edge of the median strip separating the traffic lanes of the highway, between the crash barrier and the road pavement (Fig. 2). At this locality, *Dittrichia graveolens* individuals formed six dense aggregations along a 100 m long segment, with only solitary individuals growing between aggregations. The mean density of *Dittrichia graveolens* in the aggregations was  $40.8 \pm 12.5$  individuals/m<sup>2</sup>. The dense stands covered a total area of about 12 m<sup>2</sup>; therefore,  $490 \pm 150$  individuals were present at the locality in 2023.

At the settlement Jonučiai, *Dittrichia graveolens* grew in a narrow, approximately 1 m wide median strip separating the highway traffic lanes, between two crash barriers, and immediately adjacent to the road pavement (Fig. 2). The species occupied a strip

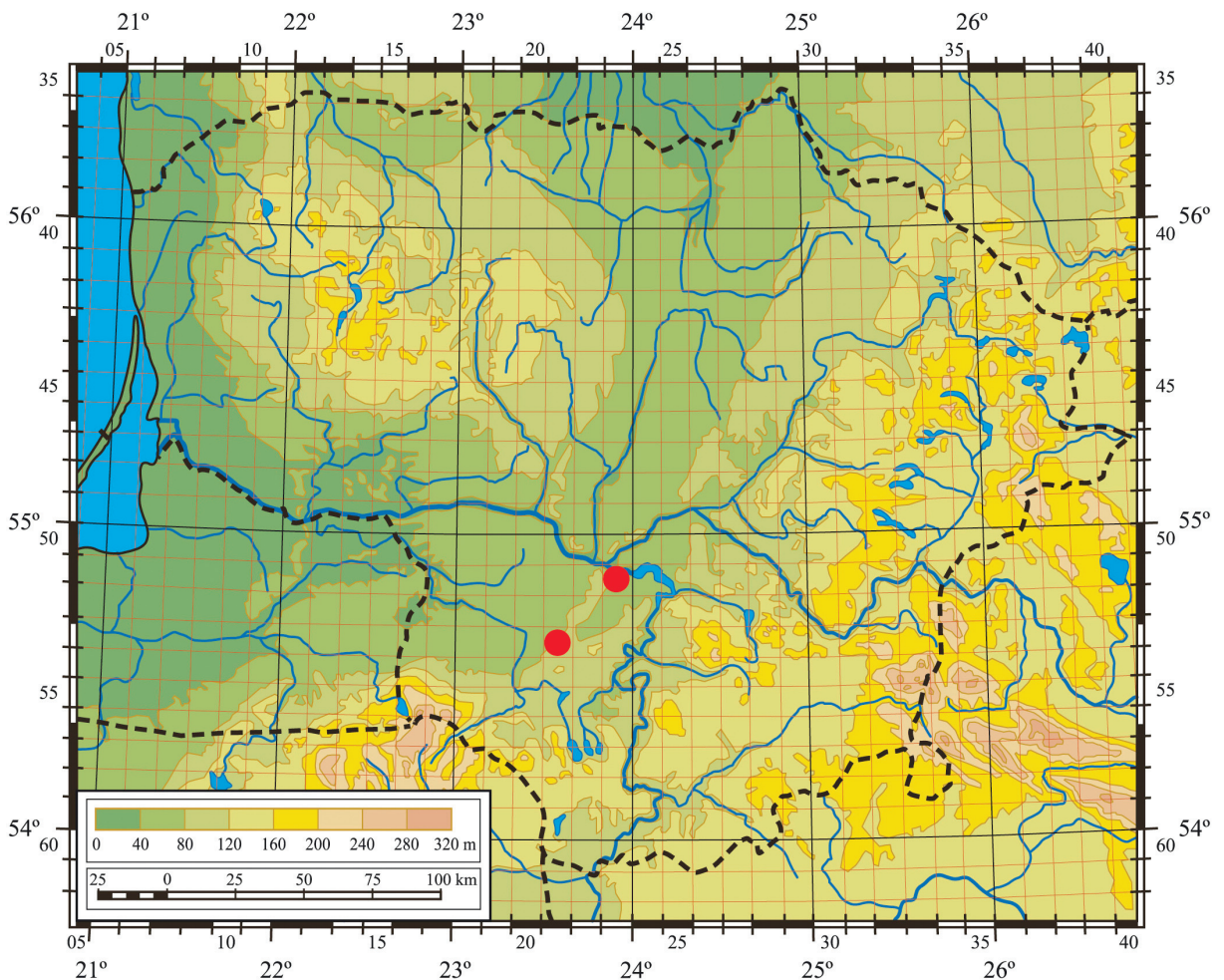


Fig. 1. Localities of *Dittrichia graveolens* in Lithuania recorded in 2023.





Fig. 2. *Dittrichia graveolens* near Pentupiai (Kazlų Rūda district), at a highway roadside, 14 October 2023. Photographs by Z. Gudžinskas.

of about 30 m long and 1 m wide. The density of plants was significantly lower ( $p = 0.011$ ) than at Pentupiai village. The mean density in this locality was  $12.8 \pm 4.4$  individuals/m<sup>2</sup>, and the total population consisted of about  $384 \pm 132$  plants. Individuals of *Dittrichia graveolens* were distributed relatively evenly throughout the 30 m<sup>2</sup> area.

In both localities, *Dittrichia graveolens* were found in the communities with plants typical of ruderal and trampled areas, such as *Achillea millefolium* L., *Argentina anserina* (L.) Rydb., *Dactylis glomerata* L., *Elymus repens* (L.) Gould, *Erigeron canadensis* L., *Lolium perenne* L., *Matricaria discoidea* DC., *Oxybasis glauca* (L.) S. Fuentes, Uotila & Borsch, *Plantago major* L., *Polygonum aviculare* L., *Portulaca oleracea* L., *Puccinellia distans* (Jacq.) Parl., *Scorzoneroideis autumnalis* (L.) Moench, and *Setaria viridis* (L.) P. Beauv. In the locality near Pentupiai, herbs covered 70% of the surface, moss cover was 10%, and 20% of the surface was bare soil, while at Jonučiai, herb cover was about 50%, there was no moss cover, and the rest of the surface was bare soil.

In the locality near Pentupiai, the mean height of *Dittrichia graveolens* individuals was  $15.9 \pm 5.5$  cm. In contrast, in the locality near Jonučiai, they were significantly taller ( $p = 0.002$ ), and their mean height was  $24.5 \pm 4.9$  cm. Some of the individuals at Pentu-

piai were cut off in summer because, in autumn, they had two or three approximately equal branches growing from the stem base. There were no such individuals in the population near Jonučiai. Nevertheless, in mid-October, plants in both populations were at the end of flowering, and some capitula had already shed their seeds (Fig. 2).

In Lithuania, the mean number of flowers in a capitulum of *Dittrichia graveolens* was  $20.5 \pm 4.9$ , and the mean number of produced fruits in a capitulum was  $18.4 \pm 5.2$ . Both studied populations significantly differed in the number of flowers and fruits they produced. The mean number of *Dittrichia graveolens* flowers in a capitulum (Fig. 3) was significantly ( $p = 0.017$ ) larger in the Pentupiai ( $23.0 \pm 4.1$ ) population than in the Jonučiai ( $17.9 \pm 4.3$ ) population. The mean number of developed seeds in a capitulum was also significantly ( $p = 0.002$ ) larger in the Pentupiai ( $21.9 \pm 4.1$ ) than in the Jonučiai ( $14.8 \pm 3.5$ ) population. The mean number of undeveloped seeds in a capitulum in the Jonučiai ( $3.1 \pm 1.7$ ) population was significantly ( $p = 0.003$ ) larger than in the Pentupiai ( $1.1 \pm 0.9$ ) population (Fig. 3). The realised fecundity of *Dittrichia graveolens* in Lithuania in 2023 was 89.7% of the potential seed production. In the Pentupiai population, this value was 95.2%, whereas in the Jonučiai population it was 82.7%.

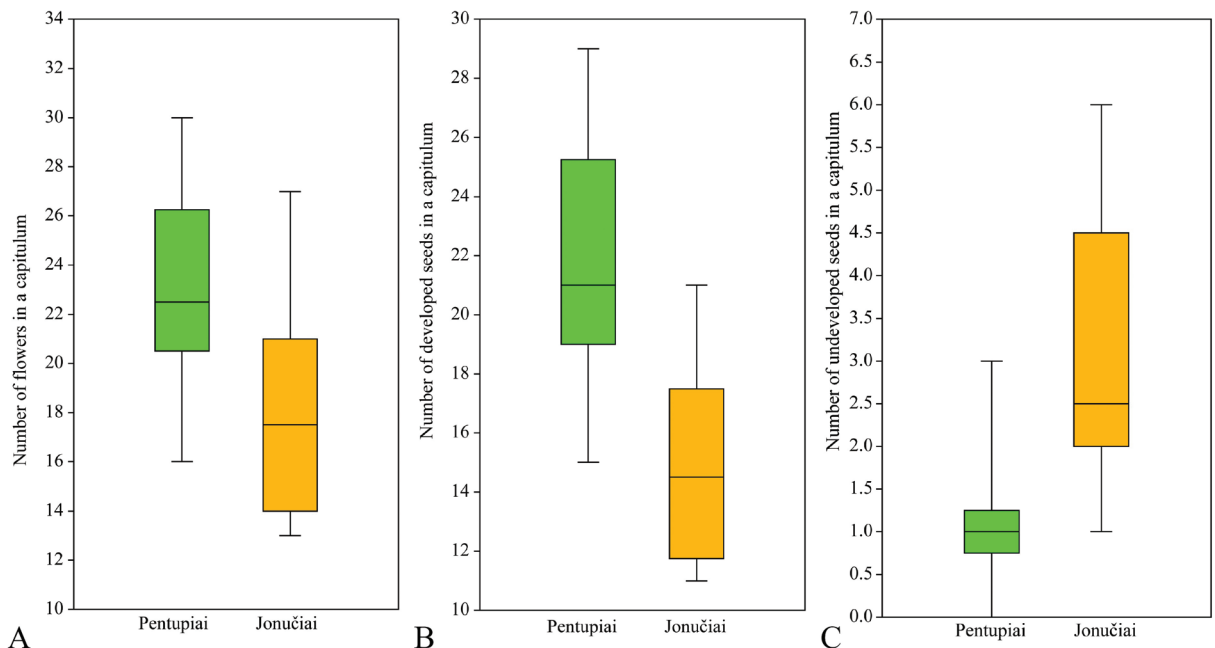


Fig. 3. Comparison of the number of flowers (A), the number of produced fruits (B) and the number of undeveloped fruits (C) in a capitulum of *Dittrichia graveolens* at Pentupiai and Jonučiai localities.



Considering the localities of *Dittrichia graveolens* in Lithuania, it can be assumed that it was introduced accidentally with vehicles, probably trucks. Seeds of these plants may have been transported with the soil adhered to the wheels or tyres of the cars and dropped along the way. Wind currents may have also blown the seeds onto the transported commodities, which may have fallen off at the roadside during transportation. The introduction of *Dittrichia graveolens* to Lithuania may have occurred two or three years ago, since relatively dense and abundant populations are evidently formed from seeds matured by plants growing in those localities. *Dittrichia graveolens* is a casual alien species in Lithuania, but there is a strong possibility of establishment and further spread along roadsides.

According to literature sources, *Dittrichia graveolens* was first found in Poland in 2013 in Silesia, near Ogradzona village (Kocián, 2015; Kozłowska-Kozak et al., 2019). An examination of the collections in the Herbarium of the Institute of Botany Institute of the Nature Research Centre (BILAS) revealed that specimens of this species were first collected in Poland in 1990. The plants were found in the southern part of Poland, near Kraków, on the Nowa Huta Steelworks slag deposits (Appendix). *Dittrichia graveolens* was already relatively abundant and widespread in a large dump area, suggesting that it was introduced to this part of Poland in the 1980s. Therefore, based on current information, Nowa Huta near Kraków should be considered the first introduction site of this species in Poland.

## DISCUSSION

*Dittrichia graveolens* is already widespread in Central Europe (Radkowitzsch, 2003; Pyšek et al., 2012; Király et al., 2014; Kocián, 2015; Takács et al., 2016; Szatmari & Hurdu, 2020) and has spread rapidly along Polish highways in recent decades (Kocián, 2015; Pliszko & Kocián, 2017; Wróbel, Nobis, 2017; Kozłowska-Kozak et al., 2019), hence it was expected that the species might have been accidentally introduced into Lithuania. A targeted search for the species proved successful, as it was found in Lithuania at two sites along a highway. Groups of *Dittrichia graveolens* can be easily spotted even when driving due to their dark green colour, distinc-

tive texture and growth form. Despite careful observation of the highway roadsides, individuals growing solitarily may have been overlooked in other areas along the Kalvarija–Kaunas highway and the other highways surveyed.

The discovery of *Dittrichia graveolens* at an early stage of its spread is a perfect example of the importance of obtaining the latest information on the occurrence of alien species in neighbouring countries. An early warning system for the spread of dangerous species and the immediate search for such species in potential habitats can help to prevent their invasion (Gudžinskas & Taura, 2020; Reaser et al., 2020). Small populations are easier to eradicate or manage at the beginning of an invasion than once a species with high invasive potential has become widespread (Green & Grosholz, 2020).

Considering the current distribution, size and abundance of *Dittrichia graveolens* populations in Lithuania, it can be concluded that this is the very beginning of its spread in the country. The species was probably introduced to these sites two or three years ago. The most likely way of introducing *Dittrichia graveolens* to Lithuania is by trucks. Less likely is the introduction of its seeds by road maintenance machinery or with de-icing salt mixtures.

*Dittrichia graveolens* produces many seeds in Lithuania and is likely to continue spreading along roadsides where large areas of permanently disturbed habitats are created. The species may spread within the country due to its high seed production (Brownsey et al., 2013). However, new populations may also arise from new seed introductions from other European regions. In October, some plants had already shed their seeds, which can be widely dispersed in dry weather by air turbulence caused by passing cars. Seeds can also be spread by road maintenance equipment, particularly road sweepers and grass cutters. *Dittrichia graveolens*, which grows only along highways, does not pose a severe risk in Lithuania, despite its allergenic properties and negative impact on animal health (Ponticelli et al., 2022). However, it could have a negative impact on native plants if it reaches the banks of water bodies, especially rivers (Szatmari & Hurdu, 2020).

Despite the small population of *Dittrichia graveolens* in Lithuania, there is little chance of stopping its spread. Continuous mowing of roadsides

and grasslands of the median strip only temporarily slows down growth and reduces seed production, but the plants quickly regrow, flower again and ripen seeds. Even if the populations could be eradicated, there is always a high probability that the seeds of these plants will be re-dispersed by trucks.

The study of herbarium specimens deposited at the Herbarium Generale section of BILAS proved that *Dittrichia graveolens* was found in Poland in 1990, more than twenty years earlier than reported in the literature (Kocián, 2015; Wróbel, Nobis, 2017; Kozłowska-Kozak et al., 2019). In September 1990, during my visit with Mr Janusz Guzik (1937–2013) to the Nowa Huta Steelworks slag deposit near Kraków, we observed a relatively large population of *Dittrichia graveolens*. Besides, Mr. Guzik had known this habitat for several years and regularly surveyed it. It is possible that herbarium specimens of *Dittrichia graveolens* earlier collected by Mr. Guzik, exist from the same area. The specimens could be deposited at the Herbarium of the W. Szafer Institute of Botany of the Polish Academy of Sciences (Kraków). If available, an examination of his collections, may provide a more precise date of the first record of *Dittrichia graveolens* in Poland. However, it is now clear that the species was already present in this country in the late 1980s.

**Author contribution.** The author conducted all the research, analysed the data and wrote the text.

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## Appendix

List of examined specimens of *Dittrichia graveolens* from Lithuania and Poland:

1. Lithuania, Kazlų Rūda district, 2 km west of Subačiškė, environs of Pentupiai village, at the Kalvarija–Kaunas highway (A5), on the edge of the median strip separating the highway traffic lanes, between the crash barrier and the road pavement. In a stretch of about 100 m, six groups with ca. 500 individuals, 14 October 2023, Z. Gudžinskas. 5321. 54.68397 °N; 23.58478 °E.
2. Lithuania, Kaunas district, near the settlement of Jonučiai, north of Viadukas Str., along the highway Kalvarija–Kaunas (A5), approximately 1 m wide median strip separating the highway traffic lanes, between two crash barriers, a strip of about 30 m long and 1 m wide, 17 October 2023, Z. Gudžinskas. 5123. 54.83266 °N; 23.85232 °E.
3. Poland, Kraków, Nowa Huta, in the slag dump of a steel plant, on slag heaps of the initial overgrowth stage, quite abundant, 10 September 1990, Z. Gudžinskas.

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