SHORT COMMUNICATION

Chemical composition of the essential oil from carnation coniferous (*Dianthus acicularis* Fisch. ex Ledeb) growing wild in Northern Kazakhstan

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**ABSTRACT**

The aim of the study was to investigate volatile compounds from the aerial parts of *Dianthus acicularis* of the genus *Dianthus* of the family *Caryophyllaceae* grown wild in Northern Kazakhstan for the first time. *D. acicularis* is a typical Trans-Volga-Kazakhstan endemic. *D. acicularis* has high resistance to the bacterial wilt, a serious disease caused by *Burkholderia caryophylli*. The qualitative and quantitative compositions of the specimens of the essential oils were analysed by the method of GC–MS. The main constituents of *D. acicularis* essential oil were methyl ketones - 2-pentadecanone (26.9–32.2%) and 2-tridecanone (4.7–17.7%), identified for the first time in the *Dianthus* genus. The methyl ketone activity provides protection of the plants from herbivores and fungal pathogens. One can suppose that the presence of 2-pentadecanone and 2-tridecanone in the essential oil of carnation coniferous provides its resistance to different insects and pathogens, including the resistance to the bacterial wilt.

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**KEYWORDS**
Carnation coniferous (*Dianthus acicularis* Fisch. ex Ledeb); *Caryophyllaceae*; essential oil composition; methyl ketones; 2-pentadecanone; 2-tridecanone
1. Introduction

The genus *Dianthus* belongs to the Caryophyllaceae family which comprises over 300 species of herbaceous plants, annuals, biennials and perennials, spread over a vast area, which includes warm temperate zones of Europe, North America and Asia, and contains many important ornamental species (Shiba & Mii 2005b; Casiglia et al. 2014a). In Kazakhstan the genus *Dianthus* includes 28 species.

*Dianthus acicularis* (Supplementary Figure S1 (online only)) – it is a perennial plant forming dense root mat; the leaves are 2–6 cm in length, adjacent to the caulis or remote from it, but not deflexed (Pavlov 1960).

*D. acicularis* is a typical Trans-Volga-Kazakhstani endemic (Rachkovskaya & Bragina 2012). *D. acicularis* grows in the far east of Europe, in West Siberia, Central Asia (Kazakhstan), in the Far East, in China (Xinjiang). In European Russia, this plant occurs in nature only in the eastern part. *D. acicularis* is considered to be a rare species in Samara Region and in the Urals.

Paleoenendemism and relatively low competitiveness of *D. acicularis* are the natural reasons of the reduction in its populations. *D. acicularis* grows in the communities with low projecting cover of the grass and subshrub layer where the competitiveness on the part of the other plants is weakened. The given species can exist over a long period of time by small in number populations on the sites with favourable edaphic conditions. It grows on rocks, stony slopes, in stony steppes and sandy pine forests. The plant blooms in June–July. *D. acicularis* is a vegetative non-motile plant, propagating only by the seed way. This plant is characterised by gynodioecy. According to the way of pollination, *D. acicularis* belongs to the entomophilic plants. The white flowers of the plant, well noticeable at night, are pollinated in the evening and nocturnal butterflies of the families of *Noctuidae* and *Sphingidae*. The flower scent composition of *Dianthus* species has relevance for pollination biology and taxonomy (Jürgens et al. 2003).

Some reports on phytochemical analyses of this species can be found in literature. In *D. acicularis* Fischer ex Ledeb, there were revealed saponins (Delektorskaya 1949), flavonoids (glycoflavonoids of apigenin – neovaroside and isoneovaroside (apigenin-6-C-anti-α-D-glucopyranoside)) (Boguslavskaya et al. 1983).

*D. acicularis* Fischer ex Ledeb has high resistance to the bacterial wilt, a serious disease caused by *Burkholderia caryophylli* (*Pseudomonas caryophylli*) (Onozaki et al. 1999). *D. acicularis* is highly resistant to the hot and humid climate in summer as well as to the cool climate of winter in Japan. Because this wild species has a dwarf nature with beautiful white flowers, its use is now anticipated in breeding programmes for the genus *Dianthus* as an important germ plasm with bacterial resistance (Shiba & Mii 2005a, 2005b).

*D. acicularis* is recommended for cultivation as an ornamental plant, having a pleasant aroma of the white flowers, thick pillow-like root mat, abundant and long-continued blossoming. *D. acicularis* has a great potential for the use in landscape gardening of parks and gardens. It can be grown on flower beds and it can be used as a border plant. It is possible to transplant *D. acicularis* into a rock garden with other species.

The aim of the study was to investigate volatile compounds from the aerial parts of carnation coniferous (*D. acicularis* Fisch. ex Ledeb) grown wild in Northern Kazakhstan for the first time.
2. Results and discussion

The chemical composition of the essential oil of *D. acicularis* growing wild in Northern Kazakhstan was determined. Characteristic of the places of collection of the plant material is given in Supplementary Table S1 (online only). The GC and GC/MS analyses allowed determining the 63 components which amounted to 82.7–85.7% of the oil. The composition of essential oil obtained by hydrodistillation of the dried material was presented in Supplementary Figures S2–S4 and Supplementary Table S2 (online only).

An interesting fact of this oil is the presence of methyl ketones - 2-pentadecanone (26.9–32.2%) and 2-tridecanone (4.7–17.7%), identified for the first time in the *Dianthus* genus but already identified in different concentrations in other oils of plants of *Passiflora edulis* Sims. (Arriaga et al. 1997); *Bowdicbiu vigilioides* Kunt. (Arriaga et al. 1998); *Pilocarpus spicatus* Saint Hill. (Andrade-Neto et al. 2002); *Pilocarpus microphyllus* Stapf. (Taveira et al. 2003); *Phlomis olivieri* Benth. (Tajbakhsh et al. 2007); *Phlomis herba-venti* subsp. *pungens* and subsp. *lenkoranica* (Khalilzadeh et al. 2008); *Chichorium intybus* L. (Judžentienė & Būdienė 2008); *Hertia intermedia* (Akhgar et al. 2012); *Cochlospermum planchonii* (Bossou et al. 2013); *Dorema ammoniacum* D. Don (Hosseini et al. 2014); *Cyrtomium fortunei* (Yang et al. 2014); *Papaver rhoeas* L. (Doğan & Bağcı 2014). 2-tridecanone was characterised as a crystalline constituent of the essential oil of matsubasa (*Shizandra nigra maxim*), a plant in the magnolia family, which is used as a bath perfume (Sengoku 1933).

The methyl ketone activity provides protection of the plants from herbivores and fungal pathogens. 2-pentadecanone and 2-tridecanone have the insect repellent properties. 2-tridecanone is effective against the tobacco hornworm (*Manduca sexta*) (Kennedy & Henderson 1978; Kennedy & Yamamoto 1979; Williams et al. 1980), the spotted spider mite (*Tetranychus urticae*) (Chatzivasileiadis & Sabelis 1997; Chatzivasileiadis et al. 1999; Antonious et al. 2003, 2014; Antonious & Snyder 2006, 2015), tobacco budworm (*Heliothis virescens* Fabricius) (Antonious et al. 2003), the green peach aphids (*Myzus persicae*) (Antonious et al. 2003), the adults of the sweet potato whitefly (*Bemisia tabaci* (Gennadius)) and the fourth instar larvae of the Colorado potato beetle (*Leptinotarsa decemlineata* (Say)) (Antonious et al. 2005), *Culex quinquefasciatus* and *Aedes aegypti* mosquitoes (Roe 2004).

2-tridecanone has broad pest control activity. Pest repellency is a potentially valuable mechanism for protecting plants from arthropod damage. Crops such as fruits and vegetables having low economic injury thresholds, and the crops susceptible to insect-transmitted viruses can especially benefit from protection by repellents (Jones 1987).

2-pentadecanone and 2-tridecanone in combination with a variety of other compounds composed of the aggregation pheromone blend in a number of *Drosophila* species (Moats et al. 1987; Schaner et al. 1989; Schaner & Jackson 1992). 2-tridecanone and 2-pentadecanone are present at the secretions of the ants *Acanthomyops claviger* (Regnier & Wilson 1968) and *Lasius* (*Dendrolasius*) *fuliginosus* (Bernardi et al. 1967). 2-tridecanone is present at the secretions of the worker ants *Lasius umbratus*, *Lasius bicornis* (Quilico et al. 1957a; Piozzi et al. 1959), and at the secretions of the slave species *Formica rufibarbis* (Bergström & Löfqvist 1968).

According to Forney and Markovetz (Forney & Markovetz 1971), methyl ketones do contribute to the olfactory stimuli evoked in insects by the essential oil in which they are present. Individual methyl ketones in plant essential oils may eventually be found to evoke subtle specific stimuli in insects which resemble those evoked by the same specific compounds synthesised by insects themselves.
2-tridecanone and 2-pentadecanone were found at lower levels in preen oil secretions of the dark-eyed Junco (*Junco hyemalis*) (both the male and the female juncos). In birds, methyl ketones may be promoting healthy feather conditions by acting as the chemical defence compounds. Perhaps they provide similar protection for feathers (Soini et al. 2007). 2-pentadecanone was revealed in secretion of the spinal glands of springboks and in secretion of the perineal glands of Guinea pigs (Burger et al. 1981).

One can also note the content of 1-hexadecanol (2.4–5.4%), geranyllinalool (1.8–3.4%) and phytol (0.1–4.7%) in the essential oil of *D. acicularis*. The presence in composition of the essential oil of secondary alcohols – 2-tridecanol (2.1–3.2%), 2-pentadecanol (1.9–2.6%), 2-hexadecanol (0.2–0.4%) and 2-heptadecanol (0.2–0.3%) – can be regarded as the reduction products of their corresponding methyl ketones.

There are no significant differences in the essential oil composition between plants of *D. acicularis* grown in dry and very dry conditions. However, the content of major components (2-pentadecanone and 2-tridecanone) in the essential oil of *D. acicularis* grown in very dry conditions lower in comparison with the essential oil of *D. acicularis* grown in dry conditions.

The chemical composition of the oil we studied is different from that of the oils from other *Dianthus* species. As can be seen from Supplementary Table S3 (online only), neither 2-pentadecanone nor 2-tridecanone, forming a part of the essential oil of *D. acicularis*, are present at composition of the main constituents of the essential oil and floral scent of different species of *Dianthus*.

### 3. Conclusion

The chemical composition of the essential oil of *D. acicularis* Fisch. ex Ledeb from Northern Kazakhstan was studied for the first time. The major components of the oil were 2-pentadecanone (26.9–32.2%) and 2-tridecanone (4.7–17.7%). One can suppose that the presence of methyl ketones of 2-pentadecanone and 2-tridecanone in the essential oil of carnation coniferous (*D. acicularis* Fisch. ex Ledeb) provides its resistance to different insects and pathogens, including the resistance to the bacterial wilt, a serious disease caused by *B. caryophylli* (*P. caryophylli*). In the future, it is possible to test the essential oil of *D. acicularis* for its ability to attract or repel insects.

### Supplementary material

Experimental details relating to this paper are available online, alongside Figures S1–S4 and Tables S1–S3.

### Disclosure statement

No potential conflict of interest was reported by the authors.

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