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ECOAREAL OF *SPIRANTHES SPIRALIS* WITHIN EUROPE: A SYNPHYTOINDICATION ASSESSMENT

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Ecoareal of Spiranthes spiralis within Europe: a synphytoindication aseessment. — M. D. Burlaka. — *There is given an overview of ecological areal of Spiranthes spiralis within Ukraine and Europe. The analysis is performed with the use of synphytoindication assessment of phytosociological relevees from ten European countries and covers 12 ecological factors (both edaphic and climatic). The narrowest amplitudes have factors of soil salt regime and continentality but there is no evidence of any strong ecological limits for the species' spread within Europe.*

Keywords: *Spiranthes spiralis, econishe, ecoareal, Europe, Ukraine, synphytoindication*

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Spiranthes spiralis is a rare species of Ukrainian flora, which has "endangered" protected status [19]. Its range covers Mediterranean, Atlantic (except northern regions) and Central Europe [6]. There are localities at the northern coast of Africa, the Northern Caucasus and Transcaucasia, West Asia and the Western Himalayas [8], in particular Nepal [1, 6]. Thus, populations of *S. spiralis* from Ukraine are on the north-eastern boundaries of the continuous part of the range (Fig. 1).

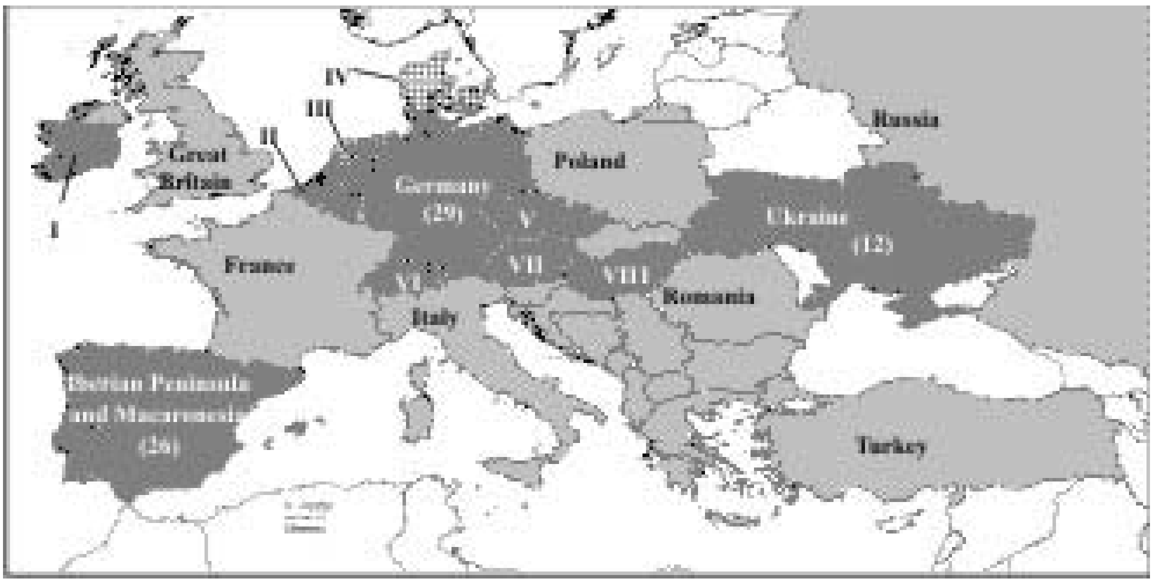

Fig. 1. Schematic map of distribution of *Spiranthes spiralis* in Europe (marked in light gray) and the countries from which the relevees for econishe assessment were taken (dark gray): I – Ireland (7 relevees from the Irish Vegetation Database, GIVD code – EU-IE-001), II – Belgium (1, VLAVEDAT, EU-BE-001), III – the Netherlands (65, Dutch National Vegetation Database, EU-NL-001), IV – Denmark (extinct), V – Czech republic (1, Czech National Phytosociological Database, EU-CZ-001 [2]), VI – Switzerland (7, Swiss Forest Vegetation Database, EU-CH-005 and Dry Meadows and Pastures of Switzerland, EU-CH-006), VII – Austria (2, Austrian Vegetation Database, EU-AT-001), VIII – Hungary (2, CoenoDat Hungarian Phytosociological Database, EU-HU-003 [3]), Iberian peninsula and Macaronesia (26, Iberian and Macaronesian Vegetation Information System (SIVIM), EU-00-004 and Vegetation-Plot Database of the University of the Basque Country (BIOVEG), EU-00-011), Germany (29, German Vegetation Reference Database (GVRD), EU-DE-014), Ukraine (12, our data and relevees from I. M. Kvakovska [12]).

In Ukraine, *S. spiralis* is known from Lviv, Ivano-Frankivsk and Transcarpathian regions (LW: Волощак, 1891; Хміль, 2004; Хміль, Сеник, 2007; LWS: Łobarżewski, 1853; (?), 1932; Бойко, 1966; Лазебна, 1975, 1977; Кваковська, 2006; Кузярін, Хміль, 2006; Борсукевич, 2010; KW: Лоя, 2006; Борсукевич, 2010; Бурлака, 2012) [9, 11-14, 18]. During the last few decades populations from the Ukrainian Roztocchia [17] and from the territory of national park "Hutsulschyna" between Kosiv and Kuty [16] have disappeared. Locality from mt. Klyfa near Lyucha village in Kosiv part of Ivano-Frankivsk region has also no recent reports. Thus, in Ukraine the species tends to reduce its spread.

S. spiralis, unlike most of the temperate zone orchids, grows on very poor clay soils, usually dry, impermeable and moderately aerated [15]. This species prefers mainly meadows and grassy slopes, forest edges and glades, bushes, sparse forests of the lower mountain belt and foothills on chalk or limestone substrates with significant grazing or mowing [7, 15]. As the main reason for disappearance of *S. spiralis* is considered a decrease in livestock and, therefore, transformation of grassland habitats with increasing turf layer, shading, height of vegetation, etc. that affects growth and development of S. spiralis individuals [9, 14].

To identify the influence of abiotic factors on *S. spiralis*, we conducted a synphytoindication assessment of species' habitats [4, 10]. We analyzed 12 factors including edaphic: soil moisture (Hd), moisture variability (fH), soil acidity (Rc), soil salt regime (Sl), carbonate (Ca) and mineral nitrogen content (Nt) in the soil, soil aeration (Ae); and climatic factors: thermoregime (Tm), ombroregime (Om), cryoregime (Cr), continentality (Kn) and light flow in habitat (Lc). To assess species' econishe across the whole areal and reveal place of Ukrainian habitats within it we analyzed 152 relevees with S. spiralis from ten European countries, covering mainly the central part of the range in latitudinal dimension and almost all of the continuous part of the range from west to east (Fig. 1). Most relevees were received from participants of the GIVD project [5]. We also used literature data and our own relevees for Ukrainian localities. Portion of informative species (those, which amplitudes of environmental factors are known) in the relevees is at least two thirds. Analysis of the data was carried out using basic statistics and discriminant analysis with differentiation by country of origin.

According to synphytoindication, Ukrainian habitats are very homogeneous for the factor of soil moisture and only partly coincide with the diversity of conditions of European habitats (Fig. 2). The difference between the medians for different countries for this factor does not exceed 10 %. In overall, the species prefers mesophytic habitats both in Ukraine and in considered European countries. The wettest soils of Spiranthes' habitats are in the Netherlands and Ireland, and habitats of the Iberian Peninsula are most diverse for this factor.

Factor of soil moisture variability has a slightly greater range of values of the medians (about 10 %). The larger factor values indicate conditions closer to the species' optimum. The greatest contrast of moisture occurs in habitats of *S. spiralis* in Belgium, Ukraine and the Czech Republic, the most stable soil moisture regime is in Switzerland. For this factor species belongs to a group of hemi-hydrocontrastophiles (species of drily ecotopes that bear uneven soil moisture).

For soil aeration factor *S. spiralis* is a hemi-aerophobe (a species that prefers moderately aerated clay soils). The difference between the habitats of species from different countries is shown in Fig. 2. In particular, the least-aerated soils occur in habitats from the Netherlands, the Iberian Peninsula, Ireland and Belgium up to soils with constant capillary moisture. Most aerated soils are in Germany and Switzerland, where they are apparently confined to the mountain skeleton soils.

S. spiralis within the entire range mostly tends to soils with light acid reaction (sub-acidophile). The highest values of soil pH are characteristic for habitats from Austria, the Iberian Peninsula, Switzerland and Hungary, while in the Czech Republic, Ukraine, and the Netherlands *S. spiralis* is confined to more acidic soils. For the salt content soils of some Ukrainian habitats are poorer than most European ones (Fig. 2). But both in Ukraine and within the overall range species belongs to a group semi-eutrophes, species of soils, enriched with salt (150-200 mg/l). Up to 1,5 % of that are for carbonates. In some habitats their part is more (Austria, the Iberian Peninsula, Switzerland, Hungary, Germany) or less (Ukraine, the Netherlands, Ireland), but within the entire range S. spiralis is acarbonatophile and bears only a small content of carbonate salts. The content of mineral nitrogen in soil of S. spiralis habitats is even lower (0,2-0,3 %), indicating a small supply of nitrates and ammonium compounds. The richest soils as for mineral nitrogen are characteristic for habitats from Belgium (Fig. 2).

As for climatic factors, the range of values is much narrower for Ukrainian communities involving *S. spiralis* than for the relevees from other European countries. This is understandable, since a variety of climatic conditions within Europe, even for certain types of communities is much wider than in the foothills of the Ukrainian Carpathians. Thus, for ombroregime *S. spiralis* in Ukraine prefers sub-ombrophytic habitats, while within the whole area it is sub-aridophyte. This difference is mostly created by the relevees from the Iberian Peninsula, which is characterized by a dry climate. Most of the habitats of other considered European countries are close to Ukrainian ones for the ombroregime factor values.

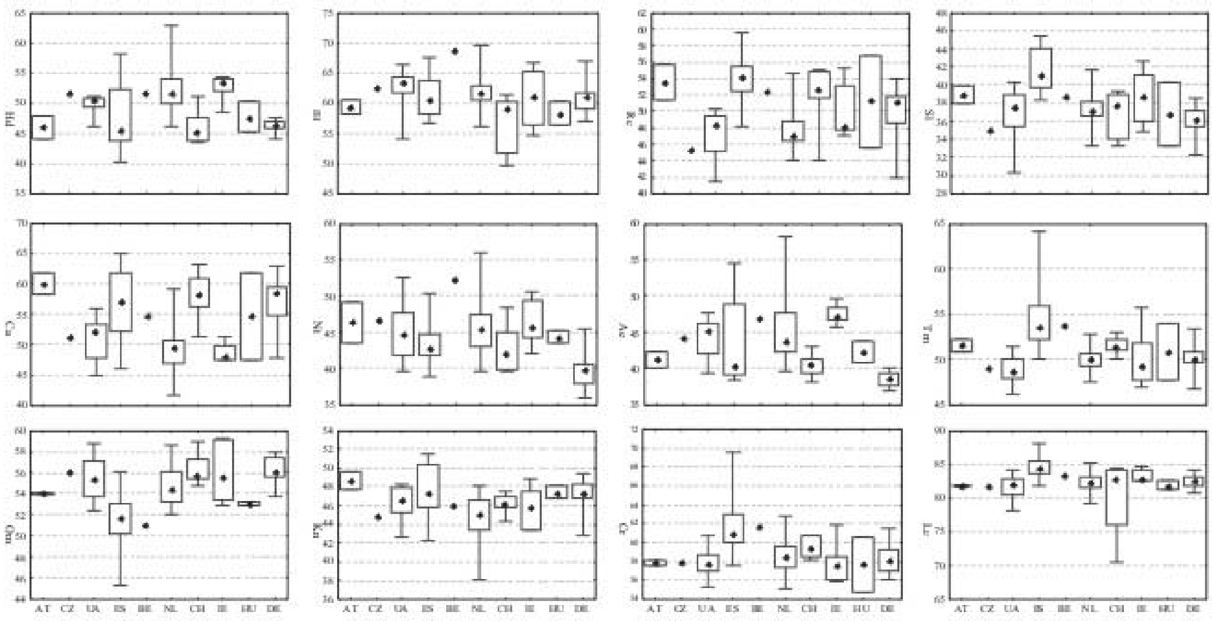

Fig. 2. The amplitudes of tolerance of *Spiranthes spiralis* to 12 environmental factors according to Didukh scales. On the horizontal axis countries are marked, on the vertical axis – factor values (as a percentage of the scale range). For each country the median value (dot), central quartiles (25-75 %, boxes) and threshold values (whiskers) are given. To the right of each graph are boxes of the total values' range for European habitats (shaded) and Ukraine (in black). Legend: Hd – soil humidity, fH – variability of soil moisture, Rc – soil acidity, Sl – soil salt regime, Ca – content of carbonates and Nt – mineral nitrogen in the soil, Ae – soil aeration, Tm – thermoregime, Om – ombroregime, Cr – cryoregime, Kn – continentality and Lc – light flow in a habitat. AT – Austria, CZ – Czech republic, UA – Ukraine, ES – Iberian Peninsula and Macaronesia, BE – Belgium, NL – the Netherlands, CH – Switzerland, IE – Ireland, HU – Hungary, DE – Germany.

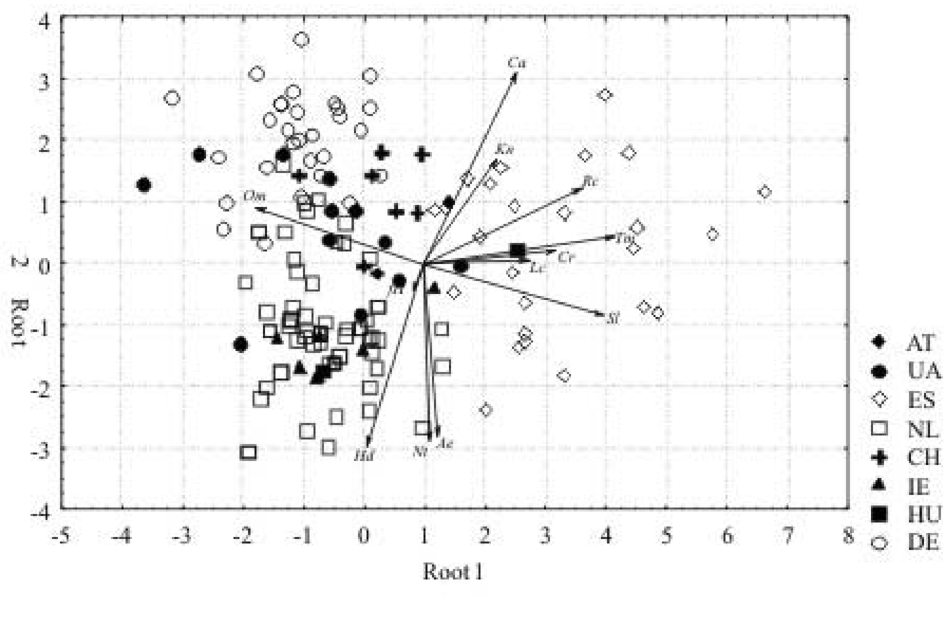

Fig. 3. Differentiation of relevees with *Spiranthes spiralis* between the canonical roots: AT – Austria, UA – Ukraine, ES – Iberian Peninsula and Macaronesia, NL – the Netherlands, CH – Switzerland, IE – Ireland, HU – Hungary, DE – Germany.

The same situation is peculiar to factors of thermo- and cryoregimes. In particular, habitats of the Iberian Peninsula are characterized by the least frosty climate in Europe along with the most income of solar radiation. And, as well as *S. spiralis* also occurs in this region, the range of values of thermo- and cryoregimes for Europe are expanded. However, habitats in Ukraine and most European countries are close for these factors and, consequently, belong to similar groups of submesothermic and hemi-cryophilic conditions.

Individuals of *S. spiralis* mostly grow in open meadows, hence tolerate significant illumination, but they also can occur among the bushes and in sparse stands of trees. Therefore, as for lighting of habitats *S. spiralis* belongs to subheliophytes.

Thus, the tolerance amplitudes of S. spiralis to twelve environmental factors take 15-25 % of the corresponding scales. So, the widths of the amplitudes of S. spiralis are predominantly hemi-stenotope. However, values for most habitats of *S. spiralis* are grouped mainly within the range of 5-10 % of a particular scale, and extreme values occur only occasionally (Fig. 2). The biggest differences between the median values are for edaphic factors. The narrowest is tolerance amplitude to ombroregime of climate.

Ukrainian habitats of *S. spiralis* differ mainly by edaphic conditions (except for soil moisture) as well as thermo- and ombroregime of climate. The difference in climate factors is caused by different location with respect to mountain arc of the Carpathians (Subcarpathian and Transcarpathian region). In overall, habitats of S. spiralis from Ukraine mostly overlap with the European ones for edaphic factors, with the exception of soil moisture.Ukrainian habitats of *S. spiralis* for most environmental factors are close to optimal conditions. The closest to the limits of amplitudes are factors of soil acidity and climate cryoregime [15]. So, for these factors the species is outside the optimum within Ukraine. On the other hand, comparing the Ukrainian and European habitats involving *S. spiralis*, we see that the species mostly exceeds the European ecoareals for soil salt regime as well as for soil acidity and thermoregime of climate. So these factors are limiting in Ukraine.

According to integral assessment of European relevees with discriminant analysis we revealed no clearly separated groups except compactly arranged relevees from Ireland (Fig. 3). Relevees from the Iberian Peninsula are singled out from the others by the first canonical root, but in general they are very scattered within the graph, so have significant intragroup differences. The first canonical root combines influences of factors of soil acidity, salt regime and the majority of climatic factors. Relevees from Germany and Switzerland are separated from relevees from the Netherlands and Ireland by the second canonical root (Fig. 3). The latter is formed by edaphic factors (soil moisture and its aeration, content of carbonates and mineral nitrogen). Thus, two canonical roots account for the influence of nearly all environmental factors. Accordingly, none of these factors could be treated as leading in differentiation of relevees within Europe.

So, we see that there is no environmental factor that severely limits spread of *S. spiralis*. The role of edaphic factors in the distribution of this species is indirect and shows in limited areas of favorable habitats. The influence of climatic factors has geographical nature and varies with distance from the main habitats of the species range.

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