Preliminary results of the studies on morphological diversity of the lowland populations of species from the genus *Anthoxanthum* L.

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Abstract. The aim of this study was to estimate the level of interspecific and intraspecific variation in the genus *Anthoxanthum* in Poland, which is represented here by 3 species - *Anthoxanthum odoratum*, *A. alpinum* and *A. aristatum*. The work presents the preliminary results of the studies on *A. odoratum* and *A. aristatum* occurring in the vicinity of Poznań (Western Poland). For *A. odoratum*, the samples were collected from the population growing in the various habitats, namely, meadows, forest and ruderal, while for *A. aristatum*, they originated from a single population occurring in the segetal habitat. They were analyzed in respect to 24 morphological traits of a panicle (e.g. panicle length, internode length, number of spiklets, spiklet length, glumes and lemma). Analyses were carried out to assess intrapopulation variability of *A. odoratum* in the different habitats and evaluate a relationships between *A. odoratum* and *A. aristatum*. Multivariate analysis of variance was applied to morphological data to determine the most discriminant characters. Subsequently, principal component analysis (PCA) and cluster analysis were used. It has been discovered statistically significant differences between *A. odoratum* and *A. aristatum* in respect to most traits, particularly, a to panicle length, length of particular internodes, length and width of upper glume and bottom glume. In the case of interspecific variation of *A. odoratum,* the analyses showed that *A. odoratum* population is significantly diversified and it represents different stages of apophytization in Poland.

Key words: *Anthoxanthum odoratum*, *Anthoxanthum aristatum*, morphology, Poland

Introduction

In the flora of Poland the genus *Anthoxanthum* L. is represented only by three species (Zając & Zając 2001), yet it is an extremely interesting object of taxonomical, phytogeographical and ecological studies (e.g. Rozmus 1960, 1963; Szwed 1986; Latowski 2005; Tokarska-Guzik 2005). This huge interest is the result of: (i) discovery of cytological diversity in the complex species of *A. odoratum* L. and the distinction of two altitude vicariads: *A. odoratum* s.s. – diploid (2n=10), which can be found in lowlands and lower parts of mountains, and *A. alpinum* Á. Löve et D. Löve – a tetraploid (2n=20), which substitutes the former one in the subalpine and alpine grasslands (Rozmus 1958, 1960, 1963); (ii) cholorogical expansion of *Anthoxanthum aristatum* Boiss., a species which originated in the western part of the Mediterranean region and since the 19th century has been spreading fast to the consecutive regions of Poland (e.g. Jackowiak 1999; Tokarska-Guzik 2005 and references therein); (iii) ecological expansion of *Anthoxanthum odoratum* L., which involves in taking up new habitats and plant communities within its current range.

Recent months have brought new, very interesting discoveries in the field of phylogeography of European species of the genus *Antoxanthum* (Pimentel et al. 2007b) and its morphometric differentiation (Pimentel Pereira et al. 2007). However it is worth noticing that in those comprehensive studies Polish populations are not represented at all.

Therefore the aim of this article is to present the morphological differentiation of several *Antoxanthum odoratum* populations in Poland. The analysis accounts for traits crucial for the description of the species' variability, as well as populations present in different habitat and phytocoenotic conditions. Due to the increasingly frequent spatial contact between the populations of native *A. odoratum* and geographically alien *A. aristatum,* the traits of the latter species have been used for comparison.

Materials and methodology

The material for the study comes from five populations located near Bagno-Chlebowo Reserve in the Puszcza Notecka (Notec Forest in Western Poland). Four of them are *A. odoratum* populations: two of a natural character (No. 3 and 4), one seminatural (No. 5) and one synanthropic (No. 2). A sample of *A. aristatum* was taken from a segetal population, i.e. a habitat most frequently occupied by this species in Poland (Table 1). Out of each populations, 3-30 tufts were collected with numerous generative tillers. Plant material was described and dried. For morphometric studies 24 traits of generative organs were chosen (Table 2). Są to

The results of measurements were prepared with STATISTICA 7.1 programme. Descriptive statistics were calculated (arithmetic average, standard deviation, minimum and maximum). Moreover, to determine the variation degree of each trait, a variation coefficient (V) was established. In order to determine statistical significance of average values of traits of the populations in question, the factor variance ANOVA F-statistics was used. The significance level was examined with Sheffe's test. The Principal Component Analysis (PCA) enabled the examination of mutual relations between the populations in the system of two first principal components. The analysis does not assume any groups *a priori*, and clusters of individuals are created on the basis of those traits which contribute most to the existing variation in the species. Due to the cluster analysis performed on the basis of the Euclidean distance, the degree of similarity between populations could be determined (Morrison 1990; Sokal & Rohlf 1997; Triola 1998; Łomnicki 2002).

Results

The analysis of basic characteristics of the traits and values of variation coefficients shows that almost all of them differentiate the population of *A. aristatum* from *A. odoratum*, irrespective of what habitats they come from. It does not apply to the length up to the awn node of a sterile flower palea (trait 19) and the length of a sterile flower lemma (21). Both traits: the length up to the awn mode of a sterile flower palea (19) and the length of a sterile flower lemma (21) are not significantly different in terms of statistics.

Values of four traits (2, 13, 18, 19) differentiate the *A. odoratum* populations in the following way:

- Traits: 2 - number of nodes in a panicle and 13 - number of spikelets on a bottom branching are characteristic for the population 2 collected from the roadsides.
- Traits: 18 – length of a sterile flower palea from the spikelet on the middle branching and 19 - length to the awn node of sterile flower palea are characteristic for the population 4 from the edge of pine forest.

The F coefficient, calculated on the basis of ANOVA variance, makes it possible to determine the impact from particular traits on the inter- and intraspecific variation in question. Most of the analysed traits is of a great statistical importance in the study of this variation (Table 3).

Primary components PCA1 and PCA2 explain altogether 51.33% of total variation, out of which the former factor described 39.61% and the latter one – 11.72% of variation (Fig. 1). The traits which were correlated most with factor PCA1 are: panicle length (1), length of subsequent internodes in a panicle (3, 4, 5, 6, 7), length of a spikelet on the second branching from a panicle top (8), as well as the features 16, 23 and 24: length of an upper glume (16),

length of lemma (23), and length of palea (24). The length to the awn node of a sterile flower palea is most strongly correlated with the factor PCA2 (19).

On the dispersion diagram the above-mentioned traits are characteristic for *A. aristatum* population and for most individuals of *A. odoratum* population no. 4. Other populations of the genus make up a single group clearly separated from *A. aristatum*. The cluster analysis (Fig. 2) proved the interspecific morphological distinction of *A. aristatum* and *A. odoratum* as well as the interspecific morphological similarity of *A. odoratum* population.

Discussion

Preliminary morphometric studies on the lowland populations of two species of the genus *Antoxanthum* from Western Poland allowed to assess the morphological differences between *A. odoratum* and *A. aristatum* and to determine the degree of morphological variation within and between *A. odoratum* populations. In the former case, the autonomy between *Anthoxanthum* species known from a specialist literature was confirmed (Rostański 1996; Pimentel et al. 2007).

An analysis of interpopulation variation in both species showed that for most trits there are statistically significant differences between *A. odoratum* and *A. aristatum*, yet the biggest differences apply to a panicle length, length of particular internodes, length and width of upper glume and bottom glume. Especially the difference in the length of internodes in inflorescence seems to be a very important trait. The trait is easy to observe and measure with great precision. It supplements the set of traits which differentiate both species that have been presented by many authors so far. The set includes mainly such features as: length and width of panicle, length and width of spikelets and size of upper and bottom glume (Rostański 1996).

In the case of interspecific variation of *A. odoratum,* the problem seems to be more complicated – also due to the lack of extensive studies on this matter. The analyses showed that *A. odoratum* population is significantly diversified and it represents different stages of apophytization in Poland (cf. Jackowiak 1999): from the forest stage (populations 3 and 4 – natural) through the meadow stage (population 5 – seminatural) to the synanthropic stage (population 2 – roadside). The populations from the synanthropic habitat (2) and the edge of pine forest (4) show some distinction, first of all with respect to the number of nodes (trait 2) and number of spikelets on a lower branching (trait 13), as well as with respect to the size of upper and bottom glume, and sterile flower lemmas and paleas. Other traits are characterized by continuous variation.

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Table 1. Ecological characteristic of the studied *Antoxanthum odoratum* and *A. aristatum* populations

Population number	Species' name	Ecological description
1	*A. aristatum*	an arable land; in rye crops on acidic, dry and impoverished sands
2	*A. odoratum*	a sandy roadside in a large coniferous complex
3	*A. odoratum*	an edge of a pine forest; a habitat similar to natural one
4	*A. odoratum*	an edge of a pine forest; a habitat similar to natural one
5	*A. odoratum*	a meadow in a valley of a watercourse crossing a vast complex of fresh pine forest

Table 2. List of morphometric traits accounted for in the analysis of *Anthoxanthum odoratum* and *A. aristatum* populations variation

Trait number	Traits' description
panicle	
1	panicle length
2	number of nodes in a panicle
3	length of the first internode
4	length of the second internode
5	length of the third internode
6	length of the fourth internode
7	length of the fifth internode
spikelet	
8	length of a spikelet on the second branching from a panicle top
9	number of spikelets on the second branching from a panicle top
10	length of a spikelet on the middle branching
11	number of spikelets on the middle branching
12	length of a spikelet on the bottom branching
13	number of spikelets on the bottom branching
glumes	
14	length of a bottom glume from the spikelet on the middle branching
15	width of a bottom glume from the spikelet on the middle branching
16	length of an upper glume
17	width of an upper glume
lemmas and paleas	
18	length of a sterile flower palea from the spikelet on the middle branching
19	length to the awn node of a sterile flower palea
20	length from the awn node of a sterile flower palea
21	length of a sterile flower lemma
22	length of the awn node of a sterile flower lemma
23	length of lemma
24	length of palea

Table 3. Analysis of variance (ANOVA) of populations of *A. odoratum* and *A. aristatum* for morphological 24 traits. F values given in boldface are statistically important at level p<0.01

Number	F
1	**30.69**
2	**6.72**
3	**28.83**
4	**21.23**
5	**19.82**
6	**17.48**
7	**22.95**
8	**15.00**
9	0.15
10	**18.49**
11	1.17
12	**6.59**
13	1.71
14	**5.64**
15	**11.85**
16	**15.71**
17	**10.37**
18	0.73
19	0.84
20	**4.40**
21	0.12
22	**17.06**
23	**13.39**
24	**17.37**

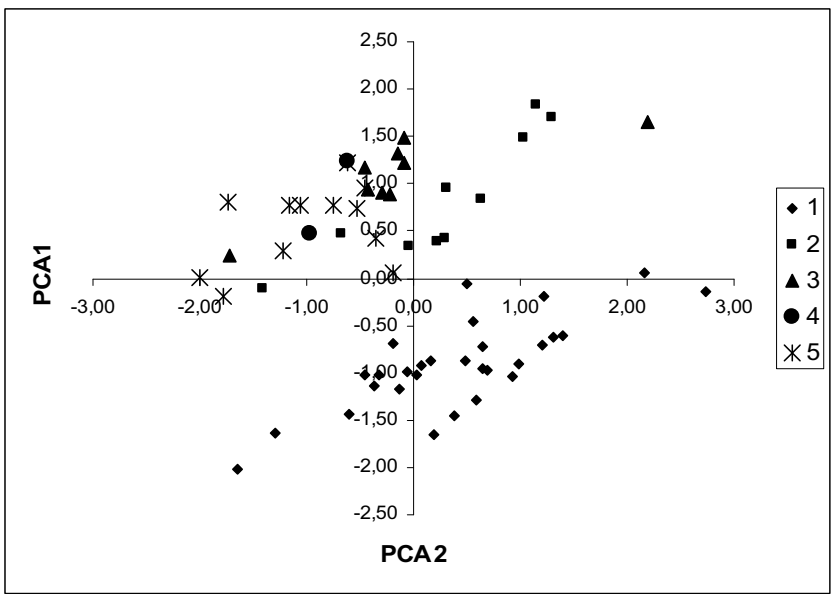

Fig. 1. Principal Component Analysis (PCA) – scatter diagram of specimens from populations of *A. odoratum* (2-5) and *A. aristatum* (1), PCA1=51.33% , PCA2=11.72%

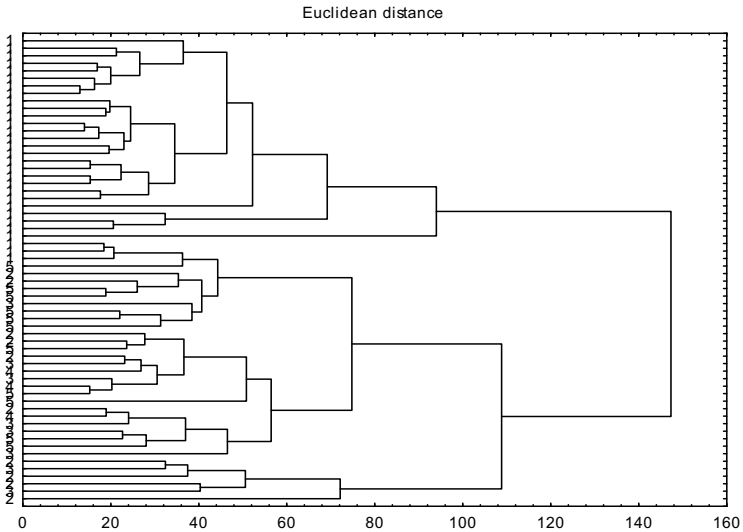

Fig. 2. A dendrogram of the studied populations of *A. odoratum* (2-5) and *A. aristatum* (1) constructed on the basis of the shortest Euclidean distances according to the single linkage method using set of 24 traits