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DIFFERENTIATION OF *EPIPACTIS PALUSTRIS* (L.) CRANTZ (ORCHIDACEAE) IN HABITATS ALTERED BY MAN BASED ON SPECIES POPULATIONS WITHIN POZNAŃ CITY (POLAND)

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Abstract

The aim of the study was to compare two populations of *Epipactis palustris* (Orchidaceae) growing in the valley of Junikowski Stream, in the south-western part of the Poznań city (square of ATPOL BD08) and to compare current results to data on the species described in the literature. Group characteristics of both populations, such as population size, average density and congestion factor, as well as the average coefficient of dispersion, were defined. Specimen variability was determined by measuring 250 generative ramets in each population. The following plant traits were included: stem length, inflorescence length, number of flowers per inflorescence, number of leaves per stem and length and width of the largest leaf. Obtained data were subjected to statistical analyses. Descriptive statistics were calculated (arithmetic average, standard deviation, minimum and maximum). The variation coefficient (V) was established to determine the variation degree of each trait. In order to determine statistical significance of average values of traits of the samples in question, the factor variance ANOVA F-statistics was used. The significance degree was examined with Scheffe's test. Principal component analysis (PCA) enabled the examination of mutual relations between the samples in the system of two first principal components. This work confirmed previous information about low variability of marsh helleborine. Individual traits in both populations were very similar. The differences concerned the group characteristics. The plants were in good condition irrespective of occupied habitat.

Key words: *Epipactis palustris*, Population, Vegetation, Urban agglomeration, Poznań.

Introduction

Epipactis palustris (L.) Crantz (Orchidaceae) is a protected species in Poland (Regulation, 2014), widespread throughout the area of the country (Zając & Zając, 2001). The number of its sites, both in Poland and in other parts of Europe, has been steadily decreasing (e.g., Summerhayes, 1985; Jenkinson, 1995; Hanssen, 1998; Zarzycki & Szeląg, 2006; Timchenko & Kuziarin, 2009; Bilz *et al.*, 2011; Grulich, 2012). In many regions of Poland the degree of the species threat is assessed as very high (Żukowski & Jackowiak, 1995; Kowalewska, 1995; Nowak, 2002; Kącki *et al.*, 2003; Jackowiak *et al.*, 2007; Parusel & Urbisz, 2011). Human interference in natural ecosystems, which results in drainage of wetlands and overgrowing of wet meadows, is the main factor endangering the populations of this species (Kowalewska, 1995; Szlachetko, 1995; Nowak, 2002; Piękoś-Mirkowa & Mirek, 2006).

However, recent reports have indicated a certain expansiveness of this species, recorded outside its natural range in North America (Larocque & Nelson, 2007). Besides unfavorable consequences for plants, human impact changes in the natural environment are of importance in the formation and development of new habitats. According to Adamowski (2006) the transformed habitats may be important as bridgeheads for anemochorous species, forming a large number of very light diasporas, spread over long distances. The appearance of the *Epipactis* species in sites not encountered until now indicates that their adaptability in relation to site conditions is greater than was first thought (Jakubowska *et al.*, 2006; Stefaniak *et al.*, 2011). Research on environmental modification of orchid populations exhibiting the ability to colonize anthropogenic habitats will allow one not only to register any changes in the structure and organization of ecological populations of these species, but also to get to know process control mechanisms of apophytism (e.g., Jackowiak, 1990; Faliński, 2000; Zając & Zając, 2000). Only a few works in the field of ecology of marsh helleborine occurring in natural sites (Kamiński & Sarosiek, 1990; Sarosiek *et al.*, 1990; Kolon *et al.*, 1995; Antkowiak & Pankros, 2000; Golis & Bednorz, 2001) and secondary habitats (Mróz & Rudecki, 1995; Tałałaj, 2004; Wyrzykiewicz-Raszewska, 2001; Wyrzykiewicz-Raszewska *et al.*, 2001) have been published so far in Poland. However, there is no comprehensive research on the species entrance on secondary habitats.

The aim of this study was to compare two *E. palustris* populations, growing in the valley of the Junikowski Stream in Poznań city, in terms of specimen and group features and to compare the results with literature data.

Study area and methods: The sites of studied populations of *E. palustris* near Karpetaj and Bączkowski Ponds are among the few of this species in Poznań (western Poland) (Jackowiak, 1993). They are located in the south-western part of the city, in the valley of the Junikowski Stream (Fig. 1), within the former ecological use Kopanina I, formed on the area of closed excavations of loam and clay (Jackowiak, 1995a; Ludwiczak, 1995). Exploitation of ceramic resources was conducted from the end of the 19th century to the 1970s (Kaniecki *et al.*, 1993). The current habitat of the site has undergone far-reaching degradation. The described area had been a site of rare plant species, but most of the natural plant communities were destroyed, and instead bog rush and meadow vegetation were fairly well developed. This place has been used for many years by local residents as a recreational area. Today, the vegetation is here exposed to strong anthropressure, which takes various forms, such as trampling, littering and burning (Jackowiak, 1995b; Kluza *et al.*, 1999).

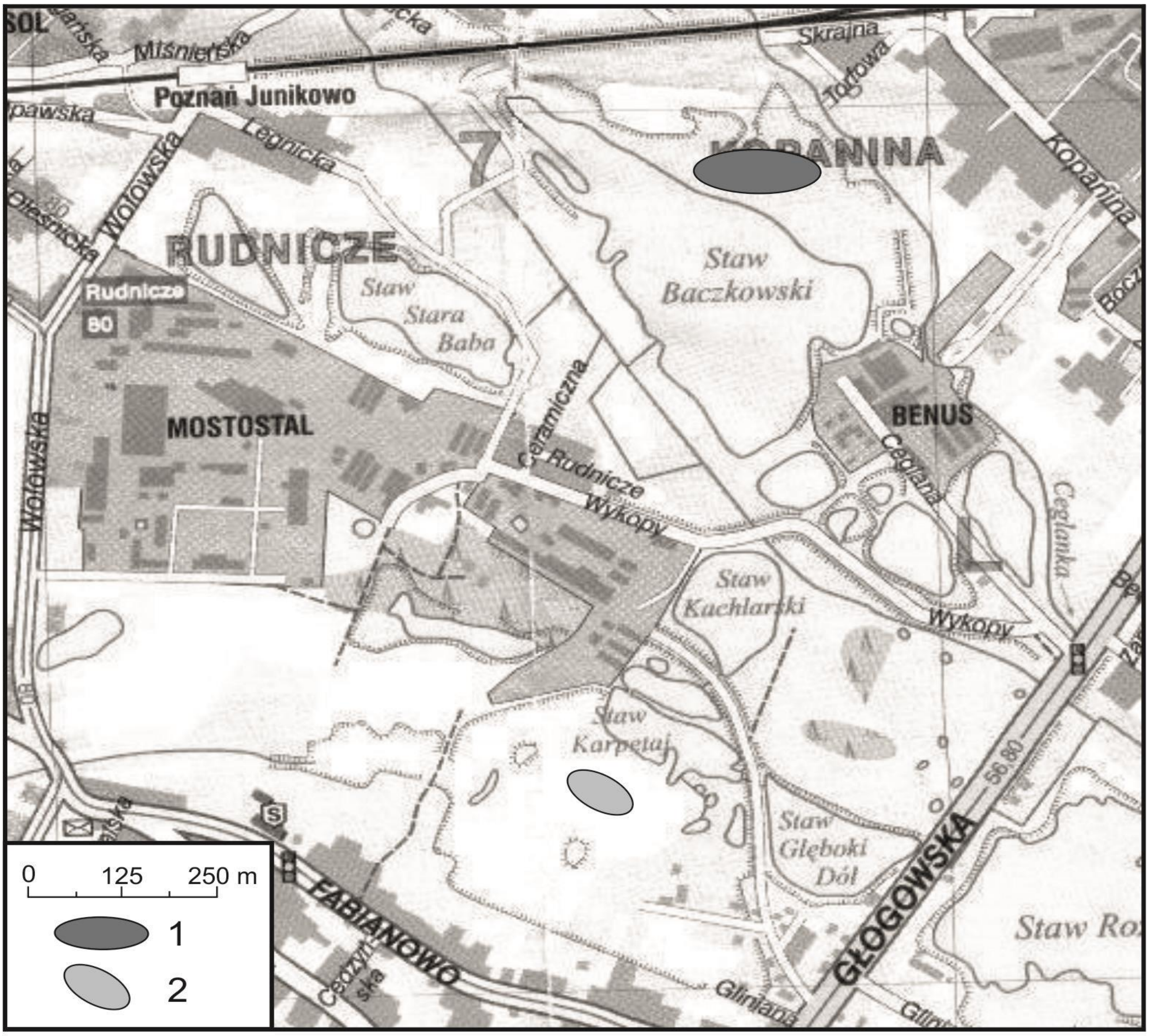

Fig. 1. Location of the studied populations of *E. palustris* within the south-western part of Poznań city (1:18 000; Poznań city plan, 2014). 1 – population associated with Baczkowski Pond, 2 – population associated with Karpetaj Pond

The site of *E. palustris* by the Baczkowski Pond was first described by Jackowiak (1993). Since 2005 it has been monitored three times. The site by the Karpetaj Pond was first documented in 2002 (Wyrzykiewicz-Raszewska, 2006). The research on *E. palustris* populations, involving plant spatial structure, were carried out on the whole area of species distribution, both at the Baczkowski (4400 m^2) and Karpetaj (980 m^2) ponds. The observation area was divided into squares of side 20 m. In each square the accurate number of ramets (orchid stems) was determined. For both sites within a chosen area of 100 m^2 the average density, congestion factor and the coefficient of dispersion were calculated (Collier *et al.*, 1978; Trojan, 1975). In both investigated populations for 250 ramets in the generative phase, the following traits were measured or counted: stem length (1), length of inflorescence (2), number of flowers per raceme (3), number of leaves per ramet (4), length (5) and width of the largest leaf (6). Obtained data allowed statistical analyses to be conducted. Descriptive statistics were calculated (arithmetic average, standard deviation, minimum and maximum). A variation coefficient (V) was established to determine the variation degree of each trait. In order to determine statistical significance of average values of traits of the samples in question, the factor variance ANOVA F-statistics was used. The degree of significance was examined with Scheffe's test. Principal component analysis (PCA) enabled the examination of mutual relations between the samples in the system of two first principal components. The analysis did not assume any groups *a priori*, and clusters of individuals were created on the basis of those traits which contributed most to the existing variation in the species (Morrison, 1990; Sokal & Rohlf, 1997; Triola, 1998; Łomnicki, 2000). The species terminology of vascular plants according to Mirek *et al*. (2002) and of bryophytes according to Ochyra *et al.* (2003) was applied. Terminology of vegetation according to Brzeg & Wojterska (2001) was used.

Relevés (Appendix 1) were made according to Braun-Blanquet (1964), with 7 classes of cover abundance (5 = cover >75%; 4 = 50-75%; 3 = 25-50%; 2 = 5-25%; 1 = numerous or scattered, but cover <5%; + = few, with small cover; and r = rare, solitary, with small cover); *, ** = species characteristic for a given phytosociological unit.

Appendix 1. Occurrence of *E. palustris* in plant community in the investigated area

Relevé 1 –Baczkowski Pond (I. Maciejewska-Rutkowska, 6 July 2012). Density of shrub layer (b) – 20%, cover of herb layer (c) – 95%; relevé area – 400 m^2; number of species – 103. ChCl. *Phragmitetea,* ChAss. *Phragmitetum autralis** et *Glycerietum maximae***: *Phragmites australis** 4.4, *Glyceria maxima*** +, *Equisetum fluviatile* r; ChAll. *Magnocaricion*, ChAss. *Phalaridetum arundinaceae** et *Caricetum acutiformis***: *Phalaris arundinacea** 3.3, *Carex acutiformis*** 2.2; ChCl. *Molinio-Arrhenatheretea* et ChO. *Molinietalia**: *Equisetum palustre** 2.2, *Cirsium palustre** 1.1, *Lathyrus pratensis* 1.1, *Leontodon hispidus* 1.1, *Ranunculus acris* 1.1, *Angelica sylvestris** +, *Poa trivialis* +, *Prunella vulgaris* +, *Rhinanthus serotinus* +, *Trifolium pratense* +, *Vicia cracca* +, *Centaurea jacea* r, *Deschampsia cespitosa** r, *Euphrasia rostkoviana* r, *Galium uliginosum** r, *Poa pratensis* r; ChAll. *Filipendulion* et ChAss. *Lysimachio-Filipenduletum**: *Lysimachia vulgaris** r, *Valeriana officinalis* r; ChAll. *Molinion caeruleae*: *Briza media* 1.1, *Molinia caerulea* +, *Carex flacca* r; ChAll. *Calthion*, DAss. *Epilobio-Juncetum effusi**, Ch. et *D. lok. *Juncetum alpini***: *Juncus effusus* +, *Cirsium oleraceum* r, *Epilobium palustre** r; ChO. *Arrhenatheretalia*: *Lotus corniculatus* 1.2, *Achillea millefolium* +, *Daucus carota* +, *Dactylis glomerata* r, *Taraxacum officinale* r, *Trifolium dubium* r; ChAll. *Arrhenatherion* et ChAss. *Arrhenatheretum**: *Galium mollugo* 2.2, *Geranium pratense* 1.1, *Arrhenatherum elatius** +, *Crepis biennis* r, *Tragopogon pratensis* r; Ch. *Scheuchzerio-Caricetea fuscae*: *Carex nigra* 2.2, *C. stellulata* r, *Juncus articulatus* r; Ch. *Caricion davallianae*: ***Epipactis palustris*** (D. *Molinion*) 2.2, *Carex flava* 1.1, *Dactylorhiza incarnata* r, *Parnassia palustris* r; ChCl./O./All. *Alnetea glutinosae* et ChAss. *Thelypterido-Phragmitetum**: *Salix cinerea* b 2.2, *Lycopus europaeus* r, *Salix aurita* b r, c r, *S. rosmarinifolia* c r, *Solanum dulcamara* r, *Thelypteris palustris** r; ChCl. *Salicetea purpureae* et ChAss. *Populetum albae**: *Populus alba** c r, *Salix purpurea* b +, c r; ChCl. *Artemisietea vulgaris*: *Carduus crispus* r, *Tussilago farfara* r; ChO. *Onopordetalia*: *Melilotus alba* +, *M. officinalis* +, *Cichorium intybus* r; ChO. *Convolvuletalia*: *Calystegia sepium* r; ChSCl. *Galio-Urticetea*: *Rubus caesius* +; ChAss. *Calystegio-Epilobietum hirsute*: *Epilobium hirsutum* +; ChAss. *Calystegio-Eupatorietum*: *Eupatorium cannabinum* 2.2; ChAll. *Sambuco-Salicion* et DAll. *Sambuco-Salicion**: *Betula pendula** a +, b +, *Populus tremula** c r, *Salix caprea* c r; DAll. *Epilobion angustifolii*: *Holcus mollis* +; ChCl. *Rhamno-Prunetea* et ChAll. *Pruno-Rubion fruticosi**: *Cornus sanguinea* c r, *Crataegus monogyna* b r, c r, *Rhamnus catharticus* c r, *Rosa canina* c r, *Viburnum opulus** c r; ChCl. *Festuco-Brometea* et ChO *Festucetalia valesiacae**: *Ononis spinosa* 1.1, *Euphorbia cyparissias* +, *Asparagus officinalis** r, *Carex caryophyllea* r, *Eryngium campestre** r, *Plantago media* r; Associate species: *Agrostis capillaris* 1.1, *Berula erecta* 1.1, *Erigeron acer* +, *Hypericum maculatum* +, *Mentha aquatica* +, *Potentilla reptans* +, *Ranunculus repens* +, *Agrimonia eupatoria* r, *Allium scorodoprasum* r, *Arenaria serpyllifolia* r, *Campanula rapunculus* r, *Coronilla varia* r, *Festuca ovina* r, *Hieracium pilosella* r, *Hypericum perforatum* r, *Juglans regia* c* r, *Juncus macer* r, *Melandrium rubrum* r, *Polygala vulgaris* r, *Potentilla anserina* r, *Scabiosa canscens* r, *Sonchus oleraceus* r, *Trifolium repens* r, *Veronica chamaedrys* r.

Relevé 2 – Karpetaj Pond (M. Wyrzykiewicz-Raszewska, 13 July 2012). Cover of herb layer (c) – 90%, moss layer (d) – 50%; relevé area – 100 m^2; number of species – 48. ChCl. *Phragmitetea*, ChAss. *Phragmitetum autralis** et *Glycerietum maximae***: *Phragmites australis** 1.1; ChCl. *Molinio-Arrhenatheretea* et ChO. *Molinietalia**: *Equisetum palustre** 2.1, *Ranunculus acris* 2.1, *Festuca rubra* 1.2, *Carex spicata* +.2, *Deschampsia cespitosa** +.2, *Poa pratensis* +.2, *Holcus lanatus* +.2, *Juncus inflexus* +.2, *Avenula pubescens* +, *Carex hirta* +, *Centaurea jacea* +, *Climacium dendroides** +, *Juncus compressus* +, *Leontodon hispidus* +, *Poa trivialis* +, *Trifolium pratense* +, *Prunella vulgaris* r; ChAll. *Molinion caeruleae*: *Carex flacca* 1.2, *Festuca arundinacea* +.2, *Briza media* (+); ChAll. *Calthion*, DAss. *Epilobio-Juncetum effusi**, Ch. et *D. lok. *Juncetum alpini***: **Blysmus compressus* (MA) 2.2, *Equisetum variegatum*** +.2, *Juncus alpinus*** +.2; ChO. *Arrhenatheretalia*: *Achillea millefolium* +, *Dactylis glomerata* +; Ch. *Scheuchzerio-Caricetea fuscae*: *Carex nigra* 2.2, *C. panicea* 2.1, *Drepanocladus aduncus* +.2, *Juncus articulatus* +.2; Ch. *Caricion davallianae*: *Campylium stellatum* 2.2, *Drepanocladus intermedius* 1.2, ***Epipactis palustris*** (D. *Molinion*) 2.1, *Dactylorhiza incarnata* 1.1, *Carex hostiana* +.2, *Parnassia palustris* +; ChCl. *Artemisietea vulgaris*: *Tussilago farfara* 1.2, *Cirsium arvense* +; ChCl. *Festuco-Brometea* et ChO *Festucetalia valesiacae**: *Ononis spinosa* +.2, *Plantago media* *, *Poa angustifolia* var. *strigosa* 1.2, *Medicago falcata* +; Associate species: *Caliergonella cuspidata* 3.4, *Brachythecium rutabulum* +.2, *Carex gracilis* +, *Plagiomnium elatum* +, *Calamagrostis epigejos* r, *Typha angustifolia* r.

Results

Analysis of the plant community: *E. palustris* by the Baczkowski Pond grows in the complex of sallow scrub, rushes and wet meadows (Appendix 1, Relevé 1). The orchid species by Karpetaj Pond is a part of calciphilous swamp, classified as *Juncetum alpini* Philippi 1960 association. This plant community represents a degenerative form including meadow, xerothermic and ruderal species (Appendix 1, Relevé 2). A relatively large share of species of transitional peat bog (*Scheuchzerio-Caricetea fuscae*) is remarkable. It proves the presence of continuous springs in the ground. Two characteristic species of this plant community – *Equisetum variegatum* Schleicher and *Juncus alpinus* Vill – are endangered with extinction in the Wielkopolska region (Jackowiak *et al*., 2007), with only sites within Poznań (Jackowiak, 1993). Similarly, *Scheuchzerio-Caricetea fuscae* is a very rare plant community, threatened with extinction, with the only site in Wielkopolska region (Brzeg & Wojterska, 2001).

Population characteristics: In 2012, the population of *E. palustris* by the Baczkowski Pond numbered more than 4700, and by the Karpetaj Pond nearly 700 stems. In both observed populations 82% of stems flowered and formed fruit (Table 1). Average densities of ramets at both sites were quite similar; however, significantly higher maximum and minimum numbers of stems per 1 m^2 were reported in the orchids by Baczkowski Pond. At the same time this population was characterized by much higher values of the obtained dispersion coefficient and congestion factor (Table 1). It was a consequence of orchid arrangement, as the ramets were scattered but always in numerous groups. In turn, this character of ramet distribution was mainly evidenced by the biology of *E. palustre*.

Mean values of stem length were greater in the population by the Karpetaj Pond. The number of flowers was similar in both populations. The values of other analyzed traits were larger in the population by the Baczkowski Pond (Fig. 2). In the examined populations, the stem length (1) was characterized by the smallest variation, while the inflorescence length (2), number of flowers (3) and leaves (4) and length of the largest leaf (5) were little differentiated; the leaf width (6) was moderately differentiated (Fig. 2). One-way analysis of variance (ANOVA) expressed by F-values ranging from 0.02 to 0.99 showed that the mean values of all traits did not statistically distinguished the investigated populations. Principle component analysis was based on all six studied morphological traits. PCA1 and PCA2 jointly explained 38.26% of observed variation. PCA1 was more strongly correlated with 1, 2, 3, 6 (Fig. 3).

The PCA diagram (Fig. 3) shows great differentiation of ramets within the population by Baczkowski Pond with negative and positive values both for PCA1 and PCA2. The population by Karpetaj Pond was less diverse and the ramets mainly concentrated in the middle part of the diagram (Fig. 3).

Table 1. Group characteristics (1-5) and specimen traits of flowering plants (6.1-6.6) in two *E. palustris* populations in the south-western part of the Poznań city.

	Baczkowski pond					Karpetaj pond				
1. No. of individuals (generative/ vegetative)	4759 (3887/872)					693 (572/121)				
2. Density (no. of individuals/m^2)	Avg		Min		Max	Avg		Min		Max
	2.40		1		59	2.55		1		12
3. Coefficient of dispersion			31.40					3.16		
4. Congestion factor			34.60					6.20		
5. Type of spatial distribution			aggregate					aggregate		
6. Trait	Avg	Min	Max	SD	VC	Avg	Min	Max	SD	VC
6.1. Length of stem (cm)	57.00	35.00	71.00	8.80	15.44	57.32	32.00	70.00	8.73	15.23
6.2. Length of inflorescence (cm)	23.57	17.00	31.00	4.27	18.12	23.35	15.00	30.00	4.04	17.30
6.3. Number of flowers	21.60	15.00	26.00	3.32	15.37	21.56	13.00	27.00	3.44	15.96
6.4. Number of leaves	7.67	5.00	9.00	1.20	15.65	7.50	5.00	9.00	1.28	17.07
6.5. Length of the largest leaf (cm)	9.99	7.50	15.00	1.77	17.72	9.91	6.00	15.00	1.82	18.37
6.6. Width of the largest leaf (cm)	3.95	3.00	6.00	0.83	21.01	3.88	3.00	5.50	0.79	20.36

Discussion

In recent years there have been many reports about the disappearance of *E. palustris* sites as well as about the population decrease of this species (Pokorny, 2008; Oklejewicz *et al.*, 2008; Wolanin & Oklejewicz, 2011). According to historical data in Poznań, from the second half of the 19th century until the twentieth of the 20th century *E. palustris* was noted in 11 locations. After 1980, it was found only in seven sites (Jackowiak, 1995a). At the turn of the century, within the urban area, two new sites were found: one at the administrative border of Poznań city near Koziegłowy village (Wyrzykiewicz-Raszewska, 2001) and the second at the north-eastern outskirts of the former ecological site Kopanina I (Maciejewska-Rutkowska *et al.*, 2008).

E. palustris is considered to be a not very variable species (Meusel *et al*., 1965; Szlachetko & Skakuj, 1997) and poorly resistant to anthropopressure. Although much less than other orchid species, it may appear in habitats, formed as a consequence of human activity. Its presence was noted in mining areas (Kołodziejek, 1998; Woźniak & Kompała, 1998), in areas of sedimentation tanks and solid waste dumps (Kozik & Nabożny, 2000), in a quarry (Mróz & Rudecki, 1995), in excavations after the exploitation of sand and gravel (Tałałaj, 2004; Czylok, 1997; Młynkowiak & Kutyna, 1999), clay (Berdowski & Spałek, 1997), chalk (Wells, 1981) and on railway embankments (Wyrzykiewicz-Raszewska *et al.*, 2001; Procházka & Velísek, 1983). The biometric studies on *E. palustris* conducted so far in Poland have shown that ramets in sites considered to be natural were on average about 9.5 cm higher than in the anthropogenically transformed sites (compare Kolon *et al.*, 1995; Antkowiak & Pankros, 2000; Golis & Bednorz, 2001; Mróz &

Rudecki, 1995; Wyrzykiewicz-Raszewska, 2001, 2002; Kamiński & Sarosiek, 1990). The longest stems of this species were observed in Wielkopolski National Park (– the natural site) (Antkowiak & Pankros, 2000), and the shortest in the quarry "Odra" (– the anthropogenic site) (Mróz & Rudecki, 1995), while the differences in the average stem length between these two populations were almost 50%. Similarly, the leaves of the orchid specimens in the natural sites were larger, but the differences in the leaf size were not significant as in the case of ramet length (on average the leaves in natural sites were longer and wider by about 0.5 cm). The average number of leaves per stem was similar (6 to 7), irrespectively of site origin. Like the stems, the inflorescences in natural sites were on average visibly longer (about 4 cm) than in ramets in the transformed sites. Despite the distinct difference in the inflorescence length, there was no difference in the average number of flowers per inflorescence (about 11). In both populations in natural sites as well as in sites of anthropogenic origin, the most variable features were the length of inflorescence and the number of flowers per inflorescence (usually with coefficients of variation in the range 30-38). Number of leaves (with coefficient of variation 11-17%) proved to be the least variable trait for both types of *E. palustris* habitats. In general, the investigated traits of ramets in both types of sites, only except for the length of the largest leaf in natural sites, were characterized by similar values of coefficient of variation. In the current biometric study on marsh helleborine no significant differences were found between two species populations of different origin – anthropogenic and natural. This phenomenon may be due to the lack of intensive human interference in both types of sites in the past 50 years.

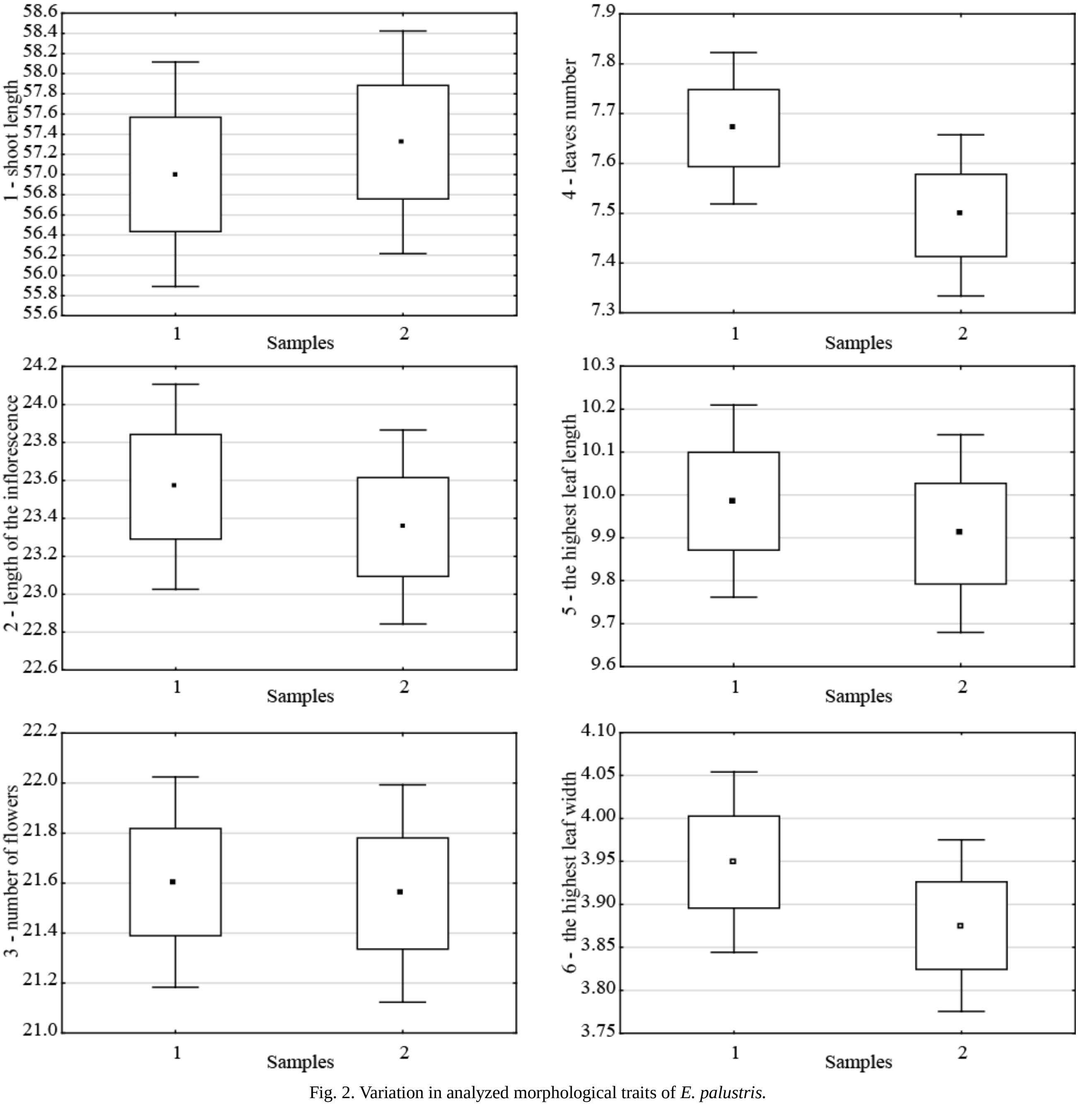

Fig. 2. Variation in analyzed morphological traits of *E. palustris*.
– Mean, – Mean ± St. Dev., – Mean ± 1.96 St. Dev.

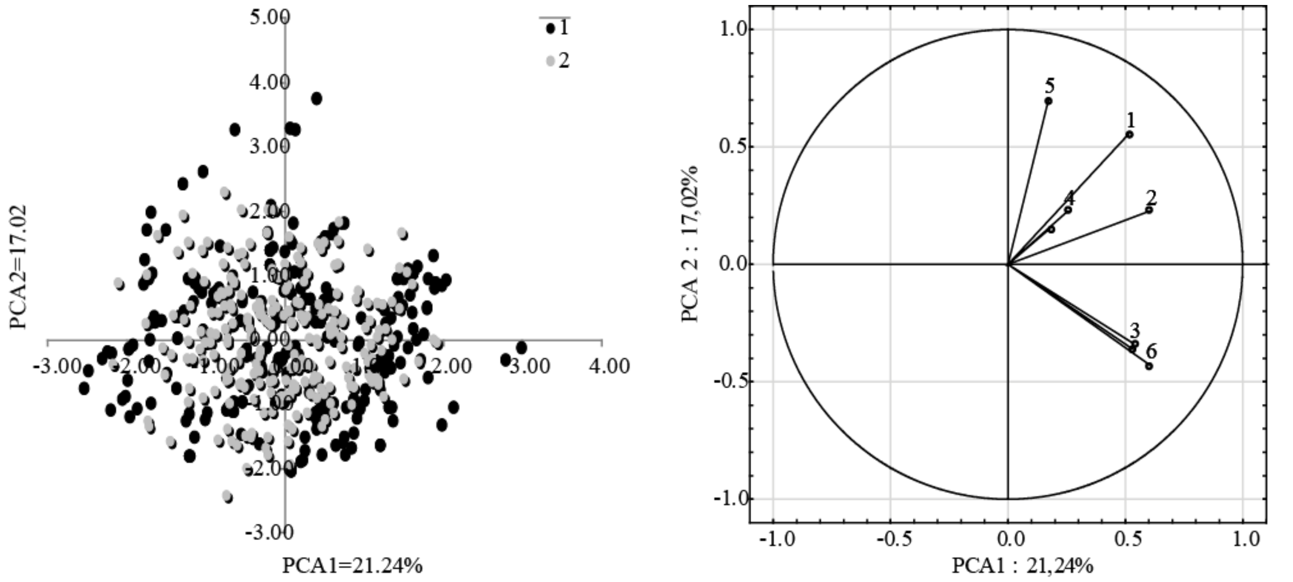

Fig. 3. Graphic picture of the principal component analysis based on 6 morphological traits for *E. palustris* populations and correlations between morphological characters (1-6) and the first two principal components (PCA1 and PCA2). 1 – Baczkowski pond, 2 – Karpetaj pond.

With previously investigated sites of this species, the population in the northern part of Poznań city near Koziegłowy village, growing in the site of anthropogenic origin, was the largest (including even more than several thousands ramets) (Wyrzykiewicz-Raszewska, 2001). A relatively large population on the natural site, although the ramet number did not exceed 4000, was described by Antkowiak and Pankros (2000). In the current study the population from the Baczkowski pond (within the site of anthropogenic origin) consisted of more than 1000 ramets compared to the above-mentioned, natural population. Based on literature data no more than 18% of ramets flowered in *E. palustris* populations in natural sites, and up to 44% of ramets had flowers in populations in sites of anthropogenic origin. However, in the current study more than 80% of ramets were in the generative stage, irrespectively of population origin. Previous studies have shown that average density in natural sites ranged from 4 to 11 stems per 1 m^2, and in the anthropogenic sites it was in the range 25-77. Comparing these data with the current results, smaller density of orchid stems in both investigated populations was noted, although similar trends had been observed. The density in the anthropogenic site was distinctly higher (average density = 24) than in the natural site (=2.6). Comparing the values of the coefficient of dispersion cited in the literature for the *E. palustris*, no relations between its value and site type could be noted. Its values ranged from 2 to 52, and the same range of this coefficient was proved in the current study. In turn, based on the literature the congestion factor was significantly larger in populations within transformed sites than of natural origin. This phenomenon was also confirmed in the presented investigation.

Anthropogenically transformed habitats provide for many native species the possibility to take over new biotopes, sometimes with living conditions significantly different from their natural environment. In many cases it comes to the expansion of native plants to this habitat type (according to Jackowiak ecological expansion) (Jackowiak, 1999). On the one hand, it promotes the disclosure of multiple plant adaptations to new conditions, and on the other hand it may prevent the penetration of these sites by anthropophytes. Knowledge of the regularities governing the penetration of native species on the transformed habitats may reduce the negative consequences of human impact on the vegetation and allow for its partial renaturalization.

Conclusions

1. The values of individual characteristics of both studied populations were very similar to each other.
2. Group features – values of congestion factor and coefficient of dispersion distinctly differentiate two analyzed populations.
3. Despite the habitat changes, the condition of orchids in both sites within Kopanina is not fundamentally different from those of other populations, both from natural and anthropogenic habitats.

Acknowledgements

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