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ANTHEMIS TINCTORIA L. (ASTERACEAE) IN THE ZIELONKA FOREST (THE WIELKOPOLSKA REGION, POLAND)

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ABSTRACT. The study presents results of investigations on morphological variation of *Anthemis tinctoria* from the most abundant site in the Wielkopolska region. The analysis included morphological characters of shoots, flowers and fruits. As a result of the study among other things new numerical data were recorded of characters previously not included in Floras or botanical keys. The analysed phytocenoses with *Anthemis tinctoria* represent the dynamic-succession stage of overgrowing perennial fallows. They reflect the mosaic character of overgrown sites, manifested in the occurrence of species from numerous syntaxonomic groups.

Key words: *Anthemis*, morphology, variation, Wielkopolska

Introduction

Genus *Anthemis* L. includes annual and/or perennial plants.

This genus is comprised of over 100 species, found primarily in the Mediterranean region in Asia Minor, in the western part of Central Asia and in the Caucasus.

Anthemis tinctoria is a perennial plant with lignified rhizomes, 30-60 cm high, grey-green, subtomentose. The stem is furrowed, usually strongly branched and leaved high towards the top. Leaves are egg-shaped in the outline or elongate sessile, pinnatisect. Anthodia vary in number from 2 to 15 (mean 5.12), single on top of pedunculate branches. Perianths are cupuliferous, with scales arranged in 2-3 rows.

Floral receptacles are semicircular; disk scales ± the length of tubular flowers, membranous, in the upper part frequently irregularly toothed. Numerous ligulate flowers (on average 29.14) mm with mean length of 13.18 mm and width of 3.40 mm, in 1-2 rows, usually bright yellow. Tubular flowers 3.0-5.4 mm long ♀♂ yellow, 0.35-0.80 mm wide.

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Achene 1.6-2.2 × 0.4-1.0 × 0.5-0.7 mm, light brown, shiny, delicately transverse sulcate, narrowing downwards, with distinct sharp lateral and rounded underside and upper edges, flat on top. *A. tinctoria* is a synantropic spontaneophyte with a relatively narrow ecological range. It tolerates full light, inhabits dry, moderately poor alkaline soils. It is a neutral species in terms of continentalism (**Zarzycki** et **al.** 2002).

Yellow chamomile L. is found almost everywhere in Europe and western Asia, and it was brought to North America. In Poland it is quite frequently found in the lowlands, whereas it is rare in the mountains and there it is recorded only in lower locations: the Gubałowskie Heights up to 1000 m a.s.l., the Pieniny Mountains up to 700 m a.s.l., the Sądecczyzna region up to 840 m a.s.l. (**Pancer-Kotejowa** 1971). It grows in xerothermic swards, dry roadsides, gravel pits and very rarely in fields. In the last decades old habitats have been observed to disappear and new ones have started to appear instead (**Zarzycki** et **al.** 2002). In the Wielkopolska region it is not found very frequently (**Jackowiak** 1990, **Chmiel** 1993, **Celka** 1999, **Czarna** 2004).

Three varieties are distinguished within *Anthemis tinctoria*: var. *tinctoria* – bright yellow ligulate flowers; var. *discoidea* (Willd.) Beck. – no ligulate flowers, this variety is rather rare in Poland; var. *pallida* DC. – light yellow or whitish ligulate flowers, a variety reported throughout the whole range, although not found in Poland (**Pancer-Kotejowa** 1971).

The number of chromosomes is 2n = 18 (**Harling** 1950, **Löve** and **Löve** 1956, **Koul** 1964, **Skalińska** 1971).

A. tinctoria is used in gardening as an ornamental plant for flower beds (**Brickell** 1993). One variety, var. *discoidea*, may be used for dry bouquets, whereas the other varieties need to have ligulate flowers removed first.

The aim of the study was to investigate variation in selected characteristics of the stem, inflorescences, flowers and fruits and to determine the range of variation in the analysed characteristics, as well as characterize the floristic composition of phytocenoses with the dominant *A. tinctoria* in the Zielonka Forest. Up to the present no studies have been conducted on the morphological variation in *A. tinctoria*.

Material and methods

Experimental material was collected from a numerous population covering the area of 8 ha in the Zielonka Experimental station of the August Cieszkowski Agricultural University of Poznań in division 40 in the years 2004-2005 (Fig. 1). At present the area of 4.0 ha is a private property.

A sample composed of 100 specimens was analysed in terms of 11 quantitative characters: stem height (1), the number of anthodia (2), anthodium diameter along with ligulate flowers (3), anthodium diameter of tubular flowers (4), the number of ligulate flowers (5), the length of ligulate flowers (6), the width of ligulate flowers (7), the length of tubular flowers (8), the width of tubular flowers (9), the length of achene (10), achene width at ½ its length (11).

Characters of tubular flowers and fruits were measured under a Brinell microscope accurate to 0.05 mm. Observations of achene sculpture were conducted under a scanning electron microscope (SEM) at the Laboratory of Electron Microscopy of the Adam Mickiewicz University of Poznań.

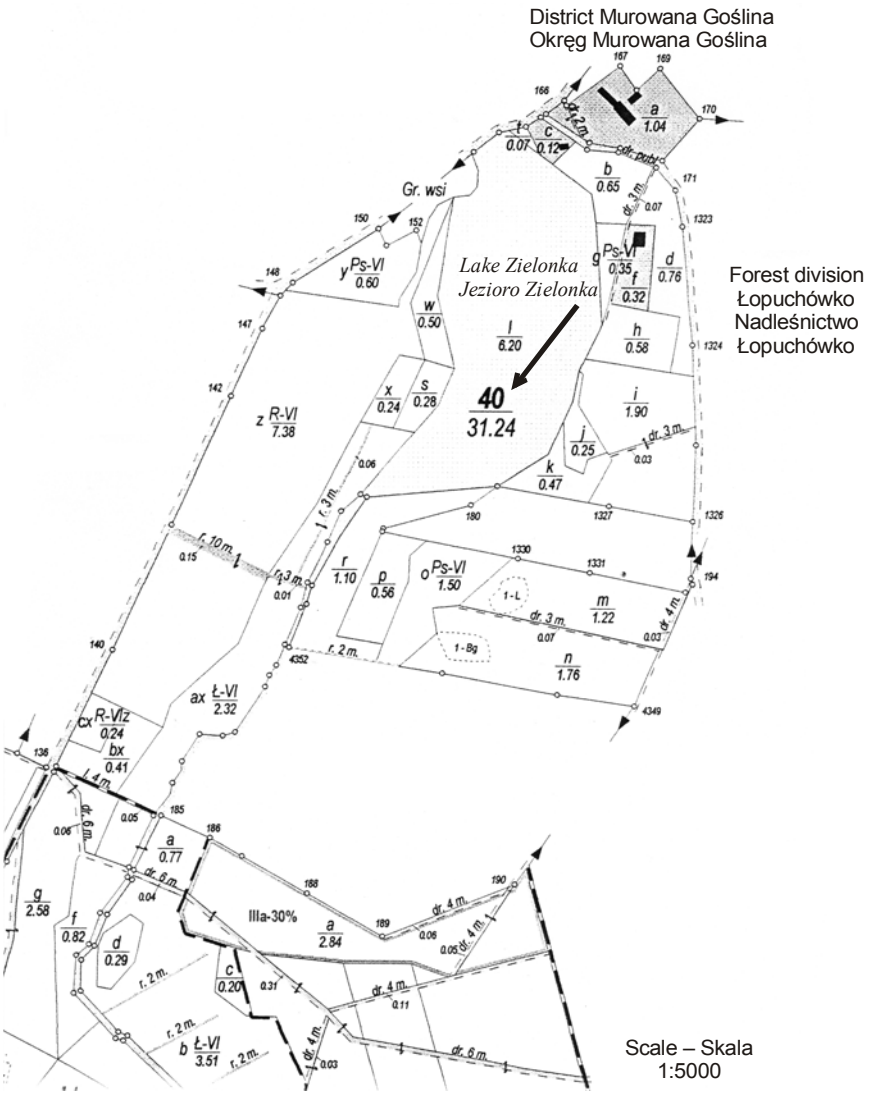


Fig. 1. Location of the site of the study
Ryc. 1. Lokalizacja terenu badań

Biometric data were analysed statistically (Table 1) by calculating the arithmetic mean, standard deviations and the coefficient of variation (**Bogucki** 1979) and Pearson's character correlations (**Sobczyk** 1999). Clustering was performed using an alternative nearest neighbour method on Euclidean distances, for which the graphic representation is a dendrogram. The Statistica 6 software package (Statistica... 2002) was used in the calculations. For the purpose of clarity the dendrogram presents the results of clustering for 50 specimens.

Table 1

Arithmetic means, standard deviations and coefficients of variation for analysed characters (1-11) of *Anthemis tinctoria*
Średnie arytmetyczne, odchylenie standardowe, współczynnik zmienności badanych cech (1-11) *Anthemis tinctoria*

	1	2	3	4	5	6	7	8	9	10	11
X	42.73	5.12	33.6	14.40	29.14	13.18	3.40	4.41	0.52	1.85	0.60
SD	65.71	2.25	3.06	1.77	4.09	1.56	0.49	0.60	0.10	7.78	0.12
V	15.38	43.88	9.09	12.31	14.04	11.84	14.56	13.71	18.82	7.78	20.27

For the area where vast patches of *Anthemis tinctoria* are found in the Zielonka Forest phytosociological documentation was prepared according to the conventional Braun-Blanquet method (**Braun-Blanquet** 1951, **Dierschke** 1994). The primary criterion for the selection of the analysed areas was a high participation of *Anthemis tinctoria*. While assessing the ground cover of species a modified quantitative scale by **Barkman** et **al.** (1964) was applied. Altogether six phytosociological pictures were taken and they were compared in an analytical table (Table 2). The formulation of plant communities and the assignment of species to taxa were adopted after **Brzeg** and **Wojterska** (2001).

Table 2

Differentiation of phytocenoses with *Anthemis tinctoria* from the Zielonka Forest
Zróżnicowanie fitocenoz z *Anthemis tinctoria* z Puszczy Zielonka

Succesive number Numer kolejny zdjęcia	1	2	3	4	5	6	Constancy – Stałość	Cover coefficient – Współczynnik pokrycia
Number of relevé in the field Numer zdjęcia w terenie	4	3	6	2	5	1		
Date – Data	24 06 05	24 06 05	24 06 05	24 06 05	24 06 05	24 06 05		
Cover of herb layer (%) Warstwa zielna (%)	85	85	70	80	80	70		
Cover of moss layer (%) Warstwa mszysta (%)	5	10	25	30	35	50		
Area of relevé (m^2) Powierzchnia zdjęcia (m^2)	35	20	40	15	25	25		
Number of species Liczba gatunków w zdjęciu	36	29	25	34	34	41		
ChCl. ***Festuco-Brometea***								
Anthemis tinctoria	3.4	4.4	4.4	2a.2	3.4	3.2	V	4 125
Arenaria serpyllifolia	+	+	+	+	+	2a.1	V	208

Table 2 – cont.

Succesive number Numer kolejny zdjęcia	1	2	3	4	5	6		
Acinos arvensis	r	.	.	+.2	.	r	III	12
Euphorbia cyparissias	.	.	r	.	.	r	II	3
Artemisia campestris subsp. *campestris*	.	.	.	.	.	2b.2	I	333
Barbula unguiculata	.	.	.	.	.	r	I	2
Festuca trachyphylla	.	.	.	.	r	+	II	10
Verbascum lychnitis	.	.	.	.	r	.	I	2
ChCl. ***Artemisietea vulgaris*** (incl. ***Onopordetalia****)								
* *Picris hieracioides*	4.5	3.4	3.4	+	1.1	1.1	V	2 467
* *Convolvulus arvensis*	.	+.2	.	.	+	.	II	17
* *Cynoglossum officinale*	.	r	.	.	.	.	I	2
Galium aparine	+	r	.	.	.	.	II	10
Artemisia vulgaris	r	.	+	.	.	.	II	10
* *Melandrium album*	.	.	r	.	.	.	I	2
Torilis japonica	r	.	.	.	.	.	I	2
* *Daucus carota*	r	.	.	.	.	.	I	2
Agropyron repens	+	+	.	3.4	1.1	+	V	733
* *Medicago lupulina*	+	.	+	.	.	1.2	III	100
* *Cirsium vulgare*	.	r	.	r	.	.	II	3
Erigeron annuus	.	.	.	.	.	+	I	8
ChCl. ***Koelerio-Corynephoretea***								
Brachythecium albicans	.	1.1	2a.2	2a.2	2a.2	3.2	V	1 208
Helichrysum arenarium	+	.	+	1.1	+	+.2	V	117
Ceratodon purpureus	1.2	+	.	1.2	.	2.2	IV	467
Cerastium semidecandrum	.	.	+	1.1	+	2a.1	IV	267
Trifolium arvense	+	.	1.1	+	.	+	IV	108
Potentilla argentea	.	.	r	r	2a.2	+	IV	178
Senecio vernalis	.	.	1.1	+	r	1.1	IV	177
Rumex acetosella	r	r	.	.	+	r	IV	13
Centaurea stoebe	.	.	.	2.1	+	1.1	III	383
Jasione montana	.	.	.	1.1	1.1	1.1	III	250
Sedum acre	.	.	.	.	1.3	.	I	83
Veronica dillenii	.	.	.	.	1.2	.	I	83
Senecio vernalis	.	2a.2	.	.	.	.	I	167

Table 2 – cont.

Succesive number Numer kolejny zdjęcia	1	2	3	4	5	6		
Trifolium campestre	.	.	.	r	.	.	I	2
Hypochoeris radicata	.	.	.	r	.	.	I	2
ChCl. ***Molinio-Arrhenatheretea***								
Tragopogon pratensis	r	r	r	+	r	.	V	15
Galium mollugo	r	r	r	.	+	.	IV	13
Achillea millefolium	+	.	.	r	.	+	III	18
Poa pratensis	+	.	.	.	+.2	r	III	18
Arrhenatherum elatius	.	+	.	.	+	.	II	17
Cerastium holosteoides	+	.	.	.	.	+	II	17
Bromus hordeaceus	.	.	.	.	+	r	II	10
Avenula pubescens	.	.	.	.	r	r	II	3
Taraxacum officinale	.	.	.	r	.	r	II	3
Anthoxanthum odoratum	.	r	.	.	.	.	I	2
Dactylis glomerata	r	.	.	.	.	.	I	2
Bromus hordeaceus	.	.	.	+	.	.	I	8
Plantago lanceolata	.	.	.	.	.	r	I	2
ChCl. ***Stellarietea mediae***								
Viola arvensis	+	+	1.1	+	+	.	V	117
Veronica arvensis	+	.	r	+	.	1.1	IV	102
Vicia angustifolia	+	+	.	+	.	+	IV	33
Conyza canadensis	+	.	.	r	r	r	IV	13
Vicia hirsuta	+	r	.	1.2	.	.	III	93
Centaurea cyanus	+	r	.	.	r	.	III	12
Bromus tectorum	.	.	.	r	r	+	III	12
Papaver rhoeas	r	r	.	.	.	r	III	5
Lactuca serriola	r	r	.	.	.	.	II	3
Arabidopsis thaliana	+	.	o	.	.	.	II	8
Erodium cicutarium	r	.	.	r	.	.	II	3
Matricaria maritima subsp. *inodora*	+	.	.	.	.	.	I	8
Vicia tetrasperma	r	.	.	.	.	.	I	2
Anchusa arvensis	.	r	.	.	.	.	I	2
Thlaspi arvense	.	r	.	.	.	.	I	2
Myosotis arvensis	.	r	.	.	.	.	I	2

Table 2 – cont.

Succesive number Numer kolejny zdjęcia	1	2	3	4	5	6		
Others – Inne								
Brachythecium rutabulum	.	2a.2	2a.2	2a.2	2.2	1.1	V	875
Petrorhagia prolifera	+	2a.1	2.1	+	+	2b.1	V	817
Hieracium pilosella	.	.	.	.	1.2	+.2	II	92
Senecio jacobaea	.	r	1.2	.	.	.	II	85
Sciuro-hypnum oedipodium	.	.	.	1.2	.	.	I	83
Cladonia chlorophaea	.	r	.	+	.	r	III	12
Hypericum perforatum	.	.	+	.	+	.	II	17
Pseudoscleropodium purum	.	.	+	.	r	.	II	10
Padus serotina	+	.	.	r	.	.	II	10
Myosotis stricta	.	.	o	.	.	.	I	0
Coronilla varia	.	.	r	.	.	.	I	2
Epilobium adnatum	r	.	.	.	.	.	I	2
Fragaria vesca	r	.	.	.	.	.	I	2
Cladonia cornuta	.	.	.	+	.	+	II	17
Agrostis capillaris	.	.	.	.	+	.	I	8
Hypnum jutlandicum	.	.	.	.	+	.	I	2
Barbula convoluta	.	.	.	.	.	+	I	8
Bryum caespiticium	.	.	.	.	.	r	I	2
Rosulabryum capillare	.	.	.	.	.	r	I	2

Results and discussion

Ranges of the analysed characters were determined as a result of biometric analysis. Stem length (1) was from 29 to 57 cm; the number of anthodia (2) ranged from 2 to 15; anthodium diameter with ligulate flowers (3) from 29.0 to 38.0 mm, the diameter of the tubular part of the anthodium (4) ranged from 11.0 to 19.0 mm; the number of ligulate flowers (5) was from 21.0 to 35.0; the length of ligulate flowers (6) was from 10.0 to 17.0 mm; the width of ligulate flowers (7) ranged from 0.3 to 4.0 mm; the length of tubular flowers (8) was from 3.0 to 5.4 mm; the width of tubular flowers (9) ranged from 0.35 to 0.80 mm; achene length (10) was 1.5-2.1 mm, while achene width at 1/2 its length (11) ranged from 0.4 to 1.0 mm.

Mean values of the analysed characters along with standard deviation and coefficients of variation are presented in Table 1.

Only two characters may be classified as exhibiting moderate variation, i.e. having the value of the coefficient of variation below 10%. They are achene length (1) and the diameter of anthodium together with ligulate flowers (3). The mean of the coefficient of variation for character (10) was 7.78%, while for character (3) – 9.09%, respectively.

Most characters exhibited considerable variation: the diameter of the anthodium tubular part (12.31%); tubular flower length (13.71%); the number of ligulate flowers (14.04%); the width of ligulate flowers (14.56%); the length of ligulate flowers (17.58%) and the width of tubular flowers (18.82%). A large variation of 23.43% was found for character (11), i.e. achene width. The most variable was character (2), i.e. the number of anthodia, for which the coefficient of variation was 43.88%.

Based on the calculated correlations it was found that only three Pearson's correlation coefficients are significant at $p < 0.05$; these are the diameter of the tubular part of the inflorescence with the width of tubular flowers (correlation coefficient of 0.39); the length of tubular flower with achene length (0.34) and the length and width of achenes (0.32).

The dendrogram of individual links of Euclidean distances, presented in Figure 2, confirms a considerable variation between individual specimens within the population. High values of distances of Euclidean links are found between specimens and six clusters of specimens were distinguished. The first internally diversified cluster includes 23 specimens (from no. 4 to 41), and the link distance is 10.2. In the second cluster there are two specimens – nos. 13 and 50. The third cluster is divided into two groups and includes ten specimens (from no. 1 to 14), while the Euclidean distance is 12.5.

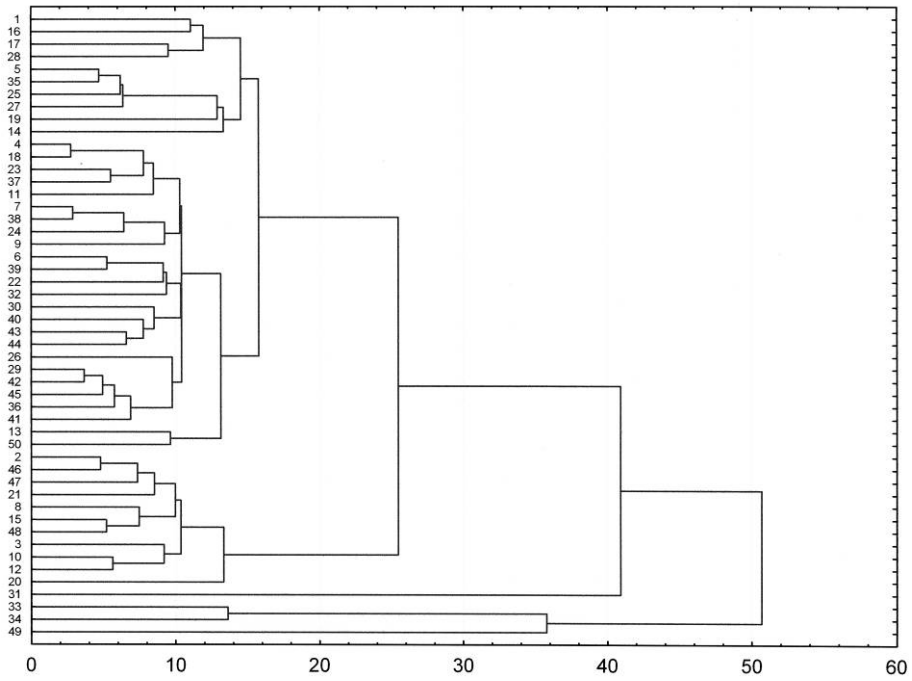
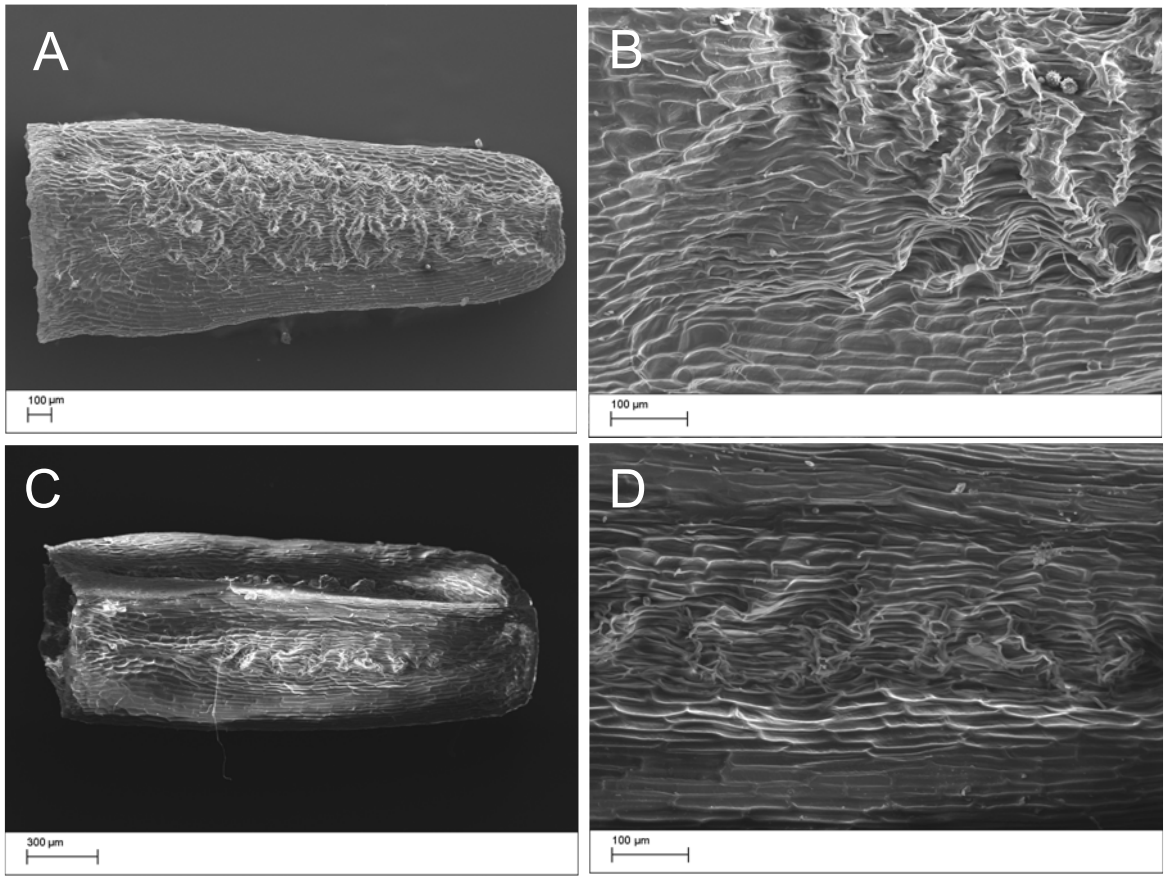


Fig. 2. A dendrogram of Euclidean distances based on 11 characters of *Anthemis tinctoria*
Ryc. 2. Dendrogram odległości euklidesowych na podstawie 11 cech *Anthemis tinctoria*



Phot. 1. SEM, fruit of *Anthemis tinctoria* (A, B – upper surface, C, D – underside surface)
Fot. 1. SEM, owoc *Anthemis tinctoria* (A, B – górna powierzchnia, C, D – dolna powierzchnia)

Phot. 2. A phytocenosis with *Anthemis tinctoria*
Fot. 2. Fitocenoza z *Anthemis tinctoria*
(photo by – fot. M. Czekalski)

The distance of the fourth cluster is 24.8. There are 11 specimens in this cluster. Specimen 20, similarly to specimen no. 31, takes an isolated position in this cluster, with the distance of 40.8. In the sixth cluster there are only three specimens: nos. 33, 34 and 49. The most isolated position is taken by specimen no. 49, which at the distance of 50.8 associates with the other distinguished clusters. The distances of links between three clusters (4-6) are statistically significant.

Achenes are oblong (Phot. 1 A, C), straight or slightly bent, 4-angled and laterally flattened, brown to dark brown, matt, with five slightly protruding ribs on both sides of the fruit. On the basis of SEM observations of fruit surface it was found that the upper surface exocarp (Phot. 1 B) is composed of elongated cells with straight walls on lateral margins and polygonal in outline with undulated walls forming numerous transverse furrows in the central part.

The underside part of the exocarp (Phot. 1 D) is similar to the upper surface part. The only existing difference is less marked furrowing and a more protruding rib. The apex of the achene is surrounded by a straight protruding, membranous crenation (a residual calyx). Previously **Kulpa** (1988) reported that there is a fine network on the surface with eyes markedly curved longitudinally, which looks like a longitudinal crease. The characteristics of the size of shoots, flowers and fruits were based only on arithmetic means for 100 specimens of one population, which is a very small number for the purpose of the presentation of the full variation in the analysed organs.

The investigated phytocenoses from the Zielonka Forest present a dynamic successional stage of overgrowing of perennial fallows (Phot. 2). They reflect the mosaic character of overgrown sites, which is expressed in the presence of species of many syntaxonomic groups. In the plant coverage of the analysed patches a large percentage is found of elements of sand swards of the *Koelerio-Corynephoretea* Klika class in Klika et Novák 1941, especially mosses, i.e. *Brachythecium albicans* and *Ceratodon purpureus*. *Jasione montana*, *Centaurea stoebe* and *Helichrysum arenarium* are representatives of vascular plants. The other group of species represents xerothermic swards (class of *Festuco-Brometea* Br.-Bl. et R. Tx. 1943). *Anthemis tinctoria* belongs to this class, giving the feature of physiognomy of the documented phytocenoses and a much smaller, but constant participation of *Arenaria serpyllifolia*. The fallow thermophilic character of phytocenoses is marked by a high participation of *Picris hieracioides* and *Agropyron repens*. A small coverage was recorded for the presence of a numerous group of annual field or ruderal species (class of *Stellarietea mediae* R. Tx., Lohmeyer et Preising in R. Tx. 1950). *Viola arvensis*, *Veronica arvensis*, *Vicia angustifolia* and *Conyza canadensis* may be mentioned here. An extensive list of species is concluded by meadow plants (class of *Molinio-Arrhenatheretea* R. Tx. 1937 em. 1970), recorded only with a small participation in the coverage of the analysed patches.

Phytosociological pictures listed in Table 2 present two forms of the discussed community with *Anthemis tinctoria*. The first (rél. 1-3) is characterized by a larger participation of *Picris hieracioides* in the plant coverage. A larger participation of thermophilic and fallow species from genus *Onopordetalia acanthii* Br.-Bl. et R. Tx. 1943 em. R. Tx. 1950 is found here along with a smaller participation of species of sand swards. These phytocenoses are markedly similar to *Dauco-Picridetum* (Faber 1933) Görs 1966 and may be identified with them. The other form (rél. 4-6), with *Agropyron repens*, has a distinct feature of sand sward given by species of class *Koelerio-Corynephoretea*. *Anthemis tinctoria* was recorded in smaller quantities in these patches. This form only partly corresponds to swards of the *Helichryso-Jasionetum* type; however, due to the

considerable participation of species from other syntaxonomic groups does not present the form of the above mentioned association.

Conclusion

Studies on the variation of morphological characters of the stem, inflorescences, flowers and fruits of a population of *Anthemis tinctoria* indicate a rather considerable variation of specimens within one population, as it was manifested in the calculated coefficients of variation and clustering of analysed specimens in cluster analysis (in the dendrogram).

Ranges of the analysed diagnostic features confirm literature data published to date (**Pancer-Kotejowa** 1971, **Garcke** 1972, **Szafer** et **al.** 1986, **Rutkowski** 1998).

Due to the small number of sites of *Anthemis tinctoria* in the Wielkopolska region, communities with the participation of this plant are poorly investigated. In the listing of plant units of the Wielkopolska region (**Brzeg** and **Wojterska** 2001) the described species has an optimum of its occurrence in phytocenoses of *Centaureo diffusae-Berteroetum* Oberd. 1957, grouped within the group of thermophilic communities of high perennials – *Onopordetalia acanthii* Br.-Bl. et R. Tx. 1943 em. R. Tx. 1950 (class of *Artemisietea vulgaris* Lohmeyer, Preising et R. Tx. in R. Tx. 1950). In patches of the above mentioned community *Anthemis tinctoria* is recorded only occasionally, both in the Wielkopolska region (**Brzeg** and **Pawlak** 1998), and in other locations in Europe (**Mucina** and **Brandes** 1985). Moreover, *A. tinctoria* is a species characteristic for class *Festuco-Brometea* Br.-Bl. et R. Tx. 1943, grouping the vegetation of xerothermic swards (**Brzeg** and **Wojterska** 2001). In the Konin Brown Coal Basin the analysed species was documented in one patch of the association of *Poo-Anthemetum tinctoriae* Müll. et Görs 1969, formed on the Pątnów-Jóźwin outer waste bank (**Balcerkiewicz** and **Pawlak** 1990). However, documented patches from the Zielonka Forest do not present the form of the *Poo-Anthemetum tinctoriae* association, described in Germany, due to the differing combination of species.

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ANTHEMIS TINCTORIA L. (ASTERACEAE) W PUSZCZY ZIELONCE (WIELKOPOLSKA)

S t r e s z c z e n i e

W pracy przedstawiono wyniki badań nad zmiennością morfologiczną *Anthemis tinctoria* z najliczniejszego stanowiska w Wielkopolsce. W badaniach uwzględniono cechy morfologiczne pędu, kwiatów i owoców. W wyniku badań podano między innymi nowe dane liczbowe cech dotychczas nie uwzględnianych w pracach dotyczących flory roślin i kluczach do oznaczania

roślin. Badane fitocenozy z *A. tinctoria* przedstawiają dynamiczno-sukcesyjne stadium zarastania wieloletnich odłogów. Są one odzwierciedleniem mozaikowatego charakteru porastanych siedlisk, co wyraża się obecnością gatunków wielu grup syntaksonomicznych.

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