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Ecological-biological reasons and sourcesof the invasive propensity of *Anthoxanthum aristatum* Boiss.

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Abstract: Annual Vernal-grass (*Anthoxanthum aristatum,* syn. *A. puelii* Lecoq & Lamotte) belongs to newer elements in the vascular plant flora of Poland, described in geographical-historical classification as kenophytes. Extraordinary abilities to colonize new areas gave it epithet of a "invasive species". In this work the results of the studies on the distribution and different factors which promote the occurrence of that interesting species in great quantities have been summarized.

The results obtained by the author allow to ascertain that the present increase of its range is connected with the simultaneous influence of two main reasons. Apart from natural, ecological preferences and developmental strategies these are circumstances of anthropogenic origin "the overlap" of which made such a spectacular success of Annual Vernal-grass..

Keywords: *Anthoxanthum aristatum*, *Poaceae*, geographical origin, distribution, invasive species, natural and athropogenic causal factors.

Introduction

Anthropogenic changes occurring in the species ranges belong to the important problems of the present phytogeography (Kornaś, Medwecka-Kornaś 1986, Faliński 2000). They were observed in different systematic groups, but the most spectacular cases of increased primary acreage were

noted among *Magnoliophyta* syn. *Angiospermae* (FALIŃSKI 1968, KORNAŚ 1990, SOLARZ W., KRÓL W. 2004). Among numerous species supplied with good documentary evidence for them consciously or unconsciously introduced, of special interest are those which create various dangers. In the flora of Central Europe these are, first of all plants brought relatively not long ago – kenophytes (ZAJĄC et al. 1998).

One of such species which colonized new areas and increased its range was Annual Vernal-grass (*Anthoxanthum aristatum*). An extraordinary ability of *A.aristatum* to occurrence in enormous numbers and its stated geographic expansion caused that researches gave it epithet of a "invasive species" (WARCHOLIŃSKA & SICIŃSKI 1976, 1996; WÓJCIK & DOMAŃSKA 1976, WÓJCIK 1978).

The range of *A.aristatum* belongs to the Atlantic-Mediterranean type (Fig. 3). That dense range includes Sardinia, Corsica, Portugal and N Spain, Central and N France, Holland, Denmark, Central and S Great Britain, N Germany (HEGI 1957, MEUSEL et all. 1965, GARCKE 1972). Moreover according to MEUSEL et al. (1965) from Germany and Poland are known in small numbers synanthropic localities clearly compact near eastern border of its range. Only some of them cross the Odra River (Fig. 3). At the end of the 1960s numerous new localities of Annual Vernal-grass, also the phenomenon of its occurrence in masses, in different regions of Poland was observed (among others MISIEWICZ 1970, SZMEJA 1970, ROLA 1975, WÓJCIK, DOMAŃSKA 1976, ROLA & KUŹNIEWSKI 1979, KUŹNIEWSKI 1995, WARCHOLIŃSKA, SICIŃSKI 1996).

Confirmation and summary of this information we can find in TOKARSKA-GUZIK'S (2001) chorological study printed in the distribution atlas of vascular plants in Poland. This cartogram (Fig. 4) in comparison with the state of the range of *A.aristatum* from the mid-20th century explicitly indicates considerable increase of the range eastward.

The spectacular changes of the *Anthoxanthum aristatum* range are the base for further studies, which aim is to find reasons and sources of its occurrence in great number and of its extraordinary effective geographical expansion.

The work is a result of the description of biological and ecological aspects and mechanisms of that process.

Material and methods

The main sources of information on the distribution of *A. aristatum* are the historical and present literature data. Whereas in the remaining analyses, not published materials either own or rendered by scientists from different research centres in Poland, were used.

The features connected with biology and morphological variability of vegetative and generative organs were defined on the material specially collected for this purpose and coming from the cereal fields of W Poland (Fig. 1).

Variability gradation was evaluated according to the quotient of the extreme values (minimum and maximum) of the particular features. The following

degrees of the variability were accepted: **I** (low): < 1.4; **II** (medium): 1.5 - 2.4; **III** (increased): 2.5 - 3.4; **IV** (high): >3.5 (ŻUKOWSKI et al. 1982).

Phytogeographical and ecological analyses were based on the 471 phytosociological releves made in agrocenoses with the share of Annual Vernal-grass in different points of its "new" range (Fig. 2).

Results

The occurrence of Annual Vernal-grass in masses in the cereal fields of Poland, determined the author to carry out the research in many aspects. First of all the variability of some morphological features within the 18 population from Wielkopolska Region (W Poland) was described. The results based on the examination of 50 individuals from every population shows Table 1. Analized features (the height of shoot, the length of highest leaf, the length of inflorescence, the number of spikelets in inflorescence) indicate quite differentiated variablity within respective populations. Whereas variability within all the populations of every analized feature assumes stage IV. Worth attention is the fact that coming up to the highest stage (IV) in the used variability index corresponds with different real values. Relatively low values achieve the height of shoots (4.3) and the length of inflorescence (3.6), whereas much more variability shows flag leaf (11.2) and number of spikelets in inflorescence (12.1).

The next stage of the studies was to describe the influence of some features on the production of caryopses. Annual Vernal-grass is an annual grass and its respective individuals grow in loose tufts created by intravaginal branches. Because there were observed individuals with differentiated branches, a series of measurements was made in order to explain if and in what way the number of culms influences generative reproduction. The results are shown in Table 2. The data from that experience indicate, that individuals of Annual Vernal-grass branch out on a large scale they can have 2 to 14 generative shoots. At the same time it should be emphasized that in all the populations studied more often individuals with 3 to 5 shoots ca be found. The mean number of spikelets for one shoot ranges from 16.5 (individuals with 11 shoots) to 26.0 (individuals with 3 shoots).

Generally it can be stated, that the size of a branch has inconsiderable influence on the decreasing of a number of spikelets, and therefore on a potential production of caryopses. Because of the small amount of the individuals studied the achieved number indicators should be treated as approximate ones.

Biologial features assisting invasive propensity of Annual Vernal-grass in Poland have been already shown experimentally some time before.

The colonizational character of the occurrence in cereal fields is also connected with the significant vitality of caryopses and the ability to germinate even after 18 years (LATOWSKI 1994). The attachment of Annual Vernal-grass to rye crops has been explained in a simultaneous germination experiment. Annual Vernal-grass germinates very well in the company of rye, but less so

with oats and the poorest results are shown in association with barley. In the repeated many times germination experiment the special attention was paid to the following regularity. After a year of storage the caryopses germinated merely in 20% in the next few years that indicator was much bigger one was stabilized on the level of 60-70%. The experiment in which a sample of caryopses was divided into two parts explained the reasons of the lower ability to germinate at the very beginning. The one part consisted of the coryopses with closely adhering to the them natural cover (lemmas) the other had no lemmas at all. Caryopses with natural glumes germinated ineffectually in comparison to caryopses without glumes (Fig. 5). Thus inhibitive influence of natural lemmas was indicated.

In the former experiments it was proved that *Anthoxanthum aristatum* germinates the best, concomitantly with caryopses of rye. The result indicated allelopathic, and at the some time positive influence of interdepedence.

The occurrence of Annual Vernal-grass in cultivated plants of Poland is a confirmation of the experimental results. Among the 471 analyses with the share of *Anthoxanthum aristatum* almost 90% examples were found in rye cultivations (Fig. 6).

Anthoxanthum aristatum indicates its great connection with soil conditions. Almost ¾ of all analyses with the share of the species discussed, refferred to poor soils, which belonged to the two agricultural complexes: 6 - weak rye complex and 7 - very weak rye complex (Fig. 7).

Conclusions

Many aspects analysis of the occurrence indicates, that *Anthoxanthum aristatum* be came invasive enlarging its range by 600 km eastward in the second half of the XXth century.

The present increase of its range is connected with the simultaneous influence of two main reasons. Apart from natural, ecological preferences and developmental strategies these are circumstances of anthropogenic origin "the overlap" of which made such a spectacular success of *Anthoxanthum aristatum.*

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References

FALIŃSKI J.B. ed. (1968): Synanthropisation of Plant Cover. I. Neophytism and apophytism in the Plant Cover in Poland. – Mater. Zakł. Fitos. Stos. UW 25: 1-229. Warszawa-Białowieża (in Polish).

FALIŃSKI J.B. (2000): The Interpretation of Contemporary Vegetation Transformations on the Basis of the Theories of Synanthropisation and Syndynamics. - In: B. Jackowiak & W. Żukowski (eds.): Mechanisms of Anthropogenic Changes of the Plant Cover. -

Publ. of the Department of Plant Taxonomy of the A.Mickiewicz University, 10: 9-30.- Poznań (in English).

HEGI G. (1957): Illustrierte Flora von Mittel-Europa. – Carl Hanser Verl. 2 Aufl. 1: 278-279. München.

GARCKE A. (1972): Illustrierte Flora. Deutschland und angrezende Gebiete. Gefässkryptogamen und Blütenpflanzen - Verlag P.Parey. 23 Aufl. p.256-257. Berlin - Hamburg.

KORNAŚ J., MEDWECKA-KORNAŚ A. 1986. Phytogeography. - PWN Warszawa 527pp. (in Polish).

KORNAŚ J. (1990): Plant Invasions in Central Europe: historical and ecological aspects. - In: F. DI CASTRI, A.J. HANSEN, M. DEBUSCHE (eds.): Biological Invasions in Europe and Mediterranean Basin. - Kluwer Academic Publishers p.19-36. - Dordrecht (in English).

LATOWSKI K. (1994): Studies on the Biology of *Anthoxanthum aristatum* Boiss. - Wyd. ART w Olsztynie, p. 131-139.- Olsztyn-Bęsia (in Polish).

MEUSELH., WEINERT R., JÄGER E. (1965): Vergleichende Chorologie der Zentraleuropäischen Flora. Text + Karten. – G.Fischer Verlag. Jena.

MISIEWICZ J. (1970): A Mass Occurrence of *Anthoxanthum aristatum* Boiss. in the Winter Rye Crops. - Fragm. Flor. Geobot. 16: 317-318. (in Polish).

ROLA J. (1975): Die Verbreitung von *Apera spica-venti*, *Poa annua* und *Anthoxanthum aristatum* in Europa. - EWRS and COLUMA, Paris 2: 55-69 (in German).

ROLA J., KUŹNIEWSKI E. (1979): Einfluss der Intensivierung und Spezialisierung der Pflanzenproduktion auf die Verunkrautung. In: Unkraut bekänpfung der industriemässigen Pflanzenproduktion. 1: Allgemeine Grundlagen Wiss., p. 22-27. Halle (in German).

SOLARZ W., KRÓL W. (2004): Alien species in Poland – pathways of introduction influence and control. Działalność Naukowa PAN 17: 43-45. Warszwa (in Polish).

SZMEJA K. (1970): *Anthoxanthum aristatum* Boiss. – an Expansive Crop Field Weeds Species of the Charzykowska Plain.- Zesz. Nauk. ATR Bydgoszcz 196(38): 193-196 (in Polish).

TOKARSKA-GUZIK B. (2001): *Anthoxanthum aristatum* Boiss. In: Zając A. & Zając M. (eds.): Distribution Atlas of Vascular Plants in Poland. - Ed. By Laboratory of Computer Chorology, Institute Botany, Jagiellonian University, p.62. Kraków.

WARCHOLIŃSKA A.U., SICIŃSKI J.T. (1976): Studies on the Occurrence and Spread of *Anthoxanthum aristatum* Boiss. in Central Poland. - Fragm. Flor. Geobot. 22(4): 409-413 (in Polish).

WARCHOLIŃSKA U.A., SICIŃSKI J.T. (1996): Expansion of *Anthoxanthum aristatum* Boiss. in Central Poland. Akad. Techn.-Roln. im. Jana i Jędrzeja Śniadeckich w Bydgoszczy. Zesz. Nauk. Rolnictwo 196 (38): 183-191 (in Polish).

WÓJCIK Z. (1978): Charakterystyka ekologiczna i geograficzna chwastów pospolitych na polach uprawnych Polski. In: Markow M.: Agrofitocenologia, p. 181-244. PWR i L. Warszawa (in Polish).

WÓJCIK Z., DOMAŃSKA H. (1976): A New Remarks on *Anthoxanthum aristatum* Boiss. Invasion in the Mazowsze. - IUNG Puławy-Wrocław, p. 285-297 (in Polish).

ŻUKOWSKI W., LATOWSKI K., NINOVA D., POPOVA M., ČEŠMEDŽIJEV I., KUZMANOV B., KLIMKO M. (1982): Tendencies in anatomical variation of *Glechoma* genus as determined by population analysis. Fragm. Flor. Geobot. 28(3): 341-362.

Tab. 1. Analysis of selected morphological features of *Anthoxanthum aristatum* against the soil background

No of sample	Crop / Soil complex	Height of shoot in cm min-max (mean)	Length of Highest (flag) leaf in cm min-max (mean)	Length of inflorescence in cm min-max (mean)	No of spikelets in inflorescence min-max (mean)
1.	Rye/6M	36.0 - 52.0 (44.6)	1.7 - 5.5 (3.1)	2.7 - 4.3 (3.4)	16 - 44 (32.5)
2.	Rye/6Dz	30.5 - 51.5 (41.1)	0.8 - 4.4 (2.5)	2.2 - 4.3 (3.2)	18 - 48 (32.0)
3.	Rye/7Bw	30.0 - 52.0 (40.0)	1.7 - 5.6 (3.2)	2.8 - 5.1 (3.7)	16 - 73 (43.0)
4.	Rye/7Bw	28.0 - 50.0 (38.0)	1.0 - 4.5 (2.1)	1.8 - 5.1 (2.8)	13 - 74 (32.5)
5.	Rye/7Bw	16.0 - 34.0 (24.2)	0.6 - 2.3 (1.2)	1.5 - 3.2 (2.4)	8 - 36 (19.7)
6.	Rye/7Bw	12.0 - 24.0 (17.9)	0.5 - 2.1 (1.3)	1.4 - 3.2 (2.3)	9 - 52 (27.1)
7.	Rye/7Bw	22.0 - 34.0 (29.0)	1.8 - 5.2 (2.8)	2.5 - 4.6 (3.1)	16 - 44 (31.2)
8.	Lupin/7Bw	18.0 - 33.0 (24.6)	0.6 - 3.2 (1.8)	1.5 - 3.4 (2.7)	14 - 56 (30.5)
9.	Rye/7Bw	14.0 - 27.0 (19.9)	0.9 - 2.6 (1.5)	1.8 - 4.0 (2.3)	11 - 34 (20.4)
10.	Rye/5F	22.5 - 52.0 (41.3)	1.4 - 4.7 (2.8)	2.2 - 4.2 (3.3)	17 - 62 (41.3)
11.	Rye/7M	24.0 - 36.0 (29.8)	1.1 - 3.0 (1.6)	2.0 - 3.6 (2.7)	12 - 54 (24.7)
12.	Rye/7Bw	22.0 - 37.5 (30.0)	1.4 - 5.6 (2.8)	1.9 - 4.0 (2.9)	18 - 58 (34.8)
13.	Rye/9M	28.0 - 43.0 (34.4)	1.2 - 3.1 (1.9)	2.1 - 3.4 (2.7)	14 - 52 (27.7)
14.	Rye/6Bw	14.0 - 38.0 (24.7)	0.7 - 2.3 (1.3)	1.6 - 3.2 (2.5)	15 - 44 (25.2)
15.	Rye/7Bw	13.0 - 37.0 (23.4)	1.2 - 4.1 (2.4)	2.0 - 4.5 (3.0)	24 - 94 (46.1)
16.	Rye/7Bw	25.0 - 40.0 (30.7)	1.1 - 3.2 (1.7)	2.0 - 3.4 (2.6)	20 - 54 (33.4)
17.	Rye/7Bw	26.0 - 40.0 (32.6)	1.2 - 5.0 (2.9)	2.1 - 4.0 (2.9)	18 - 44 (28.7)
18.	Rye/7Bw	15.0 - 28.0 (21.3)	1.3 - 4.0 (2.4)	2.2 - 3.8 (2.8)	18 - 52 (28.7)
	Variability index	IV (4.3)	IV (11.2)	IV (3.6)	IV (12.1)

Localization of the samples: explanation see Figure 1.

Tab. 2. Effect of the branching out on the number of spikelets of *Anthoxanthum aristatum*

Number of culms	Number of specimens	Number of spikelets min - max		mean/1culm
2	8	17	32	25.3
3	15	15	50	26.0
4	11	11	47	24.3
5	19	9	41	20.8
6	5	14	17	16.0
7	3	15	24	17.9
10	1	11	31	19.2
11	3	12	27	16.5
12	1	14	30	20.1
14	1	11	31	19.6

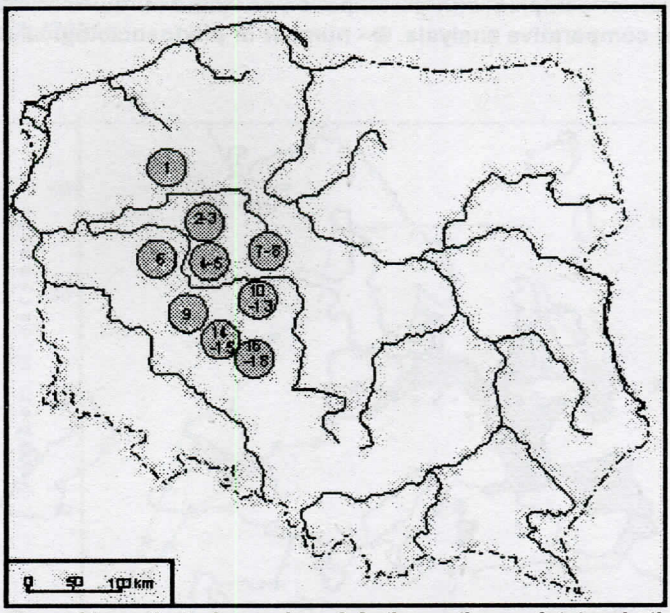

Fig. 1. Localization of investigated samples of *Anthoxanthum aristatum* in the cereal fields of W Poland. 1: Ostrówki (near Chodzież), 2-3: Bolechowo (Poznań), 4-5: Promnice (Poznań), 6: Poznań, 7-8: Jastrzębowo, Lulkowo (Gniezno), 9: Krzykosy (Środa Wlkp.), 10-13: Zapowiednia, Boguszyn, Grądy Dolne (Śrem-Pyzdry near Warta River), 14-15: Bachorzew, Wola Książęca (Jarocin), 16-18: Zalesie, Świeca (Ostrów Wlkp.).

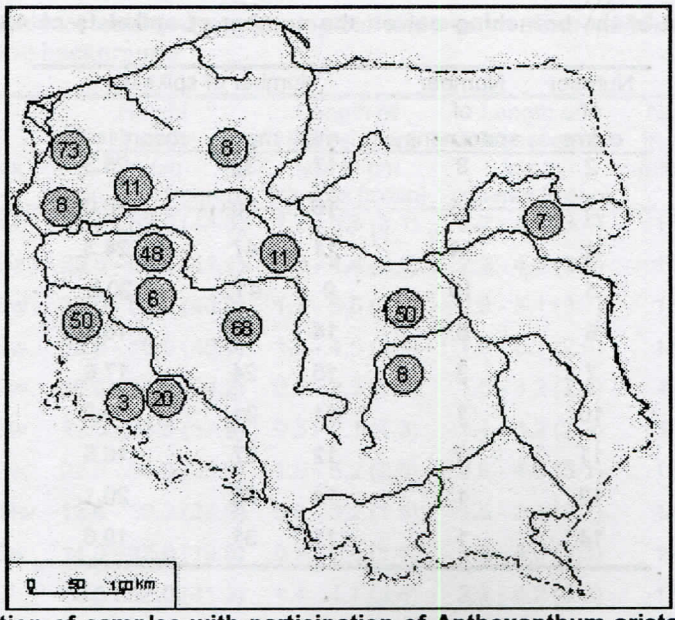

Fig. 2. Situation of samples with participation of Anthoxanthum aristatum used in the ecological comparative analysis. ® - number of phytosociological relevés.

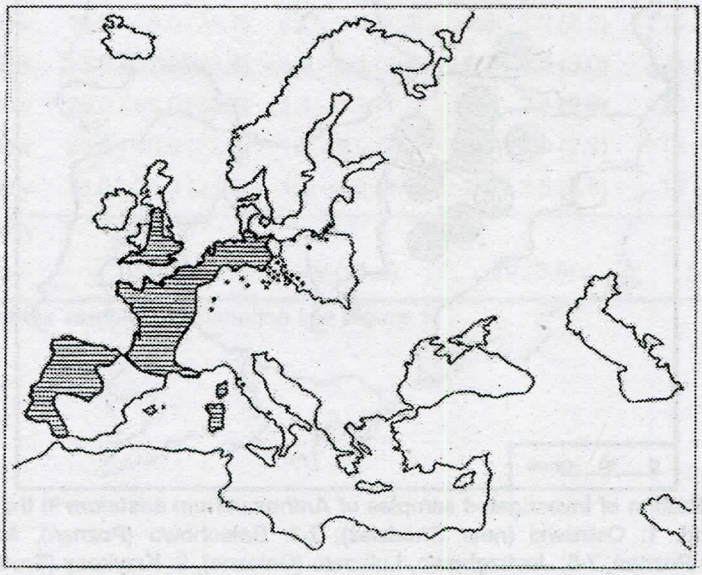

Fig. 3. Distribution of *Anthoxanthum aristatum* – range after Meusel, et all. (1965) – slightly modified.

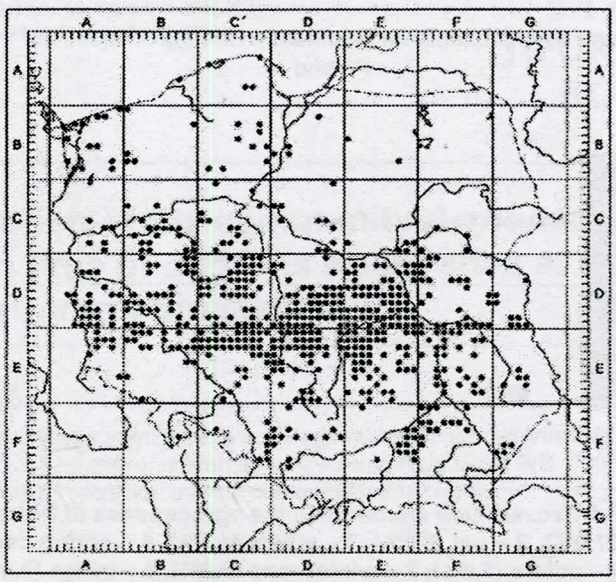

Fig. 4. Distribution of *Anthoxanthum aristatum* in Poland. Cartogram after Tokarska-Guzik (2001).

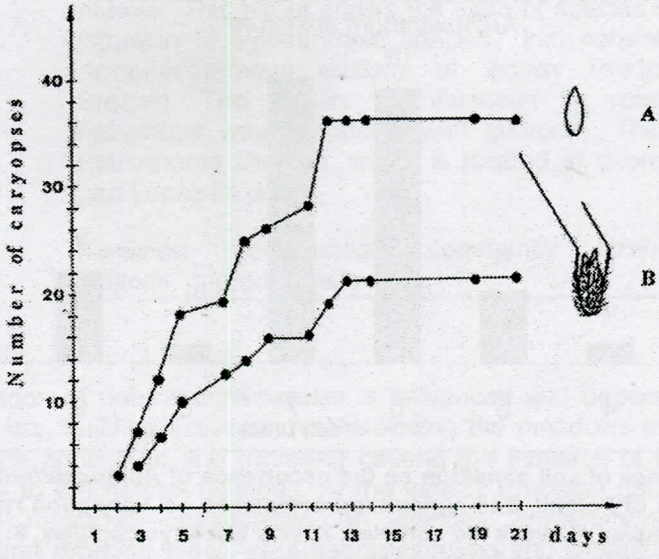

Fig. 5. Influence of natural cover (lemmas) on the germination of caryopses of *Anthoxanthum aristatum*. A - caryopses without lemmas, B – caryopses with natural cover (lemmas).

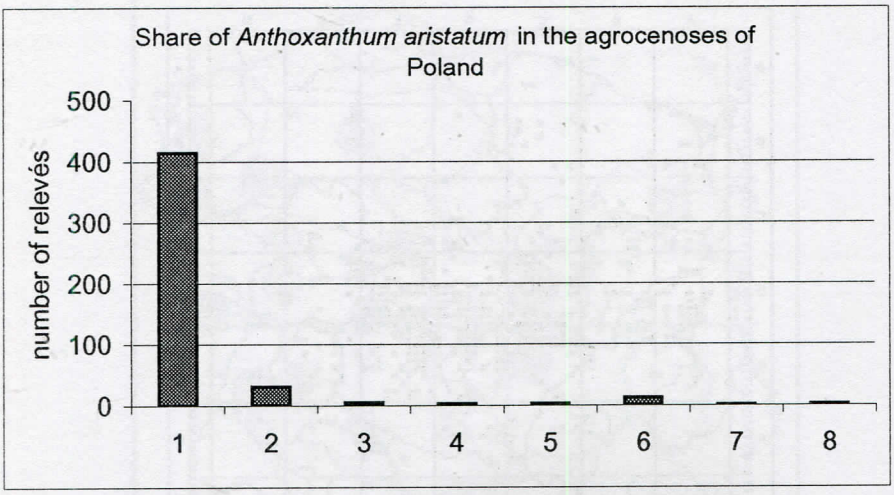

Fig. 6. Share of *Antxoxanthum aristatum* in the agrocenoses of Poland. Crops: 1- rye (87.9%), 2 – oat (6.6%), 3 – wheat (1.2%), 4 – spring cereals (0.6%), 5 - barley (0.6%), 6 – potato (2.5%), 7 – winter rape (0.2%), 8 – maize (0.4%).

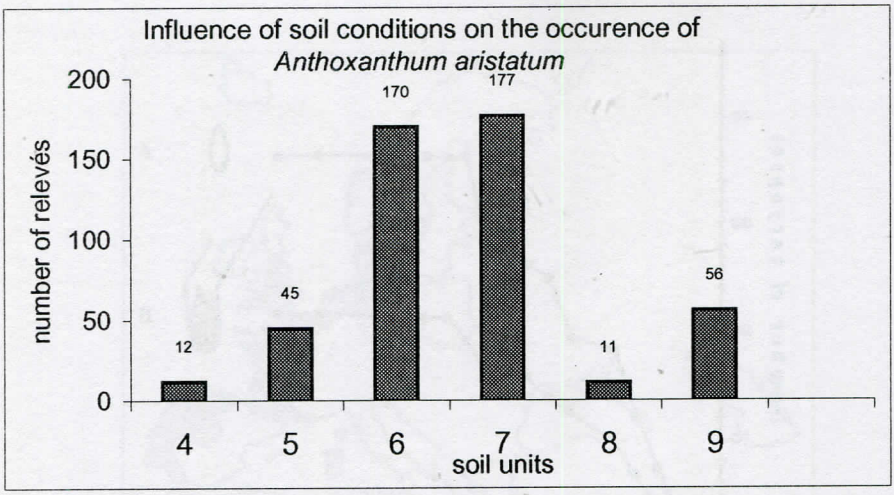

Fig. 7. Influence of soil condition on the occurrence of *Anthoxanthum aristatum* in agrocenoses of Poland. Soil agricultural complexes - 4: very good rye complex, 5: good rye complex, 6: weak rye complex, 7: very weak rye complex, 8: cereal-fodder strong complex, 9: cereal-fodder weak complex.