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Zonal character of the flora of kurgans in central and southern Ukraine

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Abstract: In the years 2004-2010 floristic studies were carried out on kurgans in 4 different climatic/vegetation zones: 3 steppe zones (west and central Pontic desert steppe, west Pontic grass steppe, west and central Pontic herb-rich grass-steppe) and a forest steppe zone. Among the 450 kurgans surveyed, 106 barrows met the selection criteria. The species composition and the contribution of different life forms to the flora of kurgans changed along the north-south gradient. Jaccard's similarity coefficient and Ward's clustering method were used to compare the qualitative composition of flora in particular zones. The results of this comparison confirmed floristic differences between kurgans located in the four zones. Kurgans in the desert steppe zone proved to have the most distinct flora among the floras considered. The biggest similarities were found between the flora of kurgans in the forest steppe zone and that of barrows in the west and central Pontic herb rich grass steppe.

Keywords: kurgans in steppe zone, kurgans in forest steppe, biodiversity on kurgans, structure of kurgan flora, climatic/vegetation zones

1. Introduction

The territory of Ukraine extends into several different climatic/vegetation zones (Lavrenko *et al*. 1991; Bohn *et al*. 2000). For years there has been a dispute in Russia and Ukraine over the location of boundaries between these zones and the specificity of flora in these areas. Some 80-90% of the plant cover have already been destroyed within the above zones. Therefore, based on the presence of remnant vegetation conclusions can be drawn regarding the original vegetation cover in this area.

Kurgans are man-made structures which form a characteristic and unique element of the Ukrainian landscape. In the area surveyed the oldest kurgans were built over 5000 years ago and the most recent ones are about 700 years old. Most kurgans, especially in the south of Ukraine, had been constructed before agriculture developed. For hundreds of years the kurgans were covered by vegetation resembling natural vegetation, which was affected by such factors as climate, fires and herbivores. Over the course of time the area around the kurgans was taken into cultivation and the flora of kurgans was enriched by weed species which infested the fields.

The aim of the present study was to determine whether and to what extent the flora of the kurgans differs between particular climatic/vegetation zones and whether these differences reflect differences in the flora of the zones.

2. Material and methods

2.1. Study area

Floristic studies were carried out within an area of about 32100 km^2, in the southern and central part of Ukraine, in the Black Sea Lowland and the Dnieper Upland, within the Kherson, Mykolaiv, Kirovograd, Cherkasy and Poltava regions. The kurgans investigated were located within 4 climatic/vegetation zones (the classification of zones according to "The Map of Natural Vegetation of Europe" – Bohn *et al*. 2000), running from south to north: D – west and central Pontic desert steppe, P – west Pontic grass steppe, R – west and central Pontic herb(-rich)-grass steppe, F – forest steppe

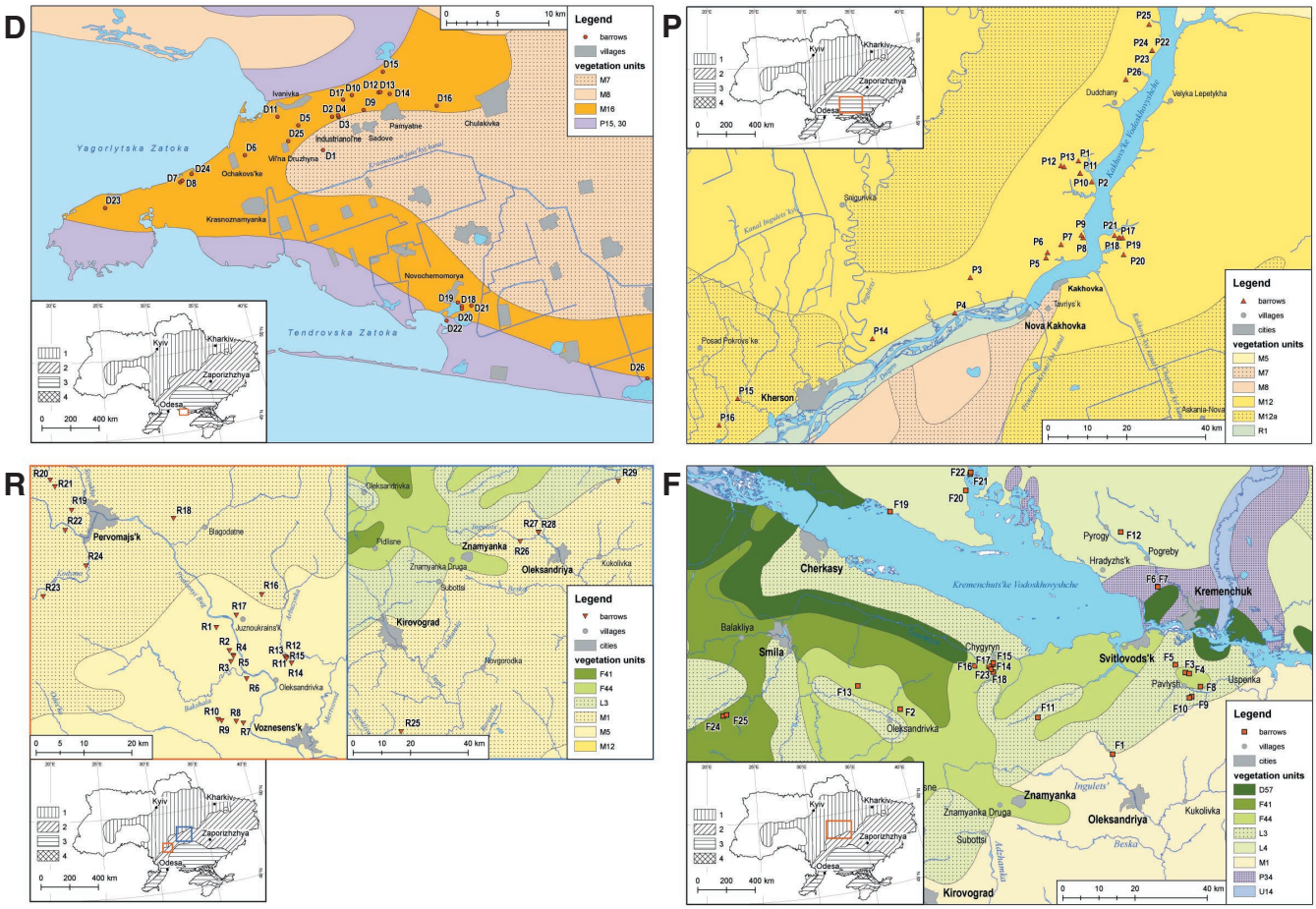

Fig. 1. Distribution of kurgans in the four climatic/vegetation zones (the classification according to Bohn *et al.* 2000)
Explanations: D – west and central Pontic desert steppe (M16), P – west Pontic grass steppe (M12), R – west and central Pontic herb(-rich)-grass steppe [further divided into two subzones: west and central Pontic herb-grass steppe (M5) and west and central Pontic herb-rich grass steppe M1)], F – forest steppe zone

zone (a general map of the investigated area and the characteristics of the three steppe zones were presented in earlier publications, e.g. Sudnik-Wójcikowska & Moysiyenko 2008b; the location of kurgans in each zone – see Figs. 1D, P, R, F). The main differences between the zones pertain to climatic characteristics, i.e. mean annual temperature (from south to north: 9-10˚C, 9-11˚C, 7-9˚C) and total precipitation (350 mm, 350-400 mm, 400-450 mm, respectively). Soil quality changes as well (from light and dark chestnut soils occurring in combination with solonetz-solonchak soils, through southern chernozem to typical humic chernozem).

The forest steppe zone, which is located farthest north, is characterized by a temperate climate, with moderately hot summers and moderately cold winters (Loginov & Hscherban 1984; Marinich *et al.* 1986; Lipinskii *et al.* 2003). The mean annual temperature is estimated at 7.7˚C . The climate becomes more continental towards the east. The average January temperatures range from -5 to -8˚C, while the average July temperatures vary from 18 to 20˚C. Mean annual precipitation is usually 550-750 mm in the west, and 450 mm in the east, which only slightly exceeds evaporation. Humidity levels are close to optimum levels. During the summer the rain comes in short, torrential bursts of showers. The main soils of the belt are deep black chernozems, podzolized chernozems and grey forest soils. Sandy soils as well as solonetzic (alkaline), solonetz and solontchak soils occur on river terraces, whereas alluvial soils are found in river valleys. The forest steppe zone is a macromosaic of forests, mainly on podzolized chernozems, and meadow steppe on deep black soils. Among forest communities, deciduous forests dominate, especially oak forests with *Quercus robur*. Other tree species such as *Fagus sylvatica* (in the west), *Carpinus betulus* (in the centre), *Acer* sp. div., *Tilia cordata* and *Fraxinus excelsior* are found alongside the oak.

2.2. Methods

Investigations on the flora of kurgans were carried out in the southern and central part of Ukraine in the years 2004-2007 and in 2008-2010. The kurgans were located within the above-mentioned four climatic/vegetation zones. From each zone, about 25-30 kurgans were selected for the study. Only the kurgans which met our selection criteria, e.g. those having the proper size and well-preserved plant cover (Moysiyenko & Sudnik-Wójcikowska 2006), were considered in this study.

Table 1. Basic floristic parameters characterizing the flora of kurgans in the three steppe zones in southern Ukraine and in the forest steppe zone

Characteristics of the flora of kurgans in the steppe and forest steppe zones	Zone			
	Desert steppe (D)	West Pontic grass steppe (P)	Pontic herb-rich grass steppe (R)	Forest steppe (F)
Number of kurgans investigated in particular zones	26	26	29	25
Total number of species on all the kurgans in particular zones	305	355	435	460
Percentage of the total flora of kurgans in the 4 zones (721 species)	42.3	49.2	60.3	63.8
Mean number of species on a kurgan	82.3	110.0	125.5	107.5
Minimum and maximum number of species on a kurgan in particular zones	48-103	72-141	89-171	85-189
Number of kurgans where the number of species exceeds 100	5	20	25	16
Percentage of halophytes in the flora of kurgans	14.8	1.3	0.5	0.4
Ratio of non-synanthropic to synanthropic species	61.4	63.7	69.5	73.6

Floristic lists were compiled for each of the 5 microhabitats identified within the kurgans (top – T, northern and southern slope – Sn, Ss, northern and southern foot – Bn, Bs). In each microhabitat the abundance of each species was estimated according to a 3-point scale (Sudnik-Wójcikowska & Moysiyenko 2008a). In the present study we used only presence/absence (0/1) data for every species on each kurgan in particular zones. Thus, every kurgan was characterized by the presence of certain species combinations. Dendrograms were calculated using Jaccard's similarity coefficient and Ward's clustering method to compare the objects. The dendrogams allowed us to determine whether the kurgans with a similar floristic composition were located within the same climatic/vegetation zone.

3. Results

Among the 450 kurgans surveyed in the 4 climatic/vegetation zones, only 106 barrows were selected for further study, as only about one-fourth of the kurgans met all of the above stated criteria. The number of kurgans investigated in particular zones and the basic floristic parameters describing the flora of kurgans are presented in Table 1.

The analysis of quantitative data shows certain south-north trends in the flora of kurgans.

A distinct increase in the species richness from south to north is observed when the total number of species on the kurgans in particular zones is compared (Table 1). A similar tendency was demonstrated in the case of the number of species per kurgan, as well as the minimum and maximum number of species on a kurgan. However, the difference between the minimum and maximum values was found to be larger for the forest steppe zone. This may be attributed to the fact that in the forest steppe zone (at least in the area we surveyed) it was difficult to find kurgans which met our selection criteria. The barrows were usually of a smaller size, e.g. the average height of the kurgans was 5.0 m and the diameter 54.1 m in the forest steppe zone, and 5.7 m and 67.1 m, respectively, in the Pontic herb-rich grass steppe. In addition, many of the kurgans were in poor condition, thus the kurgans supported an even lower number of species. The poor preservation of the barrows (at least in some places) may be ascribed to the long-term intensive agricultural utilization of these areas. However, the gradual increase in the ratio of non-synathropic to synanthropic species in zones from south to north is observed as well.

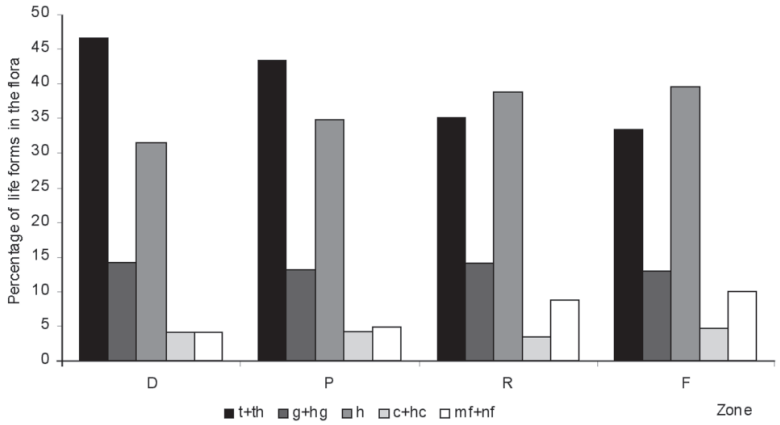

Fig. 2. Contribution of different life forms in the flora of kurgans in 3 steppe zones (D, P, R) and in forest steppe zone (F)
Explanations: (t+th) – therophytes and short living perennials, (g+hg) – geophytes, h – hemicryptophytes, (c+hc) – chamaephytes, (mf+nf) – phanerophytes

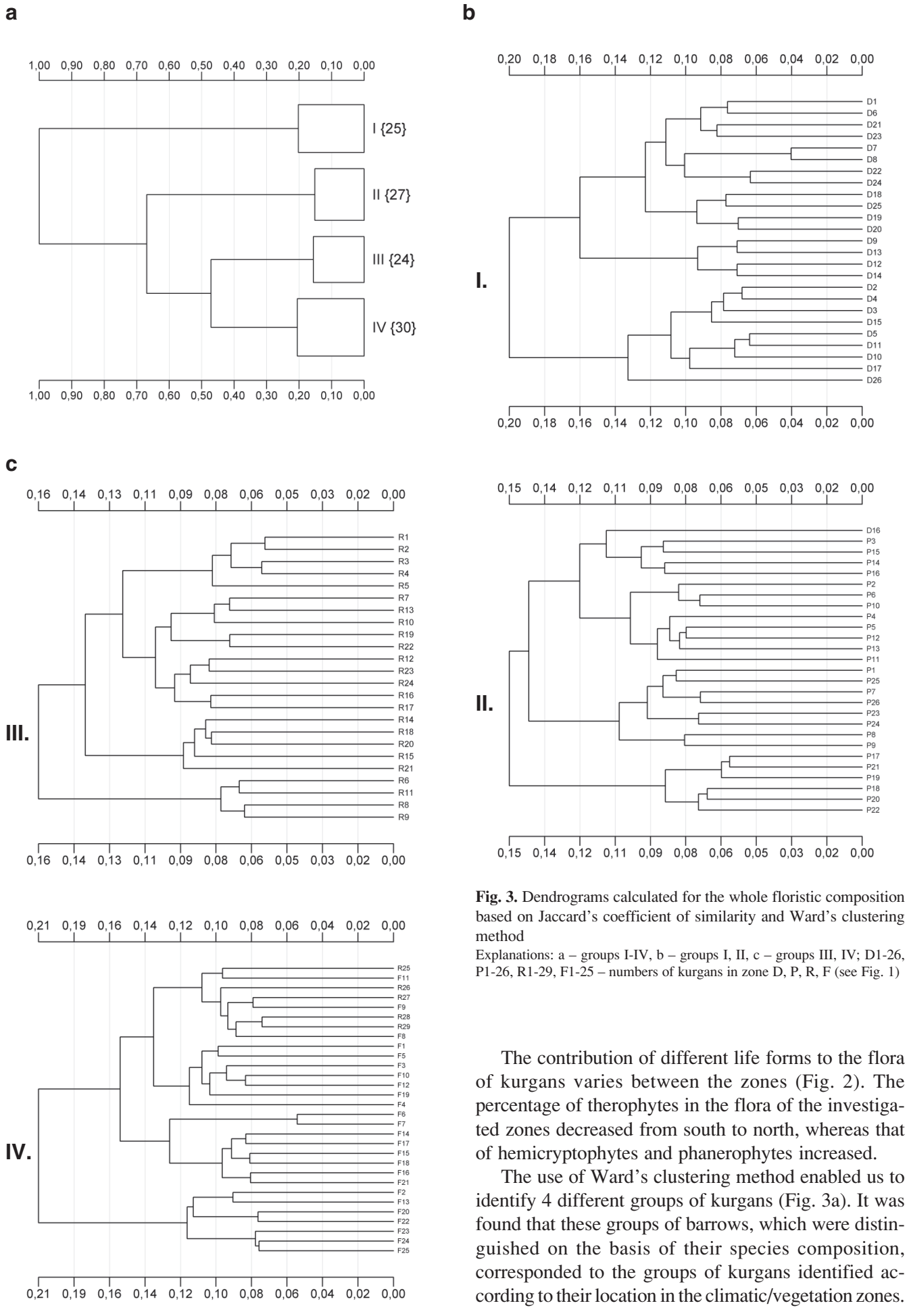

Fig. 3. Dendrograms calculated for the whole floristic composition based on Jaccard's coefficient of similarity and Ward's clustering method

Explanations: a – groups I-IV, b – groups I, II, c – groups III, IV; D1-26, P1-26, R1-29, F1-25 – numbers of kurgans in zone D, P, R, F (see Fig. 1)

The contribution of different life forms to the flora of kurgans varies between the zones (Fig. 2). The percentage of therophytes in the flora of the investigated zones decreased from south to north, whereas that of hemicryptophytes and phanerophytes increased.

The use of Ward's clustering method enabled us to identify 4 different groups of kurgans (Fig. 3a). It was found that these groups of barrows, which were distinguished on the basis of their species composition, corresponded to the groups of kurgans identified according to their location in the climatic/vegetation zones.

The flora of kurgans, therefore, confirmed the distinct floristic character of the zones. The group of kurgans situated in the West Pontic grass steppe was the most distinct of all. In the case of the other three groups of barrows the most evident similarities were found between the kurgans from Pontic herb-rich grass steppe and forest steppe zone.

The 4 groups of kurgans can be characterized as follows (Figs. 3b, 3c): (*i*) Group I: the most uniform group of kurgans – includes 25 of the 26 barrows from the desert steppe zone; (*ii*) Group II: a uniform group of barrows, includes 26 kurgans from West Pontic grass steppe and 1 kurgan from the desert steppe zone (it is interesting to note that among all the kurgans located in this zone this kurgan was situated in an old park); (*iii*) Group III: this group was most similar to group IV. It is a uniform group of kurgans and includes 24 among the 29 barrows located in Pontic herb-rich grass steppe. However, 5 kurgans from this zone were assigned to group IV; (*iv*) Group IV: includes all the 25 kurgans from the forest steppe zone and the above mentioned 5 kurgans from Pontic herb-rich grass steppe.

4. Discussion

4.1. Flora of kurgans versus flora of climatic/vegetation zones

The specific character of the flora of the steppe and forest steppe zones is manifested by a decrease in the number of therophytes from south to north and by an increase in the number of hemicryptophytes and phanerophytes (Bilyk *et al*. 1973; Lavrenko *et al*. 1991). Kurgans are structures of anthropogenic origin. In this work we attempted to answer the following question: does the structure of the flora of kurgans in each of the climate/vegetation zones correspond to the structure of the flora of these zones?

Among the 4 groups of kurgans distinguished on the basis of floristic similarity, Group I, which included only barrows from the desert steppe zone (D), was the most distinct with respect to its floristic composition. The foot and, in some cases, the top of the kurgans supported the highest number of halophytes (14.8% of all species). This group of species is typical of solonchak and solonetz areas, which exist as enclaves in the desert zone. Among the halophytes, the most numerous were the groups of annual halophytes and halophytic chamaephytes. These two groups of species, as well as tuft grasses and *Artemisia* species dominated quantitatively in the flora of the kurgans. Jointly, they occupied the largest area of the desert steppe zone, as well as the area of kurgans located in this zone.

The desert steppe zone (arid zone) is characterized by a larger number of species, which protect themselves against the winter cold as well as high temperatures and drought in summer. Such adaptations are exhibited both by annual plants (ephemerids) and perennials (ephemeroids), especially geophytes. Ephemerids are represented by therophytes, which appear in spring or autumn. Their number was much higher than that of hemicryptophytes in the desert steppe zone, as well as on the kurgans located in this zone. By contrast, the percentage of geophytes in the flora of the kurgans in the above zone was only slightly higher than in the other zones (although qualitative differences were noted). The present study also showed the presence of a very small number of tree and shrub species on the kurgans in the desert steppe zone.

Among the remaining group of 81 kurgans, a group of barrows located within the West Pontic grass steppe (P) can be distinguished (Group II). It should be noted that therophytes still dominated over hemicryptophytes in terms of species number on the kurgans from this zone. However, it was evident that hemicryptophytes, which were represented mainly by sod grasses, covered much larger surface areas than other groups of species. Phanerophytes did not play a significant role and comprised less than 5% of the flora of kurgans. The contribution of halophytes to the flora of kurgans in the above zone was much smaller than in the case of kurgans in the desert steppe zone (their percentage decreased from 14.8% to 1.3% with an increasing distance from the Black Sea).

The remaining group of 54 kurgans was further divided into 2 subgroups. One of them (Group III) included kurgans located exclusively in the Pontic herbrich grass steppe (R). The other (Group IV) consisted of kurgans found mostly in the forest steppe zone (F), but also included 5 kurgans from the neighbouring zone. It was found that 3 of these 5 kurgans were located close to the border between the two zones. The structure of the herb-layer flora on the kurgans situated in the above two zones was different from that of the barrows in the zones located further south. Therophytes were no longer the most numerous group of species. The dominant form of life form, in terms of the number of species (and area covered) were hemicryptophytes. Their number was much higher than that of therophytes in the case of the forest steppe zone. The hemicryptophytes found on the kurgans in zones R and F were more numerously represented by non-grass perennials and rhizomous grasses (especially in the forest steppe zone), whereas tuft grasses were less abundant. Trees and shrubs constituted 10% of the flora of kurgans (their percentage was higher in the case of the forest steppe zone). Halophytes made up only 0.4%-0.5% of the flora of kurgans.

The division of kurgans into 4 groups on the basis of their floristic similarities coincided with their location in the climatic/vegetation zones. Thus the structure of

the flora in the 4 zones is reflected in the flora of the kurgans located in these zones.

4.2. The role of kurgans in preserving the steppe flora

Steppes are among the most degraded habitats in Europe. It is estimated that about 82% of the total steppe area has been destroyed in Ukraine. Remnants of steppe vegetation are preserved in nature steppe reserves (e.g. Kamyani Mogily, Khomutovskii Step, Askaniya-Nova, Yelanetskii Step) and can still be found on slopes which are not suitable for agricultural use, on escarpments of river valleys, balks, in ravines and gorges. Our studies showed that kurgans are not only interesting from the archeological point of view, but also for naturalists. These man-made structures constitute a characteristic element of the Ukrainian landscape. Nowhere else in Europe do they occur in such great numbers as in Ukraine. Their number was originally estimated to be half a million. About 50 000-100 000 (or even 150 000?) kurgans have survived to date.

There is still a considerable debate about what actual climax vegetation would develop if the steppe zone was influenced by climate factors only. Some authors (e.g. Zaicev & Prozorov 2009) suggested that this vegetation would consist of shrub and semishrub species (the contribution of tree species would increase towards the north). However, such factors as fires or grazing affect the plant cover in the steppe areas (Tkachenko 2004; Lysenko 2005; Borovik 2006). Kurgans are more or less exposed to the same factors.

Most kurgans are under constant human pressure. However, our studies showed that at least 25% of the kurgans have preserved a unique steppe flora, which needs to be protected. The steppe species are found mainly on the slopes of the barrows (the northern slopes support a higher number of species). Therefore, it is necessary to protect particularly these kurgans not only as archaeological sites, but also as nature monuments. In the recent time the ownership of the land in Ukraine has changed. Many kurgans are located on private land and they are especially threatened by human activities (Bozhko 2008; Lystopad 2009). New legal regulations should be implemented to ensure more effective protection of the kurgans.

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