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THE ORNITHOLOGICAL ZONING OF THE AZOV–BLACK SEA DRY STEPPE ENCLAVE OF EUROPE

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Abstract

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The scheme of ornithological zoning of the Azov–Black Sea dry steppe enclave of Europe has been presented in the article based on domination of individual ornithological complexes, depending on the landscape structure of the territory. This enclave is a unique region due to its utmost western location and moderate continental climate. Its typical natural features and factors of their formation have been determined. The anthropogenic transformations of region have been characterized, and peculiarities of landscape changes have been caused by them. It has been found that the agrolandscapes are dominated in the Azov–Black Sea dry steppe enclave by the area. The schemes of physical–geographical zoning have been determined, which are suitable for ornithological zoning of the region; the dependence of composition of ornithological fauna on predominant landscapes has been revealed. On this basis, the scheme of ornithological zoning of the mentioned region has been proposed. The flat interfluve-steppe, stony-steppe, sandy-steppe, floodplain-river, and liman-marine ornithological areas have been singled out and have been characterized. The main differences in the ornithological regions are correlations of predominant and codominant ornithological faunistic complexes, which depend on the area landscapes and natural and anthropogenic transformation of their components; they are relief, soil, water bodies, and vegetation.

Key words: landscapes of dry steppe Ukraine, landscape zoning, anthropogenic changes of landscapes, ornithological faunistic complexes, predominant species of bird, ornithological zoning.

Introduction

The biological and the landscape diversity is one of the greatest values of Europe's natural heritage, and landscape acts as ecological, economic, and social resource (Pan-European strategy… 1995, European Landscape ... 2000). The landscapes are diverse and rich in their natural and cultural contents, and their ecosystems are characterized by great diversity of habitats, rich flora and fauna. Therefore, the task of preservation of landscapes has been defined with the strategy as an integral part of basic initiatives related to preservation of biodiversity. The diversity of landscape structure leads to diversity of habitats, according to regular growth of species diversity of biota.

One of the essential components of landscape structure of Europe is steppe landscapes. Within them, dry steppe has stood out; it is unique and inimitable for all Eurasian continent landscape complexes. The western part of dry steppe zone of Eurasia is situated within Ukraine along the Black Sea and the Sea of Azov, isolated from the continuous area of dry steppes; it is the original Azov–Black Sea dry steppe enclave.

The dry steppe landscapes, among others, stood out with instability of their functioning and vulnerability at the least changes of their natural components. This is due to the combination of natural conditions with peculiarities of anthropogenic activity and coastal location with appropriate influence of marine environment. The common manifestation of several critical factors (drought, increased wind regime, salinity, poverty of soil substrate, etc.) makes dry steppe landscape complex more impressionable and less stable. Lesser deviation of one of them can create borderline situation, and it can lead to landscape differentiation. At the same time, the same factors sometimes cause formation of complex and diverse landscape structure somewhere, far from imaginary monotony of dry steppe (Marynych et al., 1985).

The first ornithological zoning of dry land has been elaborated on the basis of distribution of bird families and number of their species (Sclater, 1858), taking into account the history of origin of fauna of different parts of the Earth (Wallace, 1876). The size and configuration of zoogeographical regions and prov-

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inces depend on physical–geographical conditions (climate, soil, etc.) in which these fauna have developed (Severtsov, 1877). The directions of resettlement of animals have been determined with predominant landscapes (Darlington, 1957), and in conditions of anthropic transformation of environment, they depend on leavings of natural landscapes; it is the original islands among agricultural and urban territories (Preston, 1962).

In classical zoogeography, the main principle of zoning is fauno-genetic. Its criteria are historical regional connections of fauna, appropriateness of their change during correlative with tempos of evolution of segments of time (Chernov, 1975). Later, in ornithology, alternative vision arose, according to which zoogeographical zoning should correspond to landscape zoning (Dementiev, 1938; Voinstvenskyi, 1960). Herewith, during consideration of large zoogeographical subdivisions, differences in fauna are mainly considered due to their autonomous history. But with more detailed zoning, modern ecological factors have become the priority (Bobrynskyi, 1967).

Due to high ecological plasticity, many species of birds of Northern Eurasia do not have clear timing to certain geographical landscape zones. But spatial heterogeneity of ornithological fauna still correlates, in general, with the main ecological factors, which are determined by the heat supply, zonality, regionality, and ongoing postglacial resettlement (Zheleznova, 2015; Boldyrev et al., 2021). That is why medium- and small-scale study of spatial distribution of birds should be guided by the fact that territorial variability of ornithological complexes has been determined with the heterogeneity of conditions of the environment: on the one hand, these factors affect bird population integrally in the form of natural–anthropogenic regimes, and on the other hand, they limit distribution of animals as individual deficit factors (Ravkin, Lyvanov, 2009).

The research of this type belongs to the sphere of biogeography; it is a science that explores preconditions, which reveals appropriateness of distribution and peculiarities of spatial organization of living organisms (plants or animals) depending on the conditions of the environment and its anthropogenic changes. Biogeography reached its maximum development in the second half of the 19th century, thanks to the efforts of the scientists of that time such as O. von Humboldt, V. I. Vernadskyi, P. -S. Pallas, L. S. Berga, and others. In modern geography, despite its close connection with biology and ecology, scientific research on geography of animals has not been carried out. It has been confirmed with a deep analysis of materials at the Congress of the Ukrainian Geographical Society, which is an important geographical forum held in April 2016 (Ukrainian Geography… 2016a,b,c).

The ornithological–geographical peculiarities of steppes of Eastern Europe were researched in the middle of the 20th century. According to predominant landscapes and composition of ornithological fauna, it is divided into two zoogeographical regions, the western steppe and the eastern steppe, and the border between them runs along the lower Dnieper (Charleman, 1936; Puzanov, 1938). However, Voinstvenskyi (1960) has proposed to divide them with a transition strip lying between lower Dnieper and Donetsk chain of hills. Besides, he has singled out "region of river valleys and marine coasts;" they are the northern coast of the Black Sea and all coast of the Sea of Azov with limans and coastal islands. According to this scheme, the Azov–Black Sea dry steppe enclave is the part of four zoogeographical units that have different ranks: two districts are the "western steppe" and "river valleys and maritime coasts," one transition strip between the west-steppe and the east-steppe districts, and one section of "lower Dnieper." But more detailed zoning of this region has not been carried out. In part, we have already made attempts to reveal dependence of bird population of dry steppe zone of Ukraine from physical–geographical zoning (Andriushchenko et al., 2015; Andriushchenko, Vorovka, 2015). So, the purpose of this study is to study ornithological zoning of the Azov–Black Sea dry steppe enclave of Europe in accordance with the existing landscape divisions of the region. The object of research is to determine the landscapes and bird populations of the mentioned enclave and subject them to ornithological zoning based on the domination of certain ornithological faunistic complexes depending on the landscape structure of their territory.

Material and methods

This article is based on the research on ornithological fauna of the Azov–Black Sea dry steppe enclave of 1986–2020, which covered all territories in all periods of the annual cycle of birds. In open territories, accounting of birds was conducted on car shuttle routes within squares of 10 × 10 km with frequent stops and survey of territory using 10-12-X binoculars and 30-X telescope. It has allowed getting information quickly about the number and distribution of birds simultaneously in different biotopes, landscapes, and, in general, individual parts of the region. The route accounting is more acceptable compared to count on ground due to the greater representativeness of transects and comparability of results, especially if the trajectory of routes is broken, which brings it closer to random distribution of samples (Ravkyn, Lyvanov, 2009). In the thickets of woody-shrub and reed-swamp vegetation, birds were counted on foot routes, in places of overnight stays and long stops as in points, and in the floodplain of the lower Dnieper, from boats. The ornithological complexes were characterized with species of birds which are dominated numerically in route accounting (Ravkyn, Lyvanov, 2009). The classification of ornithological faunistic complexes proposed by M. A. Voinstvenskyi for the steppe zone of Europe has been used for apportionment of ornithological regions (Voinstvenskyi, 1960).

The existing landscape maps of Ukraine and its regions (Popov et al., 1968; Marynych et al., 1985; Marynych, 1990–1993; Ukraine: Basic Atlas …, 1998; National Atlas…, 2007) have been taken as the basis for landscape zoning. Descriptions of dry steppe landscapes have been done using scientific sources of geological, general geographical, and biological contents (Popov et al., 1968; Dzens-Litovskaya, 1970; Lvova, 1978; Podgorodetskyi, 1988; Bagrova et al., 2001). The map scheme of peculiarities of soil cover has been provided by Grachev (2020).

Results and discussion

The territories with herbaceous grouping belong to dry steppes, in which perennial long vegetative turf cereals dominate on dark chestnut and chestnut soils (Kryvulchenko, 2005), and in some places, it is xerophilic species with very rarefied grass on the southern chernozems.

Within the Eurasian continent, dry steppe landscapes are widespread with intermittent strips of different widths from the

northern Black Sea coast in the west to Mongolia and China in the east. Traditionally, within Ukraine, strip of dry steppes is distinguished at the level of subzone (Marynych, 2000), but in the scale of Eurasia, it is often given the status of a zone (Perelman, 1975; Milkov, 1956; Pashchenko, 1999). According to climatic indicators, dry steppes of Ukraine have less continentality within Eurasia. It has promoted the formation of original population of birds not only during the nesting period, but also throughout the year. For example, only in this part of the Eurasian dry steppes, there is regular mass northern wintering of steppe birds, wetland, and forest species.

According to the map of landscapes of Ukraine (National Atlas…, 2007), near the Danube, dry steppes are widespread of small narrow islands on the Danube and maritime parts of watersheds of small rivers. As an integral strip, dry steppes of Ukraine, according to different data, begin from the left bank of Dniester liman (Marynych, 1990–1993) or the left bank of Tylihulskyi liman (National… 2007; Kryvulchenko, 2005). To the west of Tylihulskyi liman, the width of dry steppe strip along the Black Sea coast is quite narrow (about 12 km) and insignificant for mobile animals such as birds. Therefore, the population of these dry steppe islands is very leveled with the influence of ornithological complexes of adjacent from the north of all mid-steppe subzones. In this regard, Tylihulskyi liman has been identified for objective ornithonization of the western border of the dry steppe enclave (Kryvulchenko, 2005). To the east of it, dry steppe zone has a width up to 30–35 km, and in the interfluve of Ingul-Ingulets, it reaches 45 km. On the left bank of Dnieper and in northern Prysyvashshia, the strip of dry steppe of mainland part expands to 100 km. Starting from the left bank of Molochnyi estuary, the width of the strip decreases sharply and in the river mouth part of Lozuvatka, it wedges out to the coast of the Sea of Azov. It is the eastern limit of distribution of dry steppe landscapes in Ukraine.

Within Crimea, dry steppe landscapes are widespread in Prysyvashshia; it is in the northern and eastern lower parts of the peninsula with absolute heights of 0–40 m. Here, its strip stretches from Bakalska strip through Pervomaisk village; it is further to the north of Krasnohvardiiske village through Sovetske village to the base of Arabatska Spit (Marynych et al., 1985; Marynych, 1990–1993). Other landscapes of steppe Crimea are attributed to varieties of medium-steppe landscapes due to their predominantly chernozem and chernozem-like nature of soil base.

Regarding the conditions of plains in Crimea, a high degree of drought is typical (annual amount of rainfall in Tarkhankutskyi Peninsula is up to 320–350 mm) (Podgorodetskyi, 1988) and predominance of xerophilous vegetation is found. It promotes the formation of general landscape complexes, which are close to dry steppes (Malysheva, 2000; National Atlas…, 2007). Such position corresponds to the geobotanical typology of steppes (Lavrenko et al., 1991). It is an additional argument for attribution of all flat parts of the peninsula to the steppe zone. So, based on the above-listed typical features, all strips of the drought of steppe landscape complexes of Ukraine can be attributed to the Black Sea–Azov–Priazovia dry steppe landscape region, and its width in submeridional direction from the northern Prysyvashshia to the Crimean foothills reaches 180–200 km.

To the east of the Azov–Black Sea enclave, the strip of dry steppe landscape complexes is remote, that is, 400–650 km away. It starts from interfluve of middle current of Terek and Kuma and covers the eastern part of the Stavropol Upland, district of Kumo-Manytskay depression; it is the Tsymlianske reservoir. Then, almost solid strip dry steppes follow to the north, northeast, and from the Volga region, to the east to Buriatia. Then, the strip turns to the south and stretches through the central and eastern parts of Mongolia, China, inner Mongolia, and the foothill regions of Dzhungaria (Kryvulchenko, 2005). So, ornithological complexes of the Caucasus are the closest to the Ukrainian conditions; it is the south of the Rostov region, the east of Stavropol territory, and the north of Kalmykia (Andriushchenko, 2014). Thus, dry steppe landscapes of Ukraine are the utmost western outposts in Eurasia, both in terms of landscape and ornithological relations.

The general features of dry steppe landscape complexes are the greatest drought conditions compared to the northern steppe and the middle steppe (precipitation is 300–360 mm), higher annual sum of active temperatures (3300°C–3400°C), and higher evaporation (over 1000 mm). The vegetation is characterized by the spread of xerophytic fescue-feather and wormwood-cereal steppes with predominance in natural vegetation cover of feathergrass, fescue, wormwood, rye, and salt-resistant species of plants. Such conditions have led to development within its limits, mostly in dark chestnut and chestnut soil. Significant evaporation has caused the spread of solonetz and solonchaks.

Despite the unity of landscape features, the zone of dry steppe landscapes of Ukraine is distinguished by internal heterogeneity. It has been caused by a sublatitudinal length of more than 400 km, changes in tectonic and climatic factors, maritime position, and diversity of configurations of seashore. The sublatitudinal length of strip has caused differences in quality of precipitation, which decreases from the west to the east: Odessa – 402 mm, Kherson – 370 mm, Dzhankoi – 370 mm, Henichesk – 356 mm. Depending on the average annual rainfall, the vegetation cover of the territory also changes. In maritime strips, due to high drought and poverty of soil substrate, the vegetation cover is similar to semi-desert landscapes. Within the zone, there are several landscape regions different from each other: Primorskyi lowland steppe, lower Dnieper terrace-delta steppe, Prysyvasko–Pryazovskyi lowland steppe, Crimean–Prysyvaskiyi lowland steppe, Tarkhankutskyi elevated plain steppe, Central Crimean flat steppe, Kerch wavy steppe, and foothills forest steppe (Fig. 1).

The individuality of dry steppe landscapes of Ukraine from dry steppes of Eurasia, their utmost western position, and maritime location have formed specific landscape features. So, the dry steppes of Ukraine, due to their western location, face much less drought (by 20%–25%) than the dry steppes of the central and eastern regions of Eurasia. The mildness of climate (lower amplitude of temperature, higher humidity of air, and increased precipitation) and significant salinity of soil in the maritime part are also the different features of dry steppe landscapes of Ukraine (Dobrovolskyi, 2014). The coastal location along the Black Sea, the Sea of Azov, and Sivash Bay and the difficult character of coastline, valleys, and river mouths have diversified its landscape structure. Significant distribution of shoal, often quite large by area, with numerous peninsulas, bays, spits, and islands, which provide birds not only with food and water, but also safe places for rest (inaccessible for terrestrial predators and humans), attract significant number of birds to the region, such as hydrophiles, limnophiles, campophiles, and sclerophiles. All of them in post-nesting, migration and winter periods form significant accumulation here by number. The lack of solid snow and ice cover contributes to regular mass wintering of birds.

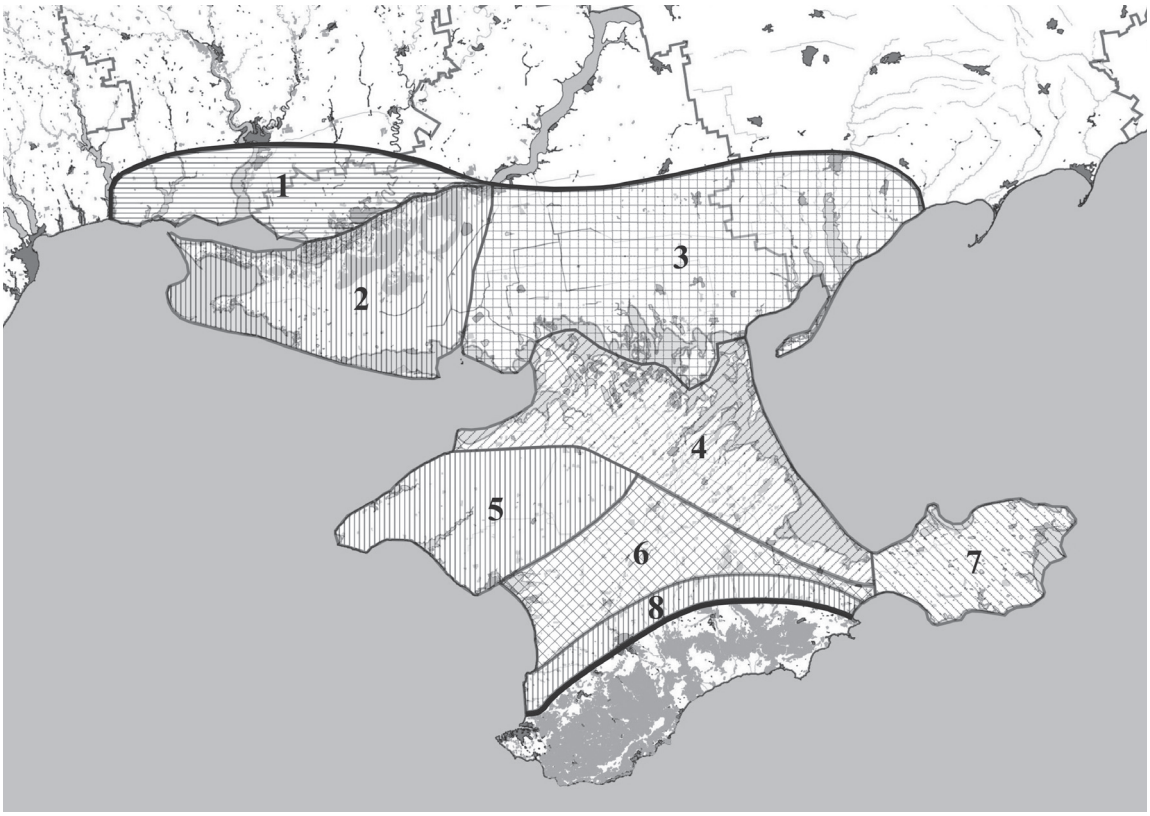


Fig. 1. Scheme of physical–geographical zoning of the Azov–Black Sea dry steppe enclave: 1 – Primorskyi lowland steppe, 2 – lower Dnieper terrace-delta steppe, 3 – Prysyvasko–Pryazovsky lowland steppe, 4 – Crimean–Prysyvaskiyi lowland steppe, 5 – Tarkhankutskyi elevated plain steppe, 6 – Central Crimean flat steppe, 7 – Kerch wavy steppe, 8 – foothills forest-steppe.

For now, characterized invariants of dry-steppe landscape complexes have been preserved little. Therefore, we should talk about variability of landscape structure and domination of transformations and changes by anthropogenic activities of natural landscapes. The deterrent factors of development of economic (mainly agricultural) activities in dry steppes until the second half of the 20th century have been a significant deficit of atmospheric moisture, salinity of soil horizons, increased content of salt in groundwater, wind erosion processes, and others. However, with flooding of territory by water of the Dnieper, creation of a network of field-protective forest stripes, and introduction of new agricultural techniques of growing of crops, opportunities of agricultural development of landscapes complexes of dry steppe have increased sharply. Therefore, they have been started to be used much more widely.

The occurrence of anthropogenic components of landscape, such as settlements, parks, gardens, agricultural lands (so-called cultural steppe), and irrigated territories, has led to the formation of original fauna of birds. It includes the species typical for this natural zone and those which have got into from adjacent territories. The appearance of new ecological niches around anthropogenic reservoirs, in field-protective forest stripes, and artificial forests has contributed to a sharp increase of species diversity due to alien species. The increase in area and diversity of anthropogenic components of landscape have affected significantly the species diversity of fauna of individual regions and number of species and their interrelations (Ilyichev et al., 1982).

At present, anthropogenic transformation of landscape complexes of dry steppe exceeds 80%, and in some regions of Prysyvashshia, it exceeds 90%. The scale of anthropogenic transformation has led to significant reduction of some species, almost to complete disappearance of some of them, and settlement or widespread existence of other species. Thus, increase in number and area of fresh and desalinated water bodies at solonchaks and solonchaks meadows has contributed to widespread settlement of hydrophilic species. All these significantly complicate ornithological zoning of the Azov–Black Sea dry steppe enclave.

The background in researched region are agricultural lands on place of dry steppe landscapes in variations with other lands, such as solonchaks, meadows, pastures, and woody-shrub plantings. Very less natural steppe landscapes have been saved, and their area has become highly fragmented. Within the dry steppe zone, rocky steppes are transformed the least. Anthropogenic pressure on them has caused the changes, but the landscape remains mostly natural. The largest areas of such steppes with the least fragmentation of area are concentrated on the Tarkhankutska Upland in western Crimea. Therefore, the population of birds within them has undergone the least changes. Close to Tarkhankutki steppes are "island" steppe rocky areas of the Crimean foothills and Kerch Peninsula. But there are valleys of watercourses (now they have been represented by chains of ponds); they are almost completely plowed, which are forested and populated. The steppes on the flat interfluves of Central Crimea, northern

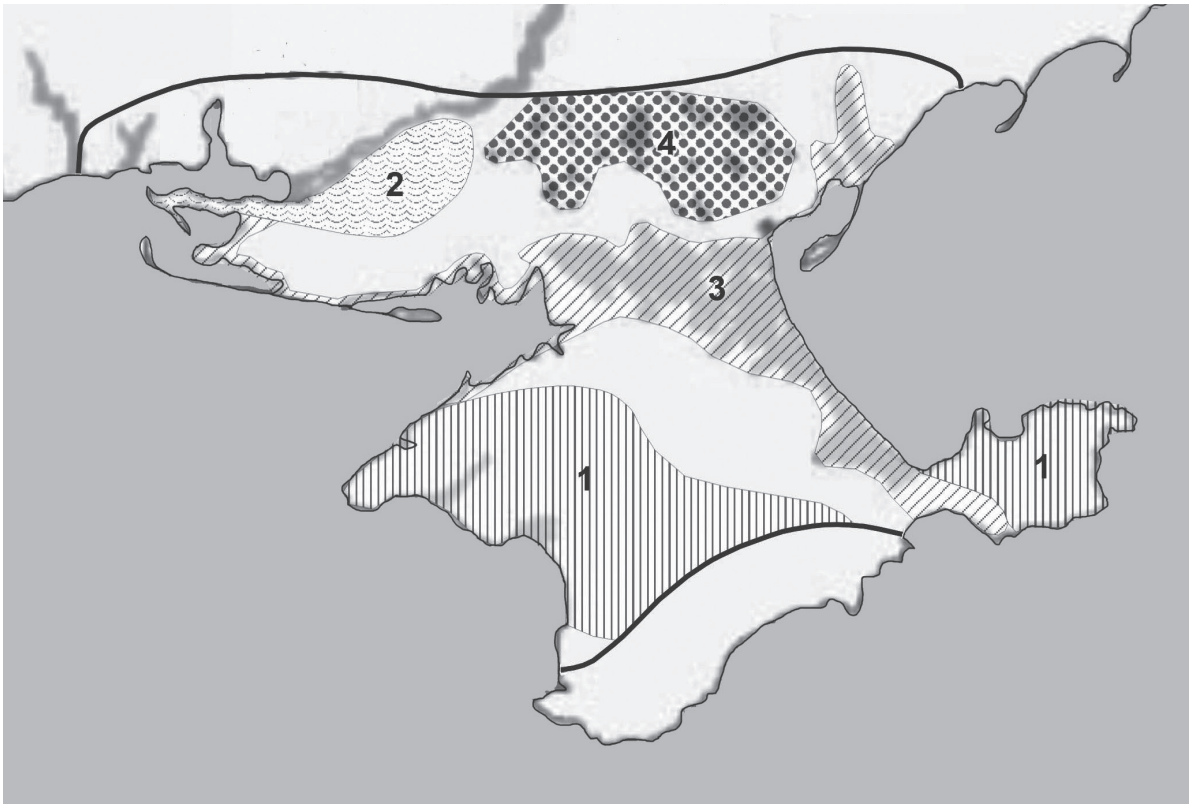


Fig. 2. Scheme of soil cover of dry steppe landscapes of Ukraine: 1 – gravelly, 2 – sand, 3 – solonchuks, 4 – salt padings and depressions.

Table 1. Peculiarities of the subregions of the Azov–Black Sea dry steppe enclave, which determine territorial heterogeneity of its population of birds.

No.	Subregions	Features of relief, soil, hydrology, or anthropogenic objects which diversify zonal landscapes	
		Natural	Artificial
11	Right bank of the Black Sea coast	Rivers, balks, limans, stony soil	Zone of stationary recreation, meliorative systems**
22	Lower Dnieper	Numerous straits, islands, coastal slope,s and cliffs	Zone of stationary recreation
33	Left bank of the Black Sea coast	Sand arenas, small stream of sloping banks***, coastal slopes, spits, islands	Artificial forests, meliorative systems, paddy fields
44	Northern Prisyvashshia	Padings***, dried-up rivers***	Meliorative systems
55	Sivash	Solonchaks, spits, peninsulas, islands	Ponds, dams, artesian wells, meliorative systems, paddy fields
66	Northwestern Priazovia	Rivers, balks, limans	Zone of stationary recreation, meliorative systems
77	Western Crimea	Dry balks, rocky shores, rocky soil	Quarries, meliorative systems, zone of stationary recreation
88	Central Crimea	Dry balks, stony soils, dried-up rivers, valleys of river	Quarries, meliorative systems
99	Kerch Peninsula	Dry balks, rocky soil, dried-up rivers, lakes, rocky shores	Quarries, meliorative systems, zone of stationary recreation
110	Foothills	Valleys of river, rocks, rocky soil	Artificial forests, quarries

Notes: *Numbers correspond to the numbers in Fig. 3; **meliorative system consists of irrigation and drainage canals with attendant dams, bridges, pumping stations, power lines, roads, forest strips, and so on; ***small stream of sloping banks, padings, and dried-up lands are described in the text.

Prysyvashshia, the Black Sea coast, and northwestern Priazovia are maximally transformed.

Steppe ornithological fauna has incurred significant losses due to appearance and increase in area of settlements, industrial objects, quarries, communicative networks (roads, tubing, and power lines), artificial forests, and so on, and on marine and river coasts, such as zones of stationary recreation. In parallel, there is an increase in area of gardens and patches of berries and vine-

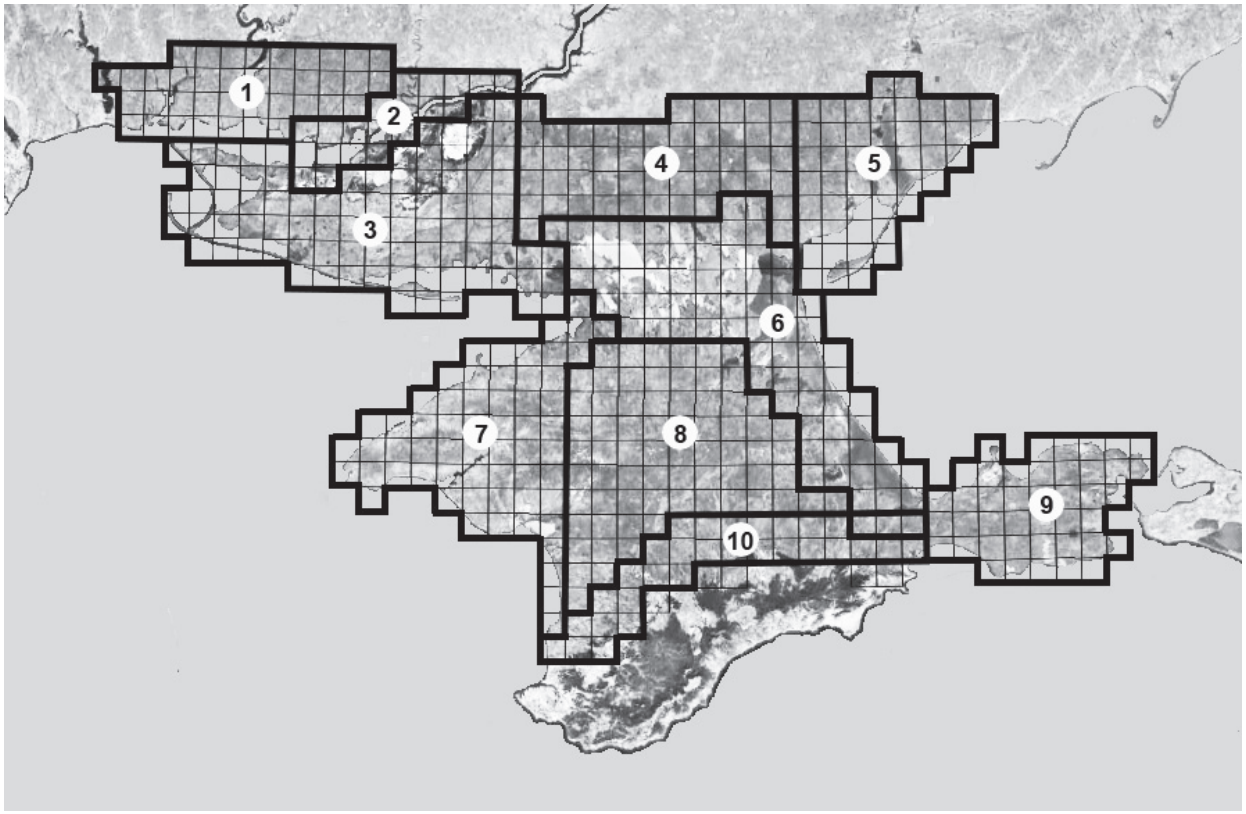


Fig. 3. Conditional division of dry steppe zone of Ukraine on account squares of 10 × 10 km and subregions: 1 – right bank of the Black Sea coast, 2 – lower Dnieper, 3 – left bank of the Black Sea coast, 4 – northern Prysyvashshia, 5 – northwestern Priazovia, 6 – Sivash subregion, 7 – western Crimea, 8 –Central Crimea, 9 – Kerch Peninsula, 10 – foothills.

yards on agricultural lands. Freshwater bodies have undergone the most significant transformations such as numerous settlements and formation of industrial and economic objects along the banks of steppe rivers. Measures have been taken to regulate runoff using creation of numerous ponds and reservoirs. At the same time, natural riverbeds of small rivers have begun to dry up during most part of the year and they are filled with water only after heavy rainfall. The plowing and development of floodplain meadows of riverbeds of many rivers have changed them to an unnatural state, such as banks of riverbeds have become steep, overgrown with reeds, and have become unsuitable as a watering place for most species of birds. Thus, some steppe species of birds have lost necessary conditions for existence, such as open areas with not high rarefied herbaceous vegetation and available for watering of fresh water with low-land shores and shoal. Locally, territories with a predominance of techno- and urban landscapes have been formed on the shores of seas and large rivers, including areas of stationary recreation, lands under gardens, vineyards, paddy fields, and irrigation.

According to previous research, other than the landscape structure of territory, the characters of grass vegetation affect the species composition, especially the number and spread of steppe birds, such as its height, projective cover, and mosaic. The majority of steppe birds, which nest and mostly feed on the surface of soil, prefer mosaic sward, such as alternation of areas of not high and rarefied sward with areas of very rarefied low grass vegetation or without it at all (Andriushchenko, 2006). Indirectly, these characteristics have been determined by the nature of predominant soil, in particular, their fertility, mechanical composition, and salinity. In the researched region, such sward is more spread on rocky soil, especially in places of access to surface of hard rocks (Tarkhankutska Upland, foothills, Kerch Peninsula, balkas of right bank of the Black Sea), on solonchaks and along them (along the shores of seas, bays, limans, lakes, on the bottoms of padings), and in sandy arenas (Fig. 2). In addition, stony, sandy, and solonetz-like soils are the least plowed, and within plowed areas, cultural vegetation cover is also mosaic due to frequent exit of rock and stone placers on the surface.

At the moment, agricultural landscapes have dominated in dry steppe enclave. It is a territorial natural–anthropogenic system in which, besides arable land, hayfields, pastures, and other anthropogenic components (field-protective forest stripes, artificial forests, various buildings, field roads, irrigation and drained canals, etc.) have preserved places with natural vegetation, mainly along the coastal slopes of sea and limans, balks, river valleys, and other small bodies of water (dried-up rivers, stream, and lakes) (Andriushchenko, Vorovka, 2015). So, according to natural and anthropogenic transformation of predominant landscapes and their components (relief, soil, reservoirs, and vegetation), the Azov–Black dry steppe enclave is divided into appropriate subregions such as the northern Black Sea coast, lower Dnieper, northern Prysyvashshia, northwest Priazovia, western

Crimea, Central Crimea, the Kerch Peninsula, and the foothills (Table 1). With some exceptions, these subregions correspond to physical–geographical zoning of dry steppe zone (Podgorodetskyi, 1988; National Atlas… 2007). Instead, from an ornithological point of view, they have divergences in configuration depending on the ecological meaning of territory for birds and also comfort of their observation by ornithologists (Fig. 3).

The right bank part of the northern Black Sea (further to the right bank Black Sea coast) almost coincides with the Primorskyi lowland steppe (Figs 1, 3). It is represented by Ochakivskyi, Posad-Pokrovskyi, lower Ingulets-Dnieprovskyi, and Buzko-Dnieprovskyi landscape regions and it differs due to deep erosional dismemberment of river valleys, spread of ravines, and soft climate. The steppe padings meet rarely within its border. The typical feature of the territory is a significant number of limans.

The left bank Black Sea coast is almost all of the lower Dnieprovskyi terrace-delta steppe, except for the lower Dnieper floodplain landscape region (Figs 1, 3). It is located on accumulative terrace plain composed of thick alluvial-deltaic sandy and loamy sandy deposits. Sandy "arenas" contribute to the formation of specific microclimatic (especially temperature and moist) peculiarities of the territory, and they make it impossible to develop a hydrographic network. Sandy deposits are reshaped with wind activity and have appearance of desert landscape. The territory is changed anthropogenically causing forest melioration, especially on the periphery of large sandy arenas. Plantations of *Pinus nigra*, *P. sylvestris*, and *Robinia pseudoacacia* dominate here. The landscape diversity of the region is increased with so-called small stream of sloping banks; it is an inaccessible depression in sandy arenas with moistening bottoms, sometimes with fresh or salt lakes (Marynych, 1990–1993). Their bottoms with temporary or permanent lakes are usually surrounded by reed swamp (or only reed) and woody shrub, and steppe vegetation is on the elevated slopes of dunes. The biotope diversity of many small streams of sloping banks is enhanced due to forests planted around their perimeter and also quarries from sand mining. The coastline is different with large areas of shoal with alternation of peninsulas, accumulative spits with islands, and bays.

The lower Dnieper is a significant part of the lower Dnieper floodplain landscape region within the valley of Dnieper with adjacent dry land (Fig. 3). Numerous islands, peninsulas, spits, bays and beaches, and also clay and limestone coastal slopes dominate here among solid freshwater settlements. The woody-shrub and swamp-reed vegetations have dominated on the islands and peninsulas, and steppe been dominated on elevated shores.

Northern Prysyvashshia consists of the Askaninskyi and Henicheskyi landscape regions, except the southern part (Fig. 3). A typical feature of the subregion is significant distribution of padings, which are expressed well in relief and vegetation cover. Padings are flat-bottomed, inaccessible reduction of relief, which range in size from several tens of meters to 10 km in diameter, with an area of hundreds and thousands of square meters (Marynych, 1990–1993). The largest (up to 5–10 km in diameter, and some even larger) have well-expressed slopes of different steepness and erosion system around the perimeter in the form of basins, balks, and small rivers flowing into them. Sloping declivities of the padings are plowed, and steep slopes and bottoms are used for pasture cattle or hayfields. At the same time, at the background of agricultural fields, most of which are under irrigation and, therefore, practically they are inaccessible steppe species of bird, padings are origonal refugium for many zonal representatives of ornithological fauna. The region is different with the lowest amount of precipitation, the highest evaporation, and the lowest indicators of relative humidity and surface runoff.

Northwestern Priazovia includes the Utliutsko-Molochanskyi and Pryazovsko-Nohaiskyi landscape districts, and also the southern part of Henicheskyi district (Fig. 3). A common feature of the subregion is the presence of coastal strip with adjacent shoal water surfaces of the Sea of Azov, Utliutskyi and Molochnyi estuaries. The territory is drained with regularly drying small rivers. The Askanian landscape is characterized by chestnut soil on a semiwavy surface with small rivers and balks, which open into numerous padings and bays of the Black Sea and Sivash. The padings are flat-bottomed closed depressions from several tens of meters to 10 km in diameter, occupying an area of hundreds and thousands of square meters (Marynych, 1990–1993). A lot of them have clearly expressed slopes of different impetuosity and a well-developed erosion network on the slopes. The gentle slopes of padings have been plowed, and the impetuous slopes are used for pasture and as hayfields. In the long term, with deep bedding of groundwater, the bottoms of padings are plowed until the beginning of heavy rainfall and rise in the level of groundwater. Sometimes, the bottoms of padings turn into shoal. In some padings, there are constant water bodies, which are fed with water from irrigation systems or artesian wells. The space between padings is actually plowed, and it is an alternation of agricultural padings and forest stripes with a network of irrigation canals. Besides sunflower and cereals, the main crops here are soybeans and rape. A lot of fields are artificially irrigated with water of the Dnieper through Kakhovka and North Crimean irrigation systems.

Western Crimea is represented by Tarkhankutskyi elevated steppe and adjacent areas of the marine coast (Figs 1, 3). Due to the fact that the peninsula significantly extends into non-freezing Black Sea, it has the longest frost-free period (224 days), the longest dry period (195 days), the least coefficient of humectation (0.24), and high relative humidity (71%). There is no fresh water, except for the upper reaches of lakes Donuzlav and Dzharylhach. The shortage of groundwater and surface water, which is typical for petrophytic steppes of this latitude, is largely compensated by the high humidity of air. Due to this, steppe herbaceous vegetation is well developed, and in lower reaches of rocky balks, woody-shrubby vegetation is common. Rocky soil in combination with some hard rocks, completely deprived of soil, prevents development of agriculture, and therefore, within the dry steppe enclave on the slopes of Tarkhankutska Upland, the maximum area of virgin steppes has been saved, which are used mainly for distant cattle breeding.

Central Crimea includes a significant part of the Central Crimean plain steppe and the western part of the Crimean–Prysyvaskyi lowland steppe (Figs 1, 3). The territory is a wide, wavy plain with flat, slightly sloping watersheds and wide, gentle depressions of upper researches of balks. Among the natural vegetation, petrophilic and xeropetrophilic steppes have dominated. It stretches in narrow strips over cliffs along rivers and balks. Woody-shrub vegetation is represented mainly by oppressed forest strips and also by small natural thickets along rivers. The territory is mainly used for agriculture and also production of building stone. Due to significant distribution of rocky steppes and agricultural fields at their place, this landscape is similar to Tarkhankutskyi elevated steppe and connects it with the same rocky foothill forest steppe.

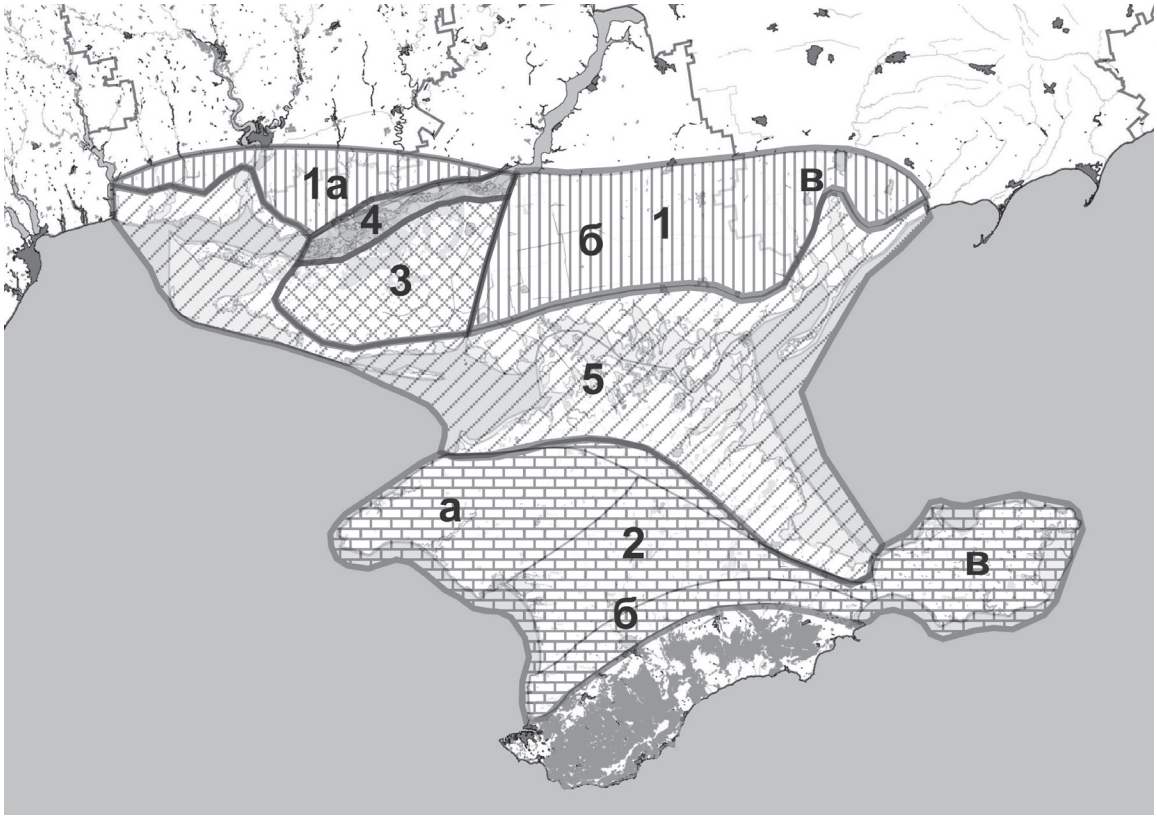


Fig. 4. Scheme of preliminary ornithological zoning of the dry steppe subzone of Ukraine ornithological regions: 1 – flat interfluve-steppe, 2 – stony-steppe, 3 – sandy-steppe, 4 – floodplain-river and 5 – liman-marine.

Table 2. Grounding of selected ornithological region.

No.	Ornithological region	Peculiarities of relief or hydrology that increase landscape diversity		Ornithological complexes**				
				Steppe	Forest	Hudrophilous		
						Maritime shores	River valleys	Precipices and ravines
1	Flat interfluve-steppe	a	Rivers and balkas	I	II		II	
		b	Padings	I			II	
		c	Rivers and balkas	I	II		II	
2	Stony-steppe	a	Dry balkas	I		II		II
		b	River valleys	I	II		II	II
		c	Dry balkas, river valleys, and lakes	I	II	II	II	II
3	Sandy-semi-desert	a	Sand arenas	I	II			
		b	Small stream of sloping banks	I	II		II	
4	Floodplain-river		Numerous straits and islands		II		I	II
5	Liman-marine		Solonchaks, spits, and islands	II		I	II	

Notes: *The numbers correspond to numbers in Fig. 4; **dominate – I, codominate – II.

The Kerch Peninsula coincides with the Kerch wavy steppe (Figs 1, 3); it is a complex relief which is represented by alternation of ridges and valley heights with inter-ridge valleys, balks, and dried-up rivers. Dried-up rivers are riverbeds of temporary watercourses, which are filled with water only after heavy precipitation or sharp melting of snow. Due to shallow bedding of groundwater, meadows with reed ridges have been formed in them. The wavy relief has caused alternation of different types of steppes, such as xerophytic on the southern slopes, petrophytic on the tops of hills, halophytic in valleys and balks, meadow in dried-up rivers, and irradiated with shrubs on the northern slopes. Numerous salt lakes and marine coasts, mostly rocky, are

added to the landscape diversity. A significant part of subregion is occupied by steppes, which have survived thanks to military training grounds. Besides, steppes are widespread on steep slopes and rocky peaks of numerous ridges.

The foothills coincide with the foothill forest steppe (Figs 1, 3), which, in terms of landscape, is the boundary between dry steppe zone and the Crimean mountains. It covers the foot of the northern slope of the outward ridges of the Crimean mountains up to 200 m. It is characterized by relief with significant amplitude of heights; it has alternation of elevations with lowlands, often narrow and canyon like, with stony soil, low-power places, and emergence of hard rock (limestone, marl, etc.). Shrub vegetation, including artificial woody plantations, is widespread along balks and river valleys. The interfluves are plowed and used for growing of cereals, oilseeds, and essential oils crops, and also grapes and fruit trees. Significant areas on the steppe slopes are occupied by steppes used for cattle grazing, and also, large and small quarries with production of building stone, both abandoned and existing, are widespread.

An exception among these subregions is Sivash, which, with adjacent padings, solonchaks, lakes, and dry land between them, belongs to integral wetlands (Chernychko, Siohin, 1993; Kucherenko, 2012; Results of the… , 2009). This land is more valuable for the support of both waterfowl and land birds than the surrounding territories, and, therefore, from an ornithological point of view, it is an individual subregion. It consists of the northern Prysyvaskyi landscape region of the Prysyvasko–Pryazovka lowland steppe landscape region and the northern part of the Crimean–Prysyvaskyi dry steppe landscape region (Figs 1, 3). The significant widespread presence of shoals, often quite large by area, with numerous peninsulas, bays, spits, and islands, provides birds not only with food and water, but also safe place for rest, inaccessible to terrestrial predators and humans. A similar pattern is observed in saline shallow wetlands in other regions of the world, such as the southern coast of the Mediterranean Sea (Elafri et al., 2017). The steppe landscapes here are relatively monotonous, but access to reservoirs with heavily dissected shorelines (alternation of many solonchaks, lakes, peninsulas, and islands) and therefore relatively difficult relief, which impedes their free movement and economic use, contribute to preservation of high species diversity of land birds. The lack of rivers is compensated by numerous sections of reservoirs, which are distilled by dropping of drainage and artesian water. Their presence attracts a large number of birds to the coast of Sivash, such as hydrophiles, limnophiles, campophiles, and sclerophiles, which, in the post-nesting, migration and winter periods, accumulate here in large numbers.

Despite the high mobility of birds in space (fodder flights, migratory, and seasonal migration) and their dynamism over time (sequential change of numbers and species composition during the annual cycle), ornithological areas should be distinguished by a comparison of their numbers, not species composition. It gives an opportunity to reveal more deeply the peculiarities of avifauna of each landscape to establish the structure and topography of their areas within the researched region, taking into account their ecological peculiarities (Strautman, 1954). The complexity of biogeographical zoning is due to the fact that the widespread presence of species depends on several groups of factors, such as modern and historical, and zonal and azonic (Neronov, Lushekyna, 1980). Therefore, ornithological zoning should be carried out with compulsory consideration of modern state of conditions that determine the population of birds of a certain subregion (climate, hydrology, habitats, landscapes, etc.). Based on this, the different components of landscape (relief, soil, reservoirs, and vegetation) for birds are factors of environment, peculiarities of their species composition, and the number and distribution depending on existence and state.

Traditionally, zoogeographical division into high-ranking regions such as regions and subregions has been carried out with determination of the number of families, genera, and species, with further association of territories with common taxonomic units (Holt et al., 2013). But for the selection of provinces and regions, species composition has been determined and compared, which depends on modern ecological conditions of different territories (Puzanov, 1938). Herewith, the main category of regional zoning along with "species" is "landscape," and its criterion is quantitative correlation of species in different landscapes (Strautman, 1954). That is why, by comparing the landscape regions or their individual parts with these indicators, it is possible to make an optimal scheme of ornithological zoning of the researched region. Thus, ornithological zoning is performed on the basis of domination (correlation of number of individuals) of different ornithological faunistic complexes; according to Voinstvenskyi (1960), in the steppe zone of Europe, five ornithological faunistic complexes have been singled out, such as steppe (primarily species of campophiles and, in part, sclerophiles), forest (mostly dendrophiles), hudrophilous (hydrophiles and limnophiles of marine coasts and river valleys), cliffs, and ravines (mainly sclerophiles), except for azonic ornithological complex of settlements.

The above-mentioned analysis of landscape-zonal structure of region and peculiarities of its zoogeographical division as part of the steppe zone of Europe allows singling out five ornithological regions such as three zonal steppes and two azonic wetlands: flat interfluve-steppe, stony-steppe, sandy-steppe, floodplain-river, and liman-marine (Fig. 4). The main difference found in ornithological regions is the correlation of predominant and codominant ornithological faunistic complexes. The species composition and the number of birds of these complexes depend on predominant landscapes by area, in particular, on the peculiarities of predominant substrate (relief and soil), and through them, on the presence and nature of water bodies and vegetation (Table 2). We have ignored ornitholofical complexes of settlements because synanthropic species of birds of different ecological groups have dominated in them, such as sclerophiles, dendrophiles, and, in part, limnophiles, due to falling out of outoctonous, such as steppe and marine campophiles and hydrophilous, which devoid of necessary conditions of existence.

1. Flat interfluve-steppe ornithological region: It covers a large part of Primorskyi lowland steppe and Prysyvasko–Pryazovskyi lowland steppe without maritime strip and adjacent marine water surfaces, limans, and bays, including Sivash. It is characterized by predominantly gently wavy relief, including padings and valleys of small rivers. Sandy loamy, loamy, and clay soils are widespread here. They promote the development of relatively even vegetation cover such as grass on the flat interfluve and woody shrub in the moistest depressions. They are characterized by predominance of steppe birds, whose fate is slightly reduced in the west and the east due to woody-shrub and hydrophilous species along the river valleys, artificial forests, and

orchards. *Corvus frugilegus*, *Melanocorypha calandra*, *Falco vespertinus*, *Hirundo rustica*, and *Passer montanus* have dominated by number in the May car accounting, and the subdominants are *Lanius minor* Gmelin, *Sturnus vulgaris*, *Passer domesticus*, *Corvus monedula*, *Emberiza hortulana*, and *E. calandra* (Andriushchenko et al., 2015).

2. Stony-steppe ornithological region: It includes Tarkhankutyi elevated steppe, the Central Crimean plain steppe, Kerch wavy steppe, foothill forest steppe, and the southwestern territory of Crimean–Prysyvaskyi lowland steppe. It is the largest dry land by area of the selected ornithological regions. It is characterized by significant amplitudes of heights due to alternation of elevations from lowlands. The latter are often narrow and canyon-like, with stony soil, low power at places, and outcrops of hard rocks (limestones, marls, etc.). It causes an uneven development of vegetation, especially woody shrubs. Due to karst, moisture in low places is not delayed, and therefore, there are almost no natural freshwater bodies with appropriate vegetation. All these have contributed to the best preservation of natural steppes here, compared to all steppe zones of Ukraine. The steppe and desert-steppe species of birds in combination with forest dominate here, mainly in the foothills and on the Kerch Peninsula, and hudrophilous species are found along the seashores and artificial reservoirs (ponds on rivers, canals with reservoirs, and also technical reservoirs, mainly in places of discharge of water from treatment plants of large cities). By numbers, in spring car accounting within district, *Melanocorypha calandra*, *Corvus frugilegus*, *Sturnus vulgaris*, *Hirundo rustica*, and *Emberiza calandra* have dominated. *Oenanthe oenanthe*, *O. pleschanka* Lepechin, and *Oenanthe isabellina* Temminck are also widely represented. The peculiarity of this ornithological region is the greatest preservation of rare species within the steppe, such as *Tadorna ferruginea*, *Aquila heliaca* Savigny, *Anthropoides virgo*, *Otis tarda*, *Tetrax tetrax*, *Burhinus oedicnemus*, *Emberiza melanocephala*, and high number of *Buteo rufinus* Cretzschmar (Andriushchenko, 2007). *Corvus frugilegus*, *Melanocorypha calandra*, *Pica pica*, *Falco vespertinus*, *Hirundo rustica*, *Columba palumbus*, *Emberiza calandra*, *Falco tinnunculus*, *Corvus cornix*, and *Sturnus vulgaris* have been found to be numerous in accounting of Tarkhankutska Upland. Due to its peninsular position, marine species is added to zonal species. *Melanocorypha calandra*, *Sturnus vulgaris*, *Emberiza calandra*, *Hirundo rustica*, *Corvus frugilegus* as well as *Merops apiaster*, *Anthus campestris*, *Emberiza hortulana*, *Apus apus*, *Corvus cornix*, *C. corax*, *Luscinia megarhynchos*, and *Alauda arvensis* are found in foothills. *Melanocorypha calandra*, *Corvus frugilegus*, *Sturnus vulgaris*, *Hirundo rustica*, *Emberiza calandra*, *Lanius minor*, *Tadorna tadorna*, *Falco tinnunculus*, *Columba palumbus*, and *Sylvia communis* Latham dominate in the Kerch Peninsula. A high number of *Sturnus roseus* grows rapidly and thrives for several years. Due to its peninsular position and widespread presence of freshwater reservoirs, numerous hudrophilous species, such as *Podiceps cristatus*, *Ardea cinerea*, *Cygnus olor* Gmelin, *Anas platyrhynchos*, *A. querquedula*, *Aythya ferina*, *Himantopus himantopus*, *Charadrius alexandrinus*, *Larus genei* Breme, *L. cachinnans* Pallas, *L. melanocephalus* Temminck, *Sterna hirundo*, and *Gelochelidon nilotica* Gmelin, are found.

3. Sandy-steppe ornithological region: Its borders almost coincide with lower Dnieper terrace-delta steppe, except for the Dnieper valley and the maritime strip with adjacent limans and marine bays. It is characterized by the flattest relief within dry steppe enclave without rivers and other watercourses, but with numerous dunes on sandy arenas and a large number of small streams of sloping banks. Due to lack of fertile soil, vegetation of sandy arenas is poorly developed, except for *Pinus robinia* artificial forests along their perimeter. Here, thanks to artificial forests on the periphery of sandy arenas and mostly natural woody-shrubby vegetation by numerous small streams of sloping banks, forest species of birds in combination with steppe species have dominated. *Corvus frugilegus*, *Hirundo rustica*, *Sturnus vulgaris*, *Passer montanus*, and *Emberiza calandra* dominated in the May car counting by number (in descending order of the number of individuals), and the subdominants are *Melanocorypha calandra*, *Passer domesticus*, *Fringilla coelebs*, and *Carduelis carduelis*. The central part of sandy-steppe ornithological region is not far away (maximum up to 10–20 km) from its surrounding large reservoirs (lower reaches of Dnieper, Dnieper-Buzkyi liman, Yahorlytska, Tendrivska, Dzharylgachska, and Karkinitska bays of the Black Sea). Therefore, wetland birds, which are capable of obtaining food on dry land, regularly make their fodder flights here. Among them, the most common are *Chlidonias leucopterus* Temminck, *Larus cachinnans*, and *Ichthyaetus melanocephalus* (Andriushchenko et al., 2015, Moskalenko, 2015).

4. Floodplain-river ornithological region. It is situated within the valley of lower Dnieper, including adjacent lakes and river mouth of tributaries. The river and woody-shrub species have dominated here, and sclerophiles are on steep banks. *Podiceps cristatus*, *Phalacrocorax carbo, Nycticorax nycticorax*, *Anas platyrhynchos*, *Aythya ferina*, *Fulica atra*, *Larus cachinnans*, *Chlidonias hybrida* Pallas, *Ch. niger*, *Sterna hirundo*, and *Acrocephalus arundinaceus* have been background in the May accounting from hudrophilous species. *Sturnus vulgaris*, *Hirundo rustica*, *Fringilla coelebs*, *Lanius collurio* and *L. minor*, *Passer domesticus* and *P. montanus*, *Merops apiaster* Linnaeus, and *Parus major* have dominated on the shores by number.

5. Liman-marine ornithological region. It consists of limans and marine bays, including Sivash, adjacent maritime strip, and the Crimean–Prysyvaska lowland steppe without its southwestern part. In the Crimean part, the border of district is furthest from the marine (Sivaske) coast due to widespread sowing of rice. Therefore, it depends significantly on the volume of water entering from the northern Crimean irrigation canal. A typical peculiarity of the wide strip of wetland landscapes of so-called "region of river valleys and marine coasts" is that in the west–east direction, it crosses with the Ukrainian dry steppe enclave. Therefore, within its boundaries, significant number of species of birds of three faunistic complexes such as forest, hudrophilous, and steppe are present. There is a significant difference between marine landscapes (coasts of seas, limans), whereby the areas besides salty water surface, solonchaks, beaches, spits, and islands have been dominated and landscapes of mouth area of river valley with large areas of reed thickets and limnetic deeps without overwater vegetation, woody-shrub valley, and meadow vegetation. It reflects undoubtedly numerical dominance of river or marine species of birds. The territory of this ornithological region is the most researched within the dry-steppe subzone of Ukraine (Winden et al., 1999; Siokhin et al., 2000; Stoilovsky et al., 2003). Marine species dominate, nesting mainly on numerous islands, spits, bays, and spatial solonchaks; it is often in large

colonies. In distilled parts, river species are added, such as *Phalacrocorax carbo*, *Egretta alba*, *Tadorna tadorna*, *Fulica*, *Charadrius alexandrinus*, *Vanellus vanellus*, *Himantopus himantopus*, *Recurvirostra avosetta*, *Tringa totanus*, *Ichthyaetus melanocephalus*, *Larus genei* and *L. cachinnans*, *Gelochelidon nilotica*, *Sterna hirundo*, *Glareola pratincola*, and so on, and steppe birds are in virgin areas.

Naturally, boundaries of these ornithological regions are quite conditional, not clear, and sometimes unstable. They can shift depending on the population, succession, climatic, or anthropogenic factors. For example, construction of the North Crimean Canal has led to occurrence and then significant expansion of area of irrigated land and rice sowing. As a result of this, many hudrophilous species in the 80s of the 20th century have started to nest en masse far from the coast of Sivash, in the depth of the Crimean–Prysyvaskyi lowland steppe. It has happened due to significant reduction of areas which are suitable for nesting of steppe species and locally complete loss of steppe–ornithological complex. After reduction of the amount of water used from the canal in the 90s, territory of nesting of hudrophilous birds, although it does not reduce significantly, but it is suitable for feeding and nesting of this group of birds, which has decreased significantly. Also, stopping of supply of water with the Northern Crimean Canal to Crimea in 2014 led to significant narrowing of liman-marine ornithological region within the Crimean Peninsula.

Conclusion

The scheme of ornithological zoning of the western enclave of dry steppes of Eurasia within Ukraine on the basis of zonal landscape structure of region has been dealt with in the article and is caused by its spatial heterogeneity of bird population only in the nesting period. But general ornithological zoning remains unspecified, based on the information about the state of ornithological complexes during all cycles of birds. Therefore, the given scheme of ornithological zoning requires more detailed revision using data summary about the population of birds in migration and winter periods.

Taking into account the significant anthropogenic transformation of natural landscapes, tempos and scales of their further changes, ornithological zoning should be carried out with obligatory consideration of the impact of anthropogenic processes and phenomena on birds. So, ornithological zoning should be dynamic to correspond to deep changes in avifauna caused by rapid and significant transformation of landscapes, such as anthropogenic, climatic, and others.

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