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## SPIDER ASSEMBLAGES (ARANEAE) OF THE HALOPHYTIC HABITATS OF THE BILOSARAISKA SPIT (UKRAINE): NEW DATA AND BIODIVERSITY ASSESSMENT

N. Yu. Polchaninova<sup>1</sup>, \*, O. M. Bronskova<sup>2</sup>, O. I. Bronskov<sup>2</sup> & T. Yu. Markina<sup>3</sup>

<sup>1</sup> V. N. Karazin Kharkiv National University, Svobody sq., 4, Kharkiv, 61022 Ukraine

<sup>2</sup> Meotyda National Park, Primorska st., 12, Urzuf, Mariupol District,  
Donetsk Region, 87455 Ukraine

<sup>3</sup> H. S. Skovoroda Kharkiv National Pedagogical University,  
Alchevskykh st., 29, Kharkiv, 61002 Ukraine  
E-mail: n.polchaninova@karazin.ua

\* Corresponding author

E-mail: n.polchaninova@karazin.ua

N. Yu. Polchaninova <https://orcid.org/0000-0003-4605-8788>

O. M. Bronskova <https://orcid.org/0000-0002-7762-7229>

O. I. Bronskov <https://orcid.org/0000-0002-3265-3810>

T. Yu. Markina <https://orcid.org/0000-0002-6313-9814>

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**Spider assemblages (Araneae) of the halophytic habitats of the Bilosaraiska Spit (Ukraine): new data and biodiversity assessment.** Polchaninova, N. Yu., Bronskova, O. M., Bronskov, O. I. & Markina, T. Yu. — Halophytic habitats are sites of conservation concern due to their rich flora and fauna. Spiders are a diverse and abundant group of salt marsh arthropods that can serve as bioindicators of a habitat's preservation and conservation value. From March to November 2020, we studied ground-dwelling spiders on the salt marsh and on the bay shore of the Bilosaraiska Spit in the Sea of Azov, within the Meotyda National Park. A total of 57 spider species were recorded, with 48 found on the bay shore and 41 on the salt marsh. The two habitats had similar species compositions, but varied in assemblage structure and individual abundance due to different eudominants: *Gnaphosa ukrainica* on the salt marsh and *Zodarion rubidum* on the bay shore. The former had its maximum abundance in October, while the latter was most numerous in mid-June and early August. By the end of 2020, a total of 92 spider species had been recorded in the halophytic habitats of the Bilosaraiska Spit, including the regionally rare species *Zelotes prishutovi*, *Nurscia albomaculata*, *Gnaphosa cumensis*, *G. saurica*, *Marinarozelotes adriaticus*, and *M. cumensis*. The spider assemblages were well preserved and demonstrated local specificity compared to other coastal halophytic habitats in Left-Bank Ukraine. Thus, the study habitats support a high spider diversity.

**Key words:** ground-dwelling arthropods, seasonal dynamics, biodiversity, salt marshes, protected areas, Donetsk Region.

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## Introduction

Salt marshes are endangered habitats, and many species are threatened due to habitat isolation, changes in tidal regime, and transformation under anthropogenic impacts (Luković et al., 2020; Gupta et al., 2024). Given that all organic components of ecosystems are interconnected and respond differently to environmental changes, biodiversity conservation requires an integrated approach (Boetzla et al., 2021; Solascasas et al., 2022). Multi-taxon studies are particularly important in protected areas for implementing optimal management. Meanwhile, the study of individual taxocenes, especially the most common groups of organisms, can also provide a basis for assessing habitat conservation values and the impact of various factors on ecosystem development (Ridel et al., 2021). In particular, spiders are widely used as bioindicators in ecological and conservation studies (Marc et al., 1999; Pearce & Venier, 2006; Gerlach et al., 2013; Solascasas et al., 2022), including the impact of climatic changes and human activity in salt marshes (Pétillon et al., 2006, 2007, 2008).

Inland and littoral marshes are important habitats for spiders with specific microhabitat requirements (Gajdoš et al., 2022), which enrich local faunas (Gajdoš et al., 2019; Mossakowski & Irmeler, 2023). Spiders of the Bilosaraiska Spit and their habitat distribution were thoroughly examined by O. Prokopenko in the 2000s (Prokopenko, 2010). These data were included in the Catalog of Spiders of Left-Bank Ukraine (Polchaninova & Prokopenko, 2013). Subsequent collections and material revisions were documented in the Supplement (Polchaninova & Prokopenko, 2017). By 2017, 176 spider species had been recorded from the Bilosaraiska Spit. However, little was known about the species' seasonal dynamics and the structure of spider assemblages. Our research aims to update the spider species list of the Bilosaraiska Spit, analyze seasonal dynamics of dominant species in halophytic habitats, and estimate spider diversity as of the end of 2020.

## Material and Methods

### Study area and the sampling sites

The Bilosaraiska Spit is located in southeastern Ukraine on the northern coast of the Sea of Azov, within the Mariupol district of the Donetsk Region. This is a typical Azov-type sea spit that extends from northeast to southwest (Tyshchenko, 2006). It has an accumulative origin; its formation is based on marine alluvium and river and beach deposits, such as sand, shells, and coastal abrasion material. The Azov spits are estimated to be approximately 2,000 years old (Nepsha, 2012). Due to alluvial processes, the spit is constantly growing. Currently, the spit is approximately 10 km wide in the continental part and slightly more than 12 km long. Its elevation above sea level does not exceed 3 meters.

The spit supports a variety of habitats, typical of the coastal zone of southern Ukraine: saline meadows, wet and dry saline marshes, saline bogs, shallow, drying-up water bodies, and estuarine wetland complexes. The sandy upper parts between them are covered with psammophytic steppe. The spit is under strong anthropogenic influence: the territory adjacent to the continental shelf is plowed and intersected by forest shelterbelts; nearly the entire eastern coast is built up with two resort villages. The western part of the spit

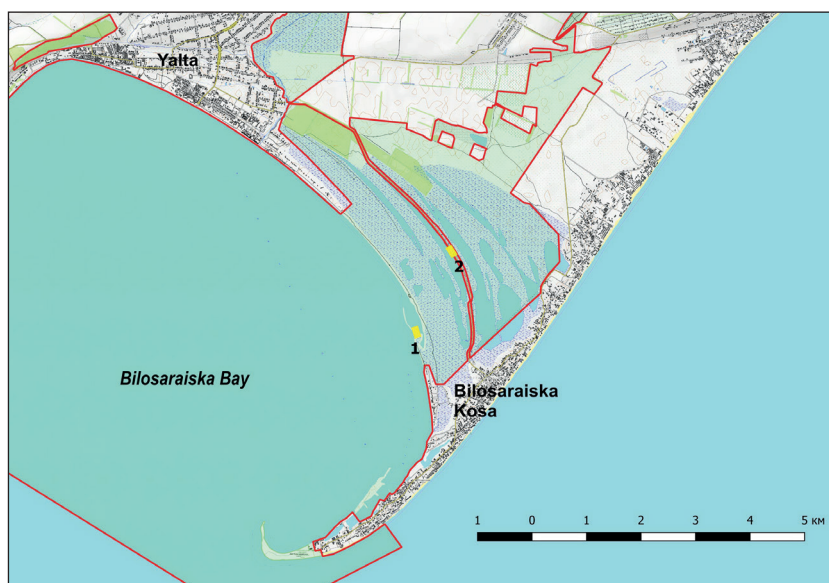


**Fig. 1.** Map of collecting localities. Base map: OpenTopoMap. Red lines — boundaries of Meotyda National Park; yellow lines — transects of pitfall traps at the study sites: 1 — bay shore, 2 — salt marsh

also neighbors the village. A little over 1,500 hectares of preserved natural complexes, divided into separate clusters, are protected in the Meotyda National Park (further NP). The restriction of economic activity is only possible in this territory.

Our research was conducted at two sites (Fig. 1).

Site 1 is located on the western side of the spit, on the shore of the Bilosaraiska Bay, on a sand-shell elevation between the beach and a swampy area of reed marshes (Fig. 2, a). According to the classification of habitats of the steppe zone of Ukraine (Didukh, 2020), this habitat type is specified as B:1.222 “White” sand-shell dunes at the initial stages of vegetation formation. According to the 2007 EUNIS (European Nature Information System) classification, it belongs to B1.324 Pontic white dunes and is included in Resolution 4 of the Bern Convention. At the study site, the vegetation constitutes a narrow (on average 13 m wide), sparsely covered linear strip between a non-vegetated sand beach and the reed marshes. The species composition is typical of the dune vegetation in the Northern Azov Sea region. The most abundant are *Leymus sabulosus* (M.Bieb.) Tzvelev, *Artemisia santonica* L., *Crambe pontica* Steven ex Rupr., as well as wetland species *Phragmites australis* (Cav.) Trin. ex Steud. and *Rumex crispus* L. The vegetation cover is very patchy. Grass height ranges from 10 to 120 m, and the total vegetation cover ranges from 20 to 60%, with herb layer cover of 20–50%. The dry litter cover is about 20–50%, and the moss and lichen cover is absent. The altitude above sea level is only 1 m.

Site 2 is located in the central part of the spit on the edge of a dried-up, elongated brackish reservoir. It was not filled during the season due to insufficient rainfall. Seawater enters the canal very rarely, only in certain years. The last time this happened was in 2014. The vegetation is combined in nature and forms three belts changing along moisture and salinity gradients. The salt marsh bottom was bare in spring. Later, a very sparse cover of *Salicornia prostrata* Pall. developed along its pe-

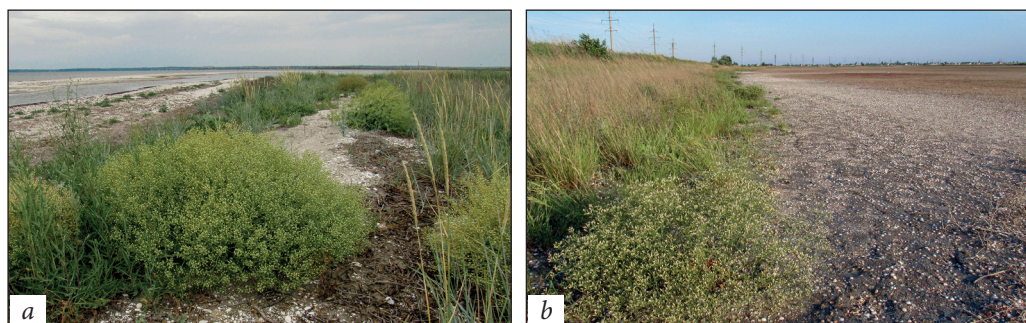


**Fig. 2.** Study habitats in the Bilosaraiska Spit. *a* — bay shore, *b* — salt marsh. Photo O. Bronskova

riphery on silty-sandy soil with an admixture of shells. The trap transect was set up at a distance of 0.5–1.0 m from the edge of the bare soil. The perimeter of the reservoir is surrounded by a narrow (up to 1.5 m) strip of low-growing halophilic vegetation dominated by *Puccinellia fominii* Bilyk and *Limonium caspium* (Willd.). The total vegetation cover of this habitat was 15–45%, herb layer cover 15–40%, litter 0–5%, and the moss and lichen layer was absent. The grass cover was 10–40 cm. The next vegetation belt covers a gentle slope 7–8 m wide, dominated by *Elytrigia elongata* (Host) Nevski, and accompanied by *Artemisia santonica* L. and *Limonium meyerii* (Boiss.) Kuntze. In the upper part, this slope is limited by an artificial road embankment. Thus, three habitats are observed here in the immediate vicinity: B:4.11 Saltmarshes without vegetation or with a predominance of annuals (Thero-Salicornietea), B:4.12 Saltmarshes with a predominance of perennials (chamephytes, hemicryptophytes) (Kalidietea foliati), and E:1.443 Halophytic meadows dominated by *Elytrigia elongata* (Didukh, 2020). According to the EUNIS classification, they correspond to the habitats A2.5 Coastal saltmarshes and saline reedbeds, E6.224 Western Pontic solonchak communities, E6.2227 Western Pontic tall grass and rush saline beds. All of them are included in the Bern Convention.

It is important to note that, at the time of the study, neither site was subject to direct human pressure, such as sand mining, livestock grazing, or recreational trampling.

### Material collection and data analysis

Spiders were collected with pitfall traps. Ten traps were set in a line, 10 meters apart at each study site. We used 300-gram plastic containers filled to 2/3 with 4% formalin as a preservative. The traps were checked every 7–13 days from April 24 to November 16, 2020. There was a one-month break from mid-June to mid-July due to technical circumstances. One sample consisted of material from 10 traps collected between the checks. A total of 34 samples were processed: 17 from each habitat. Spiders were selected and placed in 70% ethanol for identification purposes. The material amounted to 2,652 individuals (1,827 adults). Spiders and other invertebrates are deposited in the Museum of Nature of V. N. Karazin Kharkiv National University (KUMN, curators O. Drovalenko, N. Polchaninova & I. Muraviova)

We used the website Spiders of Europe (Nentwig et al., 2026) and Les araignées de Belgique et France (Oger, 2026) for the species identification. The list of species is arranged alphabetically by family and within families; the nomenclature corresponds to the World Spider Catalog (WSC, 2026). The geographic distribution of rare spe-

cies was determined using the WSC with further refinements in the respective country catalogs. The conservation values of species were assessed based on their distribution and habitat preference in Ukraine (Kovblyuk & Kastrygina, 2015; Polchaninova & Prokopenko, 2019; Hirna & Zhukovets, 2022; Iosypchuk, 2023). Species names of vascular plants are given according to the Nomenclatural checklist of vascular plants of Ukraine (Mosyakin & Fedoronchuk, 1999). We considered the species' geographic range, ecological flexibility, and habitat vulnerability. We also compared species composition of ground-dwelling spiders in salt marshes and bay shores at five sites in the Donetsk (Bilosaraiska and Kryva spits, Meotyda NP), Zaporizhzhia (Pryazovskyi NP), and Kherson (Black Sea Biosphere Reserve, Dzharylhatskyi NP) Regions to identify their distinctiveness.

Ecological groups of spiders were classified based on species' habitat distribution in the southern part of the East European Plain. (Polchaninova & Prokopenko, 2013; Ponomarev et al., 2016; Polchaninova & Iosypchuk, 2024). We distinguished twelve groups: (1) generalists (occur in various habitats across their geographic range), (2) southern generalists (species have wider or narrower ranges, being polytopic in the south of the East European Plain), (3) forest-grassland species (inhabit open forests and grasslands of various humidity), (4) forest-wetland, (5) wetland-mesic grassland, (6) grassland, (7) dry grassland, (8) steppe, (9) halophilic (occur exclusively or mainly in saline lands), (10) halophilic-dry grassland, (11) riparian species, and (12) not specified due to poor information on preferred habitats.

The dominance structure of spider assemblages was estimated according to the Engelman scale: E — eudominant (>40% individuals in the assemblage), D — dominant (12.5–39.9%), Sd — subdominant (4.0–12.4%), R — recedent (1.3–3.9%), Sr — subrecedent (<1.3%) (Engelmann, 1978). The Sørensen index of faunistic similarity and the Renkonen index of biocenotic similarity were used to compare spider assemblages of the two habitats. Their alpha diversity was estimated using the Pielou index of evenness, the Shannon index of species diversity, and the Menhinick index of species richness (Magurran, 1991). The indices were calculated using the PAST5 program; bootstrap analysis was conducted to assess the variability of the index values (Hammer et al., 2001).

Seasonal dynamics of spider abundance (ind./10 trap-days) was calculated for adults and juveniles together. Alpha diversity and assemblage structure were estimated for adult spiders only, because most juveniles cannot be identified at the species level. The indices were determined for the entire period and for three two-month periods corresponding to the sampling dates: 24 April–19 June, 16 July–14 September, and 15 September–16 November 2020.

We conducted a correlation analysis to determine whether spider activity density is dependent on the air temperature. We used data from the Mariupol weather station (WMO ID 34712) for 2020 and calculated the mean daily temperature for each sample period. According to climatic indicators, 2020 was moderately warm and fairly humid, with an unstable and short winter (+6 °C/–19.5 °C), a smooth transition to a cool spring, a moderately hot summer (mean temperature +25.5 °C), and a short warm autumn (mean October temperature +15 °C.) Observations began when the mean daily temperature rose steadily above 10 °C, and ended when it fell below 0 °C. The seasonal activity of two eudominant species, *Zodarium rubidum* and *Gnaphosa ukrainica*, was analyzed using the Spearman coefficient. This coefficient is

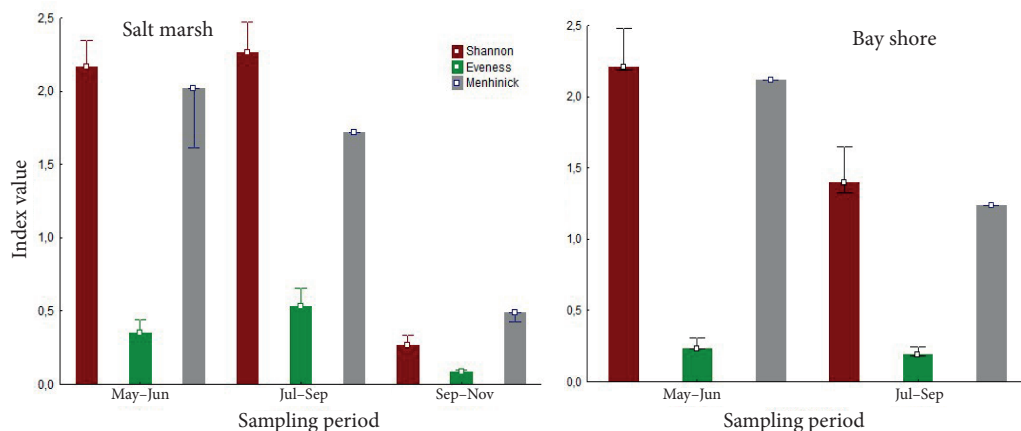


Fig. 3. Seasonal changes of spider alpha diversity in the studied halophytic habitats of the Bilosaraiska Spit in 2020

preferable when working with small and/or uneven samples that exhibit abnormal data distribution ranging from zero to extreme values. The Spearman coefficient is based on data ranking and enables accurate detection of monotonic dependencies typical of time series. Statistical significance was assessed at  $p < 0.05$ .

## Results

During our study, 57 spider species of 16 families were collected: 48 on the bay shore and 41 on the salt marsh. The family Gnaphosidae was the most species-rich (16 species, 27.6% of the entire collection). The Lycosidae, a typical ground-dwelling family in various ecosystems, encountered only five species (8.6%), fewer than the Salticidae (9 species, 15.5%). Nine species were recorded from the Bilosaraiska Spit for the first time (*Devade tenella*, *Gnaphosa ukrainica*, *Zelotes prishhutovi*, *Sintula retroversus*, *Tenuiphantes flavipes*, *Hogna radiata*, *Ero koreana*, *Aellurillus v-insignitus*, *Nuscia albomaculata*), and 14 species were new to its halophytic habitats (Table 1).

The faunistic similarity of spider assemblages in the two study habitats was very high ( $I_{\text{Sørensen}} = 71.9\%$ ), whereas the biocenotic similarity was very low ( $I_{\text{Renkonen}} = 16.1\%$ ). Each assemblage had one eudominant species with extremely high abundance: *Zodarion rubidum* on the bay shore (55.5% of collected individuals) and *Gnaphosa ukrainica* on the salt marsh (78.4%). In both habitats, the dominant complexes also included two subdominants: *Gnaphosa saurica* (12.4%) and *Civizelotes caucasicus* (6.5%) on the bay shore, and *Devade tenella* (5.2%) and *Zodarion rubidum* (4.2%) on the salt marsh. Consequently, the alpha diversity of both assemblages was low (see Table 1), especially on the salt marsh.

Spider alpha diversity varied throughout the season (Fig. 3). On the bay shore, the Shannon and Menhinick indices declined from May/June to July/mid-September with approximately stable evenness. In autumn, only five adult individuals were found, which did not provide material for assessment. The number of species dropped from 39 in May/June to four in September/November.

On the salt marsh, species richness declined gradually from May/June to September/November (25, 18, and 15 species, respectively). The evenness and Shannon

Table 1. Spider species composition, assemblage structure, and ecological traits in the studied halophytic habitats of the Bilosaraiska Spit. 2020

| Taxa                                                       | Habitat         |                  | Ecological group         |
|------------------------------------------------------------|-----------------|------------------|--------------------------|
|                                                            | bay shore       | salt marsh       |                          |
| Family Argyronetidae                                       |                 |                  |                          |
| !! <i>Devade tenella</i> (Tystshenko, 1965)*               | 13(2.1)         | <b>62(5.2)</b>   | halophilic               |
| Family Cheiracanthiidae                                    |                 |                  |                          |
| <i>Cheiracanthium</i> sp.                                  | 1(0.2)          | —                | not specified            |
| Family Dysderidae                                          |                 |                  |                          |
| <i>Dysdera crocata</i> C. L. Koch, 1838                    | 1(0.2)          | 10(0.8)          | south generalist         |
| Family Gnaphosidae                                         |                 |                  |                          |
| <i>Civizelotes caucasius</i> (L. Koch, 1866)               | <b>41(6.5)</b>  | 9(0.8)           | steppe                   |
| <i>Drassodes lapidosus</i> (Walckenaer, 1802)              | 20(3.2)         | 8(0.7)           | forest-grassland         |
| ! <i>Drassylus praeficus</i> (L. Koch, 1866)               | 1(0.2)          | 1(0.1)           | grassland                |
| <i>Gnaphosa cumensis</i> Ponomarev, 1981 ×                 | —               | 6(0.5)           | halophilic               |
| <i>G. leporina</i> (L. Koch, 1866)                         | 2(0.3)          | 1(0.1)           | grassland                |
| <i>G. saurica</i> Ovtsharenko, Platnick & Song, 1992 ×     | <b>78(12.4)</b> | 26(2.2)          | halophilic               |
| !! <i>G. ukrainica</i> Ovtsharenko, Platnick & Song, 1992* | 3(0.5)          | <b>938(78.4)</b> | halophilic               |
| ! <i>Haplodrassus bohemicus</i> Miller & Buchar, 1977      | 2(0.3)          | —                | steppe                   |
| <i>H. dalmatensis</i> (L. Koch, 1866)                      | 1(0.2)          | —                | steppe                   |
| <i>Marinarozelotes adriaticus</i> (Caporiacco, 1951) ×     | 3(0.5)          | 3(0.2)           | not specified            |
| <i>M. cumensis</i> (Ponomarev, 1979)*                      | 1(0.2)          | —                | halophilic               |
| <i>M. malkini</i> (Platnick & Murphy, 1984)*               | 10(1.6)         | 1(0.1)           | steppe                   |
| <i>Micaria rossica</i> Thorell, 1875*                      | 1(0.2)          | —                | steppe                   |
| ! <i>Nomisia aussereri</i> (L. Koch, 1872)                 | 1(0.2)          | —                | steppe                   |
| ! <i>Zelotes electus</i> (C. L. Koch, 1839)                | 4(0.6)          | —                | drygrassland             |
| <i>Z. eugenei</i> Kovblyuk, 2009                           | 2(0.3)          | 1(0.1)           | steppe                   |
| <i>Z. longipes</i> (L. Koch, 1866)                         | 1(0.2)          | 2(0.2)           | forest-grass-land        |
| !! <i>Z. prishutovae</i> Ponomarev & Tsvetkov, 2006 ×      | —               | 2(0.2)           | halophilic-dry grassland |
| Family Lathyidae                                           |                 |                  |                          |
| ! <i>Tolokoniella stigmatisata</i> (Menge, 1869)           | —               | 1(0.1)           | forest-grassland         |
| Family Linyphiidae                                         |                 |                  |                          |
| ! <i>Mecopistes peusi</i> Wunderlich, 1972                 | —               | 1(0.1)           | grassland                |
| !! <i>Sintula retroversus</i> (O. Pickard-Cambridge, 1875) | 2(0.3)          | 3(0.3)           | southern generalist      |
| ! <i>Stemonyphantes lineatus</i> (Linnaeus, 1758)          | —               | 1(0.1)           | forest-grassland         |
| !! <i>Thenuiphantes flavipes</i> (Blackwall, 1854)         | —               | 1(0.1)           | forest-wetland           |
| Family Liocranidae                                         |                 |                  |                          |
| ! <i>Agroeca cuprea</i> Menge, 1873                        | 1(0.2)          | 1(0.1)           | forest-grass-land        |
| ! <i>A. dentigera</i> Kulczyński, 1913                     | 1(0.2)          | —                | not specified            |
| <i>Liocranoeca spasskyi</i> Ponomarev, 2007                | 1(0.2)          | —                | southern generalist      |

Continued Table 1

| Taxa                                            | Habitat   |            | Ecological group          |
|-------------------------------------------------|-----------|------------|---------------------------|
|                                                 | bay shore | salt marsh |                           |
| Family Lycosidae                                |           |            |                           |
| <i>Arctosa cinerea</i> (Fabricius, 1777)        | 2(0.3)    | —          | riparian                  |
| <i>A. leopardus</i> (Sundevall, 1833)           | 1(0.2)    | 1(0.1)     | forest-wetland            |
| <i>!!Hogna radiata</i> (Latreille, 1817)        | 1(0.2)    | 10(0.83)   | steppe                    |
| <i>Pardosa luctinosa</i> Simon, 1876            | 2(0.3)    | 1(0.1)     | halophilic                |
| <i>Trochosa ruricola</i> (De Geer, 1778)        | 1(0.2)    | 1(0.1)     | southern generalist       |
| Family Mimetidae                                |           |            |                           |
| <i>!!Ero koreana</i> Paik, 1967*                | 3(0.5)    | 2(0.2)     | steppe                    |
| Family Philodromidae                            |           |            |                           |
| <i>Rhyzodromus fallax</i> (Sundevall, 1833)     | 1(0.2)    | —          | halophilic-dry grassland  |
| <i>Rh. histrio</i> (Latreille, 1819)            | 5(0.8)    | 2(0.2)     | dry grassland             |
| <i>Thanatus striatus</i> C. L. Koch, 1845       | 2(0.3)    | 1(0.1)     | wetland-mesic grassland   |
| <i>Th. vulgaris</i> Simon, 1870                 | 2(0.3)    | —          | steppe                    |
| Family Pisauridae                               |           |            |                           |
| <i>Pisaura mirabilis</i> (Clerck, 1757)         | 3(0.5)    | 4(0.3)     | forest-grass-land         |
| Family Salticidae                               |           |            |                           |
| <i>!!Aelurillus v-insignitus</i> (Clerck, 1757) | 1(0.2)    | 2(0.2)     | dry grassland             |
| <i>!Attulus ammophilus</i> (Thorell, 1875)*     | 1(0.2)    | 2(0.2)     | not specified             |
| <i>!A. zimmermanni</i> (Simon, 1877)            | 2(0.3)    | —          | forest-grass-land         |
| <i>Euophrys frontalis</i> (Walckenaer, 1802)    | 1(0.2)    | —          | forest-grass-land         |
| <i>Pellenes allegrii</i> Caporiacco, 1935*      | 10(1.6)   | 9(0.8)     | halophytic-dry grassland  |
| <i>P. brevis</i> (Simon, 1868)*                 | 3(0.5)    | 2(0.2)     | halophilic -dry grassland |
| <i>P. nigrociliatus</i> (Simon, 1875)           | 1(0.2)    | 5(0.4)     | steppe                    |
| <i>!Phlegra fasciata</i> (Hahn, 1826)           | 1(0.2)    | —          | forest-grass-land         |
| <i>Pseudomogrus vittatus</i> (Thorell, 1875)*   | 12(1.9)   | —          | halophilic -dry grassland |
| Family Theridiidae                              |           |            |                           |
| <i>Statoda albomaculata</i> (De Geer, 1778)     | 9(1.4)    | 2(0.2)     | dry grassland             |
| Family Thomisidae                               |           |            |                           |
| <i>Runcinia grammica</i> (C. L. Koch, 1837)     | —         | 1(0.1)     | steppe                    |
| <i>Spiracme striatipes</i> (L. Koch, 1870)      | —         | 4(0.3)     | dry grassland             |
| <i>X. cristatus</i> (Clerck, 1757)              | —         | 3(0.3)     | generalist                |
| <i>X. kochi</i> Thorell, 1872                   | 3(0.5)    | 2(0.2)     | generalist                |
| <i>!X. laetus</i> Thorell, 1875*                | 3(0.5)    | 3(0.3)     | steppe                    |

End Table 1

| Taxa                                                    | Habitat                |                         | Ecological group          |
|---------------------------------------------------------|------------------------|-------------------------|---------------------------|
|                                                         | bay shore              | salt marsh              |                           |
| Family Titanoecidae                                     |                        |                         |                           |
| <i>!!Nursia albomaculata</i> (Lucas, 1846) <sup>×</sup> | 20(3.2)                | 10(0.8)                 | halophilic -dry grassland |
| Family Zodariidae                                       |                        |                         |                           |
| <i>!Zodarion rubidium</i> Simon, 1914                   | <b>350(55.5)</b>       | <b>51(4.3)</b>          | not specified             |
| Total individuals                                       | 631                    | 1196                    | —                         |
| Total species                                           | 48                     | 41                      | —                         |
| Alpha-diversity indices                                 |                        |                         |                           |
| Menhinick index                                         | 1.911                  | 1.186                   | —                         |
| Shannon index                                           | 1.983<br>(1.952/2.197) | 1.132<br>(1.049/1.240)  | —                         |
| Evenness                                                | 0.151<br>(0.147/0.188) | 0.0786<br>(0.070/0.085) | —                         |

Notes: !! — the first record from the Bilosaraiska Spit; ! — the first record from the halophytic habitats of the Bilosaraiska Spit; × — species of conservation concern; number of individuals and share in assemblages of the dominant complex species are in bold; confidence interval for the dominance index values is given in parentheses. For the explanation of the ecological group names, see Material and Methods.

index were highest in July and mid-September, but the latter was not significantly higher than in May/June. The autumnal assemblage was the least diverse, but the richest in individual abundance (Fig. 4). Except for this peak, spider dynamic density in the salt marsh remained low throughout the season. On the bay shore, in contrast, it had two summer maxima and single finds in autumn.

Two eudominant species differ in their seasonal life cycles and determine the general dynamics of spider individual abundance in each habitat. *Zodarion rubidum* occurred on the bay shore from early May to mid-September (Fig. 5). In May, only males were collected. Females appeared in the first half of June during the period of the first maximum of males. The second maximum of both sexes was fixed in the first decade of August. The juveniles also appeared in August and were not numerous until September. There was a weak positive correlation between the number of individuals and mean daily temperature ( $p = 0.36$ ), but it was not statistically significant ( $p = 0.28$ ). Being subdominant in the salt marsh, *Z. rubidum* reached its maximum individual abundance in the last decade of July and, to a lesser degree, in the first half of September. In both cases, the species had a mixed sexual and age structure of its population. Single males had been fixed until the end of October.

*Gnaphosa ukrainica* was fixed on the salt marsh from early May to mid-November (Fig. 6). Adults and juveniles were present in May–June, but in small numbers. Their dynamic density began to increase in late September, reaching the highest numbers of both males and juveniles in late October. During this time, males were more numerous than juveniles and females. The peak for females occurred in early October. In November, juveniles became more dominant, with abundance higher

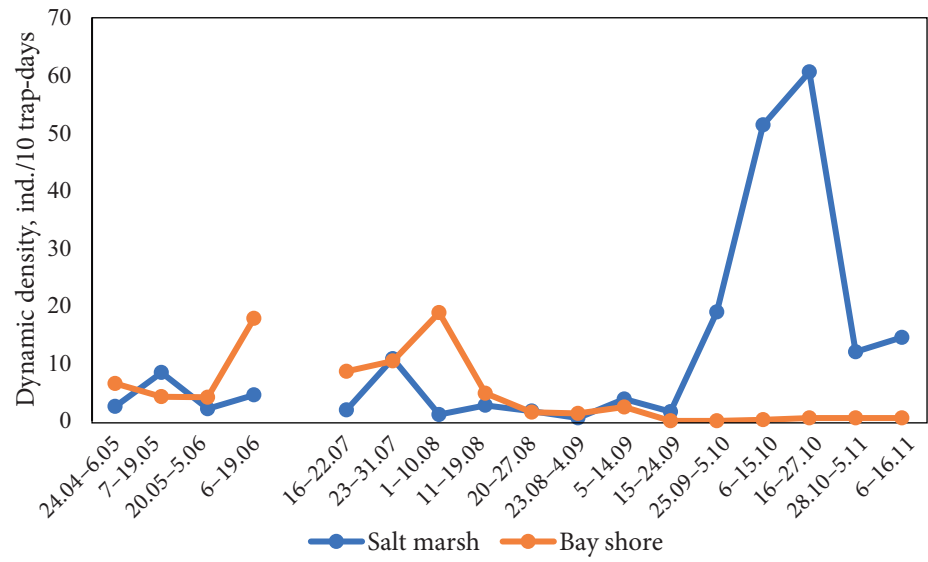


Fig. 4. Seasonal dynamics of spider individual abundance in the studied halophytic habitats of the Bilosara-iskia Spit in 2020

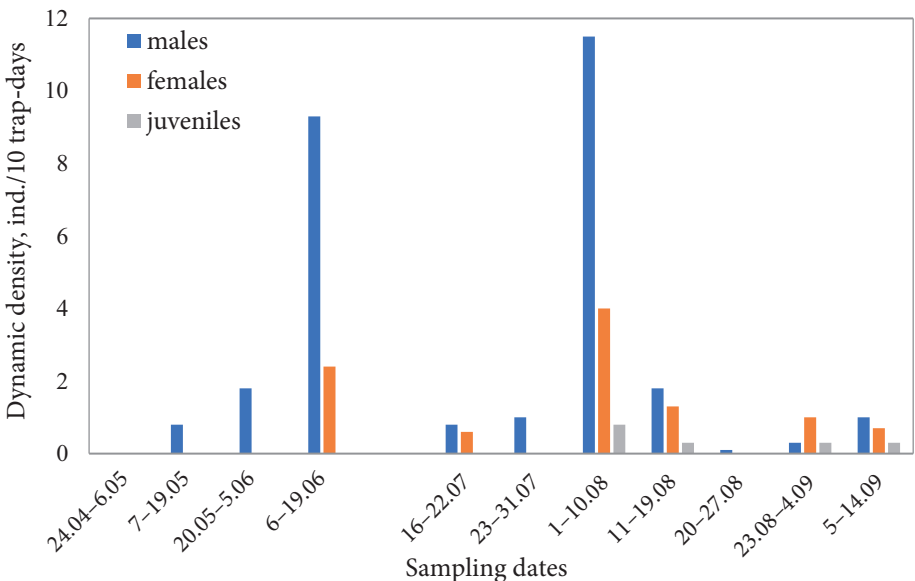


Fig. 5. Seasonal dynamics of *Zodarion rubidum* numbers on the bay shore of the Bilosaraiska Spit (May-September, 2020)

than in early October. The number of adults dropped sharply in the last month of autumn, especially among females. Interestingly, that October maximum was observed at a mean daily temperature of 13.8 °C. During the next sampling period, 28 October - 5 November, the temperature gradually decreased (10.6 °C) while the species abundance dropped from 59.7 ind./10 trap-days to 11.8 ind./10 trap-days. We fixed a weak negative correlation between the abundance of *G. ukrainica* and temperature ( $\rho = -0.13$ ), which was statistically insignificant ( $p = 0.73$ ).

In terms of habitat preferences, the richest group was that of steppe species (12 species, 22.6% of the species list). All of them occurred on the bay shore, while only seven species were fixed in the salt marsh (Table 1). The second-richest group

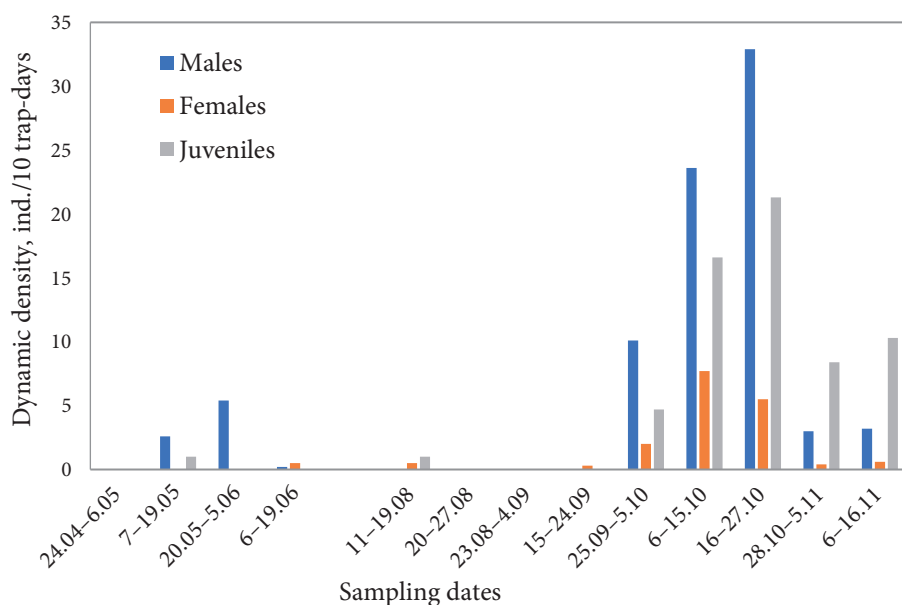


**Fig. 6.** Seasonal dynamics of *Gnaphosa ukrainica* numbers on the salt marsh of the Bilosaraiska Spit (May–November, 2020)

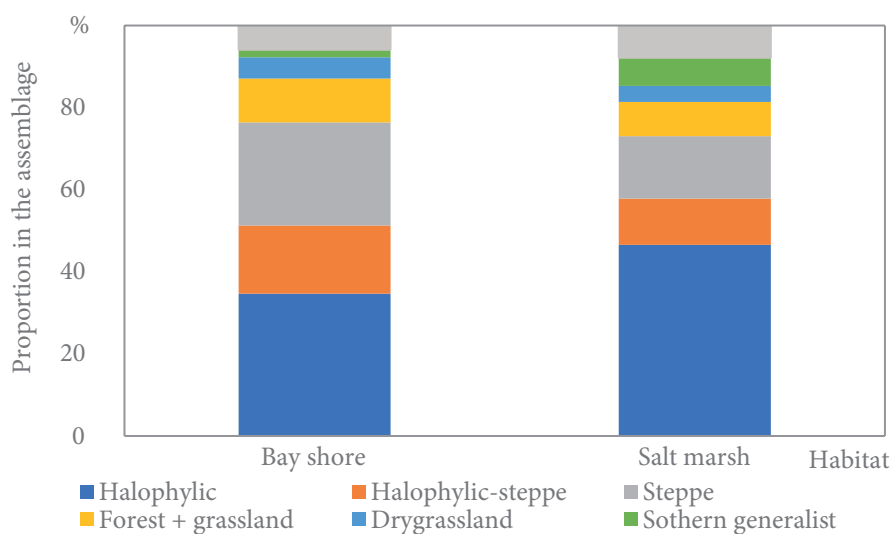


**Fig. 7.** Ratio of the ecological groups in spider assemblages in the studied halophytic habitats of the Bilosaraiska Spit, 2020

was forest-grassland species (9 species, 17.0%), i.e., species with wide ecological plasticity that avoid wetlands. The specialist halophilic and halophilic-dry grassland dwellers encountered five species each. All ecological groups, except the steppe one, were represented by a similar number of species in both habitats.

By contrast, the individual abundance of each group depended on its habitat. We excluded herb dwellers that occasionally fall into the traps and eudominants (*Z. rubidium* on the bay shore and *G. ukrainica* on the salt marsh) to see the proportion of other species in the assemblages. The three dominant groups are halophilic, steppe, and halophilic-dry grassland dwellers (Fig. 7). The share of the first group

was higher on the salt marsh, while the others had higher proportions on the bay shore. Southern generalists were also more abundant on the salt marsh due to the high number of *Dysdera crocata*. The eudominants, *Z. rubidum*, with unclear preferences, and halophilic *G. ukrainica* represent the overwhelming majority of individuals in their ecological group and, accordingly, in the assemblage.

## Discussion

Currently, 190 spider species are known from the Bilosaraiska Spit; of these, 92 species have been recorded from halophytic habitats. The recent collection contributed nine species to this list; four of them are new to the Donetsk Region.

*Zelotes prishutovi* has a narrow geographic range, outlined with the Volgograd Region of Russia in the north to the northeastern Mediterranean in the south (Polchaninova et al., 2021; Ponomarev, 2022; Nentwig et al., 2026). Although it was described from the steppe slopes in the south of the Rostov-on-Don Region (Ponomarev & Tsvetkov, 2006), in mainland Ukraine, *Z. prishutovi* has been found only on salt marshes in the Zaporizhzhia and Donetsk Regions.

*Nurscia albomaculata* has previously been recorded in Ukraine from Crimea (Kovblyuk & Kastygina, 2015), Zaporizhzhia (Polchaninova & Iosypchuk, 2024), Odesa (Thorell, 1875), and Kherson (Iosypchuk, 2024) Regions, where the species is common in halophytic and/or dry steppe habitats. The record from the Bilosaraiska Spit lies on the northern border of its geographic range within the East European Plain.

In Ukraine, *Hogna radiata* is a common species in the Crimea (Kovblyuk & Kastygina, 2015) and the south of Odesa (Deli et al., 2009) and Kherson (Iosypchuk, 2024) Regions, where it inhabits natural dry grasslands and salt marshes. The northernmost record in the East European Plain is located in the southern part of the Dnipropetrovsk Region, on ore mine waste dumps (Iosypchuk, 2025). The species is known from the Mediterranean to Central Asia; the record from Bilosaraiska Spit fills in the gap in the Donetsk Region.

The geographic range of *Gnaphosa ukrainica* extends from the left-bank part of the Kherson Region of Ukraine to West Siberia in the east and to Azerbaijan, Iran, and Turkmenistan in the south (Polchaninova et al., 2021; Nentwig et al., 2026). The species has a patchy distribution and is limited to halophytic habitats in the western part of its range.

Most of the recorded species are widespread in the southern part of the East European Plain (Polchaninova & Prokopenko, 2019; Ponomarev, 2022). Nevertheless, we can mention a few notable finds. *Sintula retroversus* occurs in southern Europe, the Caucasus, Turkey, and Israel. In Ukraine, it is known from Crimea (Kovblyuk & Kastygina, 2015), Mykolaiv (Gnelitsa, 2012), Donetsk and Kherson Regions (Polchaninova & Prokopenko, 2017) as a generalist of seaside habitats. The western range limits of *Gnaphosa cumensis*, *G. saurica*, and *Marinarozelotes cumensis* lie in the Kherson Region and Crimea, where they inhabit dry steppes and salt marshes along the seacoasts. *Marinarozelotes adriaticus* is distributed from Italy to China. In Ukraine, it has been found in the southern parts of the Donetsk and Kherson Regions in natural habitats. It has also been recorded from the iron ore mine

waste dumps in the Dnipropetrovsk Region and in gardens in the Kharkiv Region, likely as an introduced species (Iosypchuk, 2025; Polchaninova et al., 2025). In total, we recorded 16 species of conservation concern (Table 1) associated with isolated halophytic and/or dry-steppe habitats of the Bilosaraiska Spit.

According to literature and personal data, 153 species of ground-dwelling spiders have been recorded from saline marshes, saline meadows, and seashores within Left-bank Ukraine. A comparison of their assemblages has shown a high local variability. Only three species were fixed in all five study sites (*Pardosa luctionosa*, *Arctosa leopardus*, and *Trochosa ruricola*), and the three (*Civizelotes caucasius*, *Gnaphosa ukrainica*, and *Micaria rossica*) in four of them. Moreover, spiders are unevenly distributed across the same site, being absent from one or several neighboring habitats. First, this applies to halophilic or halophilic-dry grassland species. In the Pryazovskyi NP, *Gnaphosa ukrainica*, *Devade tenella*, and *Heriaeus horridus* were collected in two out of five salt marshes; *Pardosa luctinosa* and *Arctosa cinerea* inhabited only one salt marsh (Polchaninova & Iosypchuk, 2024). In the Dzharylhatskyi NP, *Gnaphosa ukrainica* dominated mainland salt marshes, while *Gnaphosa saurica* prevailed on the Dzharylhach Spit (Iosypchuk, 2025). *Pardosa vittata* and *Halocosa cereipes* were observed in some saline habitats of the Black Sea Biosphere Reserve and Dzharylhatskyi NP (Polchaninova & Prokopenko, 2017; Iosypchuk, 2025). The long-term studies of the Bilosaraiska Spit and the Black Sea Reserve revealed an equal number of spider species in halophytic habitats (92 and 91, respectively), but not more than half were common ( $I_{\text{Sørensen}} = 49.2\%$ ).

Species inhabiting salt marshes have different ecological traits. Our studies showed that halophilic specialists are not numerous in species (five to seven at each site), but abundant in individuals. These data coincide with studies of tidal salt marshes in France (Pétillon et al., 2006), salt marshes in Great Britain (Ford et al., 2017), and inland salt marshes in Slovakia (Gajdoš et al., 2022). Steppe species dominate the bay shores with relatively dense vegetation, while sand and/or shell beaches host poor spider communities (Polchaninova & Iosypchuk, 2024; O. Prokopenko, pers. data). Wetter conditions in the salt marshes surrounded by the dry steppe attract mesophilous forest-dry grassland species, although they never dominate in terms of individuals (Iosypchuk, 2025; O. Prokopenko, pers. data). Some species are identified as halophilic at a local scale, viz. *Haplodrassus minor* and *Agroeca lusatica* in Western France (after Pétillon et al., 2007), although they have wider habitat distribution. Perhaps, being tolerant to salinity changes (Ridel et al., 2021), they choose salt marshes as the most suitable habitats in the given region. *Crustulina sticta*, *Argenna patula*, and *Zelotes mundus* are classified as halophilic not only in France, but also in inland salt marshes in Slovakia (Gajdoš et al., 2022). In southern Ukraine, the first two species prefer salt marshes, although they have been found in meadows, banks of freshwater brooks, and forest shelterbelts. The latter has been recorded from steppe and agricultural fields, being less common in salt marshes (Polchaninova & Prokopenko, 2013, 2017). These findings suggest potential shifts in habitat preferences across the species' range driven by climatic differences and landscape transformation resulting from human activity.

The diversity of most ground-dwelling spiders is higher in the first part of the growing season. In southern Ukraine, this period occurs in May and June (Prokopenko, 2010; Polchaninova, 2021; Iosypchuk, 2025), due to the high variety and mating activity of the dominant families Gnaphosidae and Lycosidae (Nadolny, 2014; Kovblyuk et al., 2016).

These families dominated all the studied salt marshes, with Linyphiidae being numerous in the Black Sea Reserve and Bilosaraiska Spit. The sex ratio of spider species is male-biased in the early season, shifting to female-biased in mid-summer (Mallis & Hurd, 2005), which aligns with our studies. If the species has only one generation per year with hibernating juveniles, they comprise a significant part of the autumnal assemblage. However, several species have two mating periods a year or a main peak of abundance in late summer-autumn. Therefore, spider assemblages would be underestimated without the late-season samples (Braschler & Baur, 2016). Autumnal spiders are not rich in species but specific (Nadolny, 2014; Polchaninova et al., 2019). The October and November studies revealed a second main peak of *G. ukrainica*'s seasonal activity. Previously, only one peak in June was fixed (Polchaninova & Iosypchuk, 2024; Iosypchuk, 2025), but the research periods ended in late August. In autumn, the *G. ukrainica* population consisted of two generations: newborn juveniles and adults developed over the summer. Juveniles are a hibernating stage. This species has a broad geographic range that extends to West Siberia. Presumably, it is adapted to a wide range of temperatures. In our samples, it was active at mean daily temperatures from 5.4 °C to 24.5 °C. We assume that photoperiod is the main factor determining its activity. Data on the phenology of *G. ukrainica* have been received for the first time.

The functional traits of zodariid spiders have been analyzed in many species worldwide (Pekár, 2024). *Zodariion rubidum* is a European species that demonstrates spreading tendencies. It is currently known from Denmark to Spain and Italy, and from Great Britain to Georgia and southern Russia (Nentwig et al., 2026). Both males and females occur from April to October. In Central Europe, adults appeared in late April. Their activity increased until June and July, then gradually decreased until October (Pekár, Král, 2001). On the Bilosaraiska Spit, the species was also registered from late April to late October. However, they had different peaks of abundance in the two studied habitats, viz., mid-June and early August on the bay shore, and late July and early September on the salt marsh. Their activity had splashes and falls, in contrast to the gradual changes at the studied Slovakian site. The dynamic varieties may be explained by differences in observation methods (e. g., visual vs. pitfall traps) and weather conditions during the study periods.

In our studies, spider activity on the bay shore ended in mid-September. At the same time, various species were present on the salt marsh until late October. We hypothesize that the cracked soil of the salt marsh provided shelter for spiders and their prey in the crevices, maintaining moisture throughout the season. Moreover, located in a small depression apart from the sea, the salt marsh was partly protected from winds and the periodic splash of sea waves. Sparse vegetation on the mobile sand and shell surface on the bay shore was less comfortable in the autumnal period and did not create suitable conditions for hibernation.

## Conclusions

Spiders in the halophytic habitats of the Bilosaraiska Spit are species-rich and show assemblage composition that varies by habitat. They include salt marsh and steppe specialists, as well as species with a wide ecological range, with salt marsh specialists comprising the most individuals collected. Spider dynamic density varied seasonally,

showing an autumnal peak on the salt marsh and a summer peak on the bay shore, driven by the activity of the main dominants. The most recent arachnological studies on the Spit were conducted in 2020. As of that time, 92 species were known from its saline lands. Based on spider species richness and ecological traits, we can state that the study habitats were well preserved and host a specific halophytic community. The current assessment of their biodiversity state is impossible due to the Russian invasion; the results of our study could serve as a basis for assessing the impact of military actions on Ukraine's protected areas.

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