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Estimating distributional patterns of non-marine Ostracoda (Crustacea) and habitat suitability in the Burdur province (Turkey)

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A B S T R A C T

We explored distributional patterns and habitat preferences of ostracods in the Burdur province (Turkey). At 121 sites we recorded 35 taxa (22 recent, 13 sub-recent), of which 23 represent new records for the province. According to the Index of Dispersion and d-statistics, the individual species exhibited clumped distributions. Cosmopolitan species dominated (63.64%). A direct effect of regional factors (e.g., elevation) was not observed, while local factors (e.g., water temperature) best explained species distribution among habitats. Based on alpha diversity values, natural habitats (springs, ponds, creeks) were more suitable than artificial habitats (e.g., troughs, dams), suggesting that natural habitats define regional species diversity. Twenty-two of the recorded species had wider ecological ranges than previously reported. Cosmopolitan species appeared to suppress non-cosmopolitan species due to their wider ecological range.

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1. Introduction

Ostracods are bivalved aquatic crustaceans that are generally small (0.3–5.0 mm, although some marine species may reach up to 30 mm in length) (Meisch, 2000). Their outer chitinous carapace has an epidermis of low magnesium calcium carbonate (calcite) that covers a calcitic shell which can be fossilized in sediments (Chivas et al., 1986). Fossil ostracods can be used to reconstruct paleo-environmental conditions. The first (oldest) undoubted fossil ostracod dates back to the Silurian period about 425 mya. These fossils represent the oldest known microfauna (Delorme, 1991; Siveter, 2008; Williams et al., 2008). Desiccation and freezing resistant eggs, and active and passive dispersal mechanisms contribute to their wide distribution throughout the world (McKenzie and Moroni, 1986; Horne and Martens, 1998; Rossi et al., 2003; Rodriguez-Lazaro and Ruiz-Muñoz, 2012; Külköylüoğlu, 2013) and in a variety of marine and non-marine aquatic habitats (Delorme, 1991; Meisch, 2000; Horne, 2003; Külköylüoğlu, 2013; Escrivà et al., 2014). The distributions of ostracods are effected by multiple factors such as temperature, sediment type, depth, vegetation, elevation, pH, dissolved oxygen, transparency of water and salinity (Malmqvist et al., 1997; Mezquita et al., 2001; Külköylüoğlu, 2005a; Martín-Rubio et al., 2005; Pérez et al., 2010; Szlauer-Łukaszewska, 2012). Although species-specific responses to these factors (Benson, 1990; Delorme, 1991), some species are tolerant to a wide range of environmental conditions (e.g., water temperature, dissolved oxygen, etc.) (Uçak et al., 2014). Therefore, ostracods are bioindicators of aquatic conditions and are commonly used in different scientific fields such as geology (biostratigraphy), archeology, palaeobiology, palaeoclimatology, palaeolimnology, palaeoecology, wetland conservation, elemental and isotopes studies and evaluations of anthropogenic pollution (Forester, 1991; Holmes et al., 1998; Külköylüoğlu, 1998; Alvarez Zarikian et al., 2000; Mourguiart and Montenegro, 2002; Padmanabha and Belagali, 2008; Jiang et al., 2008; Sarı and Külköylüoğlu, 2010; Rodriguez-Lazaro and Ruiz-Muñoz, 2012; Ruiz et al., 2013). Ostracods are particularly valuable as indicator species for estimating the past and present environmental changes. However, this requires an understanding and sophisticated knowledge of species-specific ecological requirements and tolerance ranges (limits) across habitats. Additionally, one may also question the type(s) of suitable habitats for ostracods and how ostracods respond to changes in such conditions (Külköylüoğlu, 2003a, 2004). The present study attempts to provide this understanding through a regional evaluation of ecology, distribution and habitat preferences of non-marine ostracods.

Species may exhibit random, clumped (aggregation) and uniform distributional patterns in response to biotic and abiotic factors. Of which, random distribution describes all individuals have equal probability of occurring in habitats. This distribution is also named as "Poisson distribution model" when population variance (s^2) equals the mean (μ) (Ludwig and Reynolds, 1988

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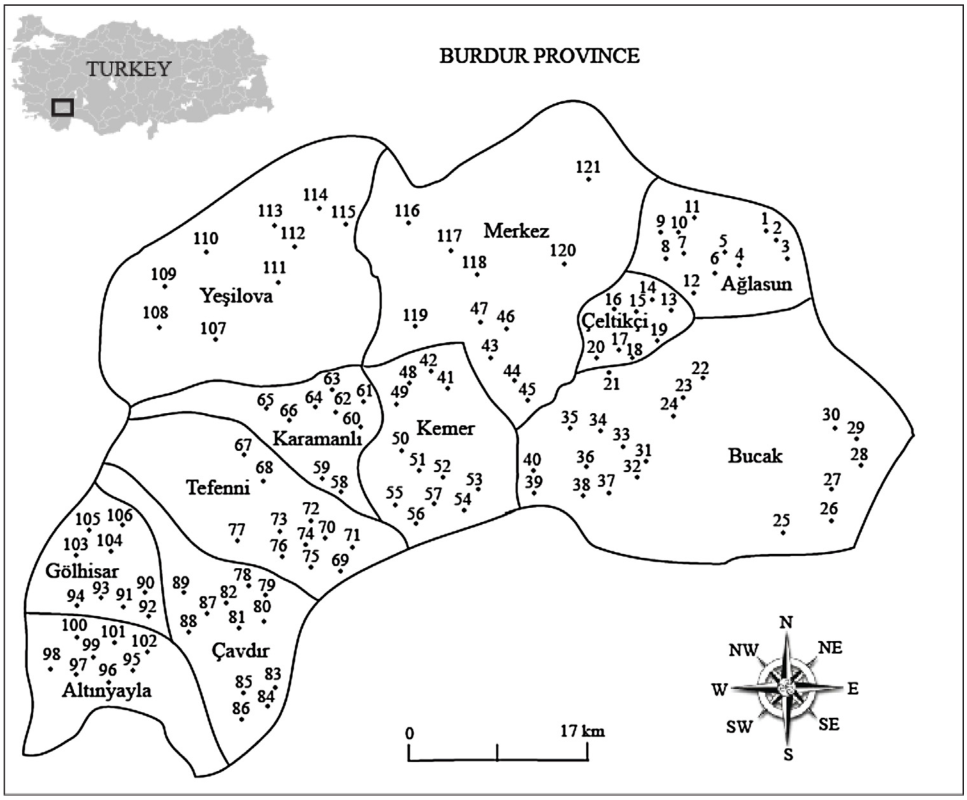

Fig. 1. 121 ramdomly selected sampling sites from 11 counties (Merkez, Ağlasun, Çeltikçi, Bucak, Kemer, Yeşilova, Karamanlı, Tefenni, Çavdır, Gölhisar, and Altınyayla) of Burdur.

Zar, 1999). On the other hand, uniform and clumped distributional patterns show equal spacing and accumulation of species in an area and/or habitat, respectively (Ludwig and Reynolds, 1988). Determining the modes of these patterns can provide evidence to the effect of regional and local factors on species occurrence. While local factors (e.g., elevation) can influence the distribution of species residing in a particular habitat (e.g., lake, spring, etc.), regional factors can exert substantial influence on colonization and immigration of the species among the regions (Paradise et al., 2008). Determining type of such distributional patterns with those effective environmental variables on species distribution can help to protect species from extinction in particular areas. Despite this, there are no other extensive regional-scale geographical and ecological studies evaluating the distributional patterns of ostracod species (but see Yavuzatmaca et al., 2015).

Like most regions around the world, our knowledge about ostracod ecology and distribution in Turkey contains large gaps. For example, Burdur province (Fig. 1) has received no systematic survey and habitat characterization for its ostracod fauna. Here, we present the results of the first extensive study on Burdur province ostracods. Accordingly, the main objectives of the present study are i) to determine distributional patterns (clumped, uniform, random) of ostracod species in Burdur, ii) to discuss the relationship between habitat suitability and ostracod species diversity, iii) to elucidate the most important environmental factors (local and/or regional) affecting species distribution among habitats along, and iv) to estimate species' ecological optimum and tolerance levels.

2. Material and methods

2.1. Site description

The province of Burdur with 6887 km^2 of surface area (also known as the 'Lake District Area') is located in the South Anatolia between 36°53″–37°50′ north latitude and 29°24″ –30°53′ east longitude. The province is surrounded by some extentions of the West Toros Mountains in the south, Lake Burdur and the Karakuş Mountain in the north and Lake Acıgöl and Eşeler Mountain in the west. Also, the province has 2.7% upland, 19% lowland, 60.6% mountains and 17.6% hilly lands (Burdur valiliği, 2014). High mountains seperate the district from the Mediterranean region, and summer is hot but winter is very cold (Burdur, 2014).

2.2. Sampling and measurements

Total of 121 sampling sites with six different aquatic habitats (spring, lake, dam, pond, creek and trough) were randomly visited and sampled between August 30 and September 02, 2012 (Fig. 1). Sampling sites were 5 to 10 km apart to prevent bias on similarities in species diversity and distribution. Eight environmental variables (dissolved oxygen (DO, mg L^{-1}), percent oxygen saturation (% sat.), water temperature (Tw, °C), electrical conductivity (EC, µS cm^{-1}), total dissolved solids (TDS, mg L^{-1}), salinity (Sal, ppt), pH, atmospheric pressure (mmHg)) were recorded with a YSI-Professional Plus before sampling to prevent possible results of "Pseudoreplication" (Hurlbert, 1984). *In situ* water phsyicochemical measurements should be taken without any disturbance of the sampling site that can result from ostracod collection and subsequent increased turbidity and water column mixing. Air temperature (Ta, °C), wind speed (km h^{-1}) and air moisture (%) were obtained by a Testo 410-2 model anemometer, and basic geographical data (elevation, coordinates) were recorded with a geographical positioning system (GARMIN etrex Vista H GPS) (Appendix A).

Ostracod samples were collected from each site with a standard sized hand net (200 µm mesh size). We preserved samples in 250 ml plastic bottles and fixed with 70% of ethanol. In the laboratory, each sample was filtered through four standardized sieves

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