Revista Mexicana de Biodiversidad 85: 513-522, 2014
DOI: 10.7550/rmb.38104

Microarthropod communities related with biological soil crusts in a desert scrub in northwestern Mexico

Comunidades de microartrópodos relacionadas con costras biológicas de suelo en un matorral desértico en el noroeste de México

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Abstract. In arid ecosystems, biological soil crusts closely interact with microarthropod communities. Together, both communities play one of the most important environmental services: decomposition of organic matter. In a desert scrub in the southern Baja California Peninsula of Mexico, microarthropod communities were correlated to biological soil crusts and the way soil properties influence distribution of the microarthropods. Twenty five soil samples were taken from 3 site types: without crusts (10), with crusts (10), and eroded surfaces (5). Microarthropods were extracted; specimens were identified to family level and feeding groups were identified. Of the 4 682 microarthropods within 40 taxa, Prostigmata had the greatest richness. The lack of plant coverage at eroded sites seems to affect micro-environmental conditions, so that no microarthropods were found at these sites and biological soil crusts were simple in structure. Among desert scrub, biological soil crusts were complex in structure, and edaphic properties were more favorable for microarthropods to thrive. Specific dissimilarities in community structure of microarthropods for each microhabitat were related to feeding preferences of each taxa.

Key words: Acari, Collembola, edaphic properties, microflora.

Resumen. En los ecosistemas áridos, las costras biológicas de suelo junto con las comunidades de microartrópodos dan lugar a uno de los servicios ambientales más importantes: la descomposición de la materia orgánica. La relación entre comunidades de microartrópodos y costras biológicas de suelo, así como la influencia de las propiedades edáficas en la distribución de microartrópodos fueron estudiadas en un matorral desértico en el sur de la península de Baja California. Se tomaron 25 muestras de suelo de 3 sitios: sin costras (10), con costras (10) y superficies erosionadas (5). Se extrajeron los microartrópodos, que fueron identificados hasta familia y se identificaron hábitos alimenticios. Se encontraron 4 682 microartrópodos en 40 taxa, Prostigmata con la mayor riqueza. La falta de cobertura vegetal en los sitios erosionados parece afectar las condiciones micro-ambientales, por lo que no fueron encontrados microartrópodos en estos sitios y las costras biológicas encontradas fueron simples. En el resto del matorral, las costras biológicas eran complejas en su estructura y las propiedades edáficas fueron más favorables para el desarrollo de microartrópodos. Se relacionaron las diferencias específicas dentro de la estructura de la comunidad de microartrópodos para cada microhábitat con los hábitos alimenticios de cada taxa.

Palabras clave: Acari, Collembola, propiedades edáficas, microflora.

Introduction

Over more than 70% of the surface of the world is arid and semiarid soils, where vascular plants are widely dispersed or absent; there, a highly specialized microorganism community of biological soil crusts (BSC), composed of cyanobacteria, algae, microscopic fungi, lichens, and mosses predominates (Belnap, 2001a). These organisms grow inside or on the surface of the upper layer of the soil; during its development, polysaccharides secreted by cyanobacteria and algae, together with filaments of lichens and moss, adhere to soil particles (Coleman et al., 2004). Consequently, BSC stabilize and reduce the susceptibility of soil to water and wind erosion. Furthermore, BSC supply a source of nitrogen for desert soils, which can support germination and establishment

Recibido: 01 mayo 2013; aceptado: 11 agosto 2013

of vascular plants (Belnap, 2001a). Flat and rough types of BSC have been identified from a mountainous range of southern Baja California Peninsula (Maya et al., 2002).

According to Neher et al. (2009), there is a close relationship between the porous structure of BSC and the edaphic fauna; this microhabitat of microarthropods also supplies its main source of food. In turn, microarthropods support the bacteria and fungi by supplying detritus (Palacios-Vargas, 1983), as well as disseminating bacteria and fungi spores, and lichen fragments and soredia (Steinberger, 1991). Hence, microarthropods are important regulators of the bacterial and fungal populations of soil. Since microarthropods are relatively sedentary, they reveal soil conditions better than mobile microfauna (Olfert et al., 2002); hence, they can be used as bio-indicators of the health of desert soils (Sandor and Maxim, 2008).

Unfortunately, from the terrestrial ecosystems, soil comprises one of the less studied resources (Coleman et al., 2004), both in its biodiversity and its internal processes. Of the microarthropods only ~10% have been examined and probably only 10% of the species described (André et al., 2002). The basis of distribution of the edaphic fauna and the way it interacts and develops are far from being understood. As a result, the importance of the biota in the soil processes are commonly underestimated (Coleman et al., 2004), regardless of the importance of the services provided to humanity and the rest of the biota. Few studies have been made regarding interactions between biological soil crusts and microarthropod communities. It is remarkable that in North America, studies of microarthropods in arid lands have focused on the Chihuahuan and Mojave Deserts and not the Sonoran Desert. The main objective was to analyze the influence of some edaphic parameters in microarthropod communities related to BSC in a desert scrub.

Material and methods

Study site. The study was conducted at the Northwest Biological Research Center (CIBNOR) reserve, located on an alluvial plain dominated by desert scrub vegetation; the common shrubs include *Jatropha cinerea*, *J. cuneata*, *Prosopis articulata*, *Bursera microphylla*, *Fouquieria diguetti*, *Cyrtocarpa edulis* and the cardon cactus *Pachycereus pringlei*. Summers are hot and arid, with occasional tropical storms bringing most of the rain. There is only one rainy season, from August to February with 2 peaks in September and January, with the greatest precipitation in summer; winter storms provide <10% of the annual total (León de la Luz et al., 1996).

Biological soil crusts are distributed in patches on the soil surface. Based on appearance, they are designated as "flat" or "rough" crusts; rough crusts contain very conspicuous lichens; in contrast, flat crusts are dominated by cyanobacteria. Flat crusts were found on eroded soils; rough crusts on scrubland soils. Stereoscopic and bright-field microscopy show that filamentous cyanobacteria are dominant in both crusts, most species belonging to *Microcoleus*, as well as many species of the genera *Scytonema* and *Nostoc*, which are nitrogen fixers.

Sampling. Field work was performed in September and October 2011. From a satellite image of 22 July 2009, we identified 25 sites in this area, of which 10 sites had BSC, 10 sites were without BSC, and 5 sites were eroded. To collect microarthropods, a sample of litter and the upper layer of the soil were excavated (together with the crusts, if present). At 10 sites (5 with and 5 without crusts) a soil sample (0-10 cm deep) was collected for analysis. From each sample, a volume of 500 mL of soil (or soil + litter) was placed in a box. At each site, the surrounding vegetation and the type of BSC (flat or rough) was described. The following soil properties were measured: pH, electrical conductivity, total dissolved solids, soluble phosphorus, organic matter, calcium, magnesium, total nitrogen, sodium, potassium, soil texture, bulk density, pore space, temperature, and relative humidity (the 2 last in the field).

Microarthropod extraction and identification. Microarthropods were extracted from the soil samples using Berlese-Tullgren funnels (Palacios-Vargas and Mejía, 2007). Voucher specimens of each family were mounted in Hoyer's fluid on glass slides for initial identification and subsequently archived (Palacios-Vargas and Mejía, 2007). Only colembolans (Christiansen and Bellinger, 1998) and mites (Balogh and Balogh, 1988; Kethley, 1990; Walter et al., 2009) were identified to family. Feeding groups were assigned to each Acari family based on the feeding behavior (McDaniel, 1979; Neher et al., 2009; Walter et al., 2009). The groups were: predators (nematode and other microarthropods), phytophages, microphytophages (fungi and algae eaters), and saprophytes.

Data analysis. Kruskall-Wallis analysis was used to determine differences between the edaphic parameters in both conditions ("soil with crusts" and "soil without crusts"). For each condition, the diversity, evenness, and dominance were estimated. For diversity, the Shannon index (H') was used; evenness was obtained by dividing the value of Shannon's diversity index by the logarithm of the number of taxa, and dominance was obtained with the Berger-Parker index (Magurran, 1988). To assess differences in richness between crust types, Whittaker's similarity index was used (Arellano and Halffter, 2003).

Multiple regression tests identified the association between edaphic parameters and abundances of each taxon. For these correlations, only taxa that were present