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Distribution patterns of Dikarya in arid and semiarid soils of Baja California, Mexico

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ARTICLE INFO

Article history:
Received 18 April 2012
Revision received 19 August 2012
Accepted 13 September 2012
Available online 27 November 2012
Corresponding editor:
Kevin K. Newsham

Keywords:
Baja California
Dikarya
Fungal diversity
ITS region
Molecular ecology
Mycobiota
RFLPs
Semiarid ecosystems

ABSTRACT

Approximately four-fifths of the land area of Baja California (BC) in Mexico are occupied by arid and semiarid soils, the mycobiota of which is virtually uncharacterized. In the first culture-independent study of the mycobiota of BC, we collected soil from five different locations in the region and constructed a Dikarya-specific gene library for the ITS region of nuclear ribosomal DNA. Clones were analyzed by RFLP, were sequenced for phylogenetic analyses, and diversity and similarity indices were calculated. The ascomycete *Penicillium dipodomyicola* was the most frequent fungus found in soil at the most arid location studied, and the basidiomycete *Coprinellus radians* was the most frequent at the location receiving the highest rainfall. Other frequent members of the soil mycobiota were identified as *Alternaria* spp., *Ceratobasidium* sp., *Coniozyma leucospermi*, *Nematoctonus robustus*, *Penicillium griseofulvum*, *Tulostoma kotlabae* and uncultured members of the Dikarya. Several sequences were identified as those of uncultured fungi, one of which was previously reported from other hot deserts. Arid soils and the transitional zones between arid and semiarid soils had the most similar fungal diversity, with the former soils having a community from which basidiomycetes were absent, and the soil receiving the highest precipitation having a community dominated by basidiomycetes.

Introduction

As in other biomes, fungi in arid and semiarid ecosystems (defined as areas receiving <254 mm total annual precipitation) participate in mineralization, organic matter decomposition and mobilization of nutrients (Fragoso & Rojas 2010). Despite this, in comparison with boreal and tropical ecosystems, little is known of fungal diversity in arid and semiarid soils, even though deserts occupy more than one-third of the Earth's land surface (Collins *et al.* 2008). The majority of studies on fungal

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http://dx.doi.org/10.1016/j.funeco.2012.09.004

diversity in desert soils have been culture-based, and have identified ascomycetes as frequent members of the mycobiota of the soils (Mouchacca 2005). For example, species of *Penicillium* and *Aspergillus* – xerotolerant and xerophilic fungi that can grow at water potentials below −22.4 MPa (Magan & Lacey 1984) – have been isolated from desert soils in Mexico, Chile, Argentina, Saudi Arabia, Iraq and Israel (Abdel-Hafez 1981; Abdullah *et al.* 1986; Giusiano *et al.* 2002; Piontelli *et al.* 2002; Samaniego-Gaxiola & Chew-Madinaveitia 2007; Grishkan & Nevo 2008). Melanized dematiaceous fungi such as *Alternaria* and *Exophiala* have also been isolated from desert soils in these countries, as well as in Libya and the USA (Bates *et al.* 2006; El-Said & Saleem 2008). These genera, along with other uncultured and unclassified fungi, have also been found in culture-independent studies (Bates *et al.* 2006). Some taxa have been reported exclusively from desert soils in the Middle East (e.g. *Aspergillus carneus*) (Abdullah *et al.* 1986; Ali-Shtayeh & Jamous 2000; El-Said & Saleem 2008), whilst some others have been reported from desert soils worldwide (e.g. *A. flavus* and *A. fumigatus*) (Abdel-Hafez 1981; Giusiano *et al.* 2002; Piontelli *et al.* 2002; El-Said & Saleem 2008).

Approximately four-fifths of the land area of Baja California (BC) in Mexico is occupied by arid and semiarid soils (Peinado *et al.* 2006) that receive 100–200 mm total annual precipitation (INEGI 2011). BC is classified as having a Mediterranean climate with latitudinal transitions from arid to semiarid, and temperature extremes lessened by cool sea breezes, along with exceptionally low humidity (Meigs 1966). The region exhibits latitudinal and longitudinal macroclimatic gradients owing to the peninsula's location and physiography (Markham 1972), which, along with soil chemistry and geomorphology, influence plant species composition (Franco-Vizcaino *et al.* 1993; Ward & Olsvig-Whittaker 1993; Peinado *et al.* 1994a). Much is known of plant diversity in the region (Delgadillo 1992; Peinado *et al.* 1995, 2006), but knowledge of soil fungi is much more limited, with the macromycetes *Geastrum triplex, Calvatia sculpta, Astraeus hygrometricus,* as well as the micromycetes *Coccidioides* spp., *Aphanoascus keratinophilus* and *A. canadensis* being the only fungi reported from BC (Ayala & Ochoa 1991; Baptista-Rosas *et al.* 2012). Therefore, in order to enhance knowledge of soil mycology in BC, we conducted the first culture-independent analysis of the fungi present in the soils of the region.

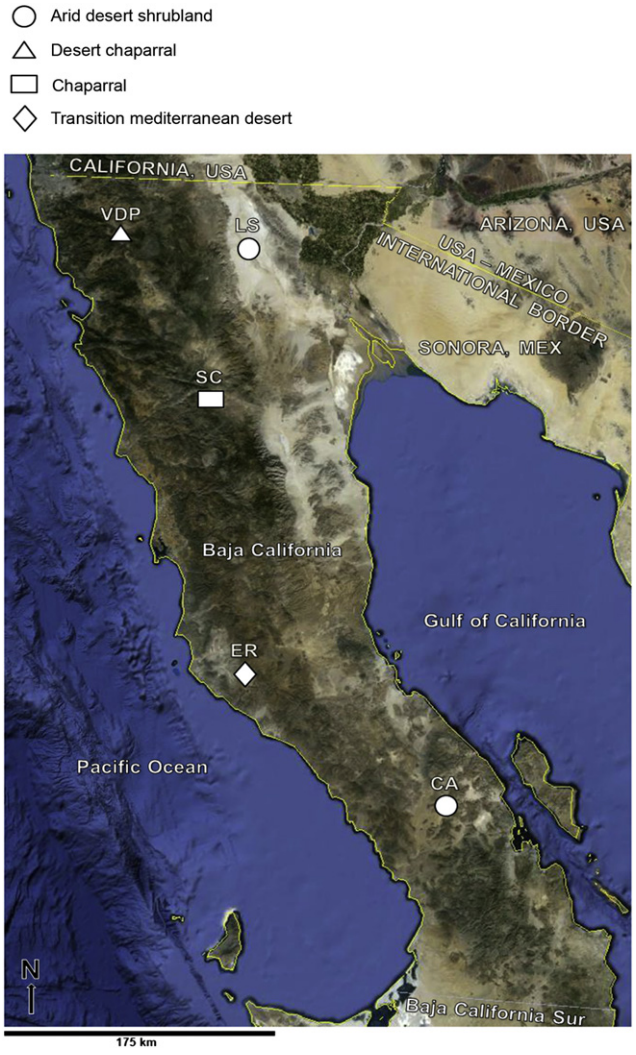

Fig 1 – Map of the State of Baja California (Google Earth V5.1 2009) showing the location of the five sites, where soil samples were collected (LS, Laguna Salada; VDP, Valle de las Palmas; SC, Santa Catarina; ER, El Rosario; CA, Cataviña). The ecosystem type, based on the vegetation composition of each of the locations, can also be observed. Worth noting, the ecosystems transcend from North to South bound, ending with the same ecosystem type at the South and the North of the state.

Methods

Site descriptions

We selected five representative inland habitats, ranging from arid to semiarid and transitional ecosystems (Fig 1). The selected locations were Laguna Salada (LS), Valle de las Palmas (VDP), Santa Catarina (SC), El Rosario (ER) and Cataviña (CA). Details of these locations, and their climates, soil types and vegetation, are shown in Table 1.

Sampling and soil analyses

Five soil samples were collected from each of the five locations between May and Jul 2009. Sampling points, established randomly, were located at least 1 km from paved road in undisturbed areas that were >50 m apart. All soil samples were from areas that lacked a plant canopy (i.e., interspaces) and a conspicuous litter layer. Bulk soil (*c.* 100 g), lacking roots or visible organic matter, was collected from between 10 and 15 cm below the soil surface with a clean disposable spoon into sterile containers and were transported to the laboratory. The soil was stored at room temperature (*c.* 23 °C) in the dark for 1 week before DNA extraction. Measurements of soil moisture, total organic matter, pH and water retention capacity (WRC) were obtained for each of the samples. Soil moisture and total organic matter were measured gravimetrically (110 °C for 48 hr and 380 °C for 4 hr, respectively) and pH was measured in a slurry of soil (10 g) and water (20 ml). WRC