EUROPEAN JOURNAL OF SOIL BIOLOGY 44 (2008) 71–79

available at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/ejsobi

Original article

Soil microbial activity and free-living nematode community in the upper soil layer of the anticline erosional cirque, Makhtesh Ramon, Israel

Stanislav Pen-Mouratov[a], *Nosir Shukurov*[a,b], *Josef Plakht*[c], *Yosef Steinberger*[a,*]

[a]*The Mina & Everard Goodman Faculty of Life Sciences, Bar-Ilan University, Geha Road, Ramat-Gan 52900, Israel*
[b]*Institute of Geology and Geophysics, Academy of Sciences, Tashkent 700041, Uzbekistan*
[c]*Ramon Science Center, Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev, P.O. Box 194, Mizpeh Ramon 80600, Israel*

ARTICLE INFO

Article history:
Received 8 November 2004
Accepted 6 July 2007
Published online 20 August 2007

Keywords:
Nematode community
Trophic groups
Microbial biomass
Respiration
Makhtesh Ramon
Ecological indices

ABSTRACT

The physical–chemical peculiarity of soil rock formations is one of the leading factors determining diversity and abundance of soil biota. The main aim of the present research was to study soil microbial and free-living nematode abundance and diversity on different soil rock formations (basalt, sandstone, limestone, granite and gypsum) of the Makhtesh Ramon erosional cirque. The obtained results showed the strong effect of soil features of different soil formations on microbial biomass and respiration as well as on the soil free-living nematode communities and its trophic and species composition. The Sorenson-Czenkanowski similarity index indicated significant differences between soil properties as well as between soil biota in observed soil formations. The qCO_2, which is known to increase according to the level of environmental stress, reached maximal values in the sandstone soil formation. The values of ecological indices such as Simpson's dominance index, maturity index and modification and species richness pointed to a specific ecological condition in the studied soil formations dependent on low content of an essential soil matter as soil moisture, organic matter and cations.

1. Introduction

The Makhtesh (Hebrew for crater) Ramon is located in southern Israel in the Negev Desert area. Structurally, the area is an anticline with a central eroded valley, mostly drained by a single river, Nahal Ramon. Makhtesh Ramon exposes numerous geological features: a large variety of rock types with superb assemblages of macro- and micro-fossils from the Triassic (~220 million years BP) up to the upper Cretaceous (~70 million years BP [18]. Evolution of the present exposure of Makhtesh Ramon is the result of post-Eocene erosion and structural modification [20]. Physical–chemical weathering resulted in the formation of soil horizons on the truncated surfaces of bedrocks with different compositions [26].

The abundance and species of soil organisms are dependent on the type and physical characteristics of the soil [10]. Many studies have been published in which changes in soil microbial parameters and soil free-living nematodes gave an

* *Corresponding author*. Tel.: +972 3 5318571; fax: +972 3 7384058.
E-mail address: steinby@mail.biu.ac.il (Y. Steinberger).
1164-5563/$ – see front matter
doi:10.1016/j.ejsobi.2007.07.003

early warning of decreasing soil quality (e.g. [14,45]). Parameters that describe the amount, activities, and diversity of soil microorganisms are also used as biological indicators of soil quality and health [33], integrating the chemical and physical properties of the ecosystem. Soil microorganisms are usually studied and monitored at the process and biomass levels. The process level includes overall activities of the soil microorganisms, especially respiration [33]. An additional important soil biota component which plays a major role as regulator of energy and nutrient flow is the nematode population [39]. According to Bongers and Ferris [5], the soil free-living nematodes are among the most numerous groups of multi-cellular animals participating in fundamental ecological processes in soil, such as decomposition and nutrient cycling [7]. Since they are sensitive to ecosystem disturbances [39,45], they can be used as stable indicators for understanding processes in the soils of different ecosystems, including semi-arid and arid desert zones [22].

There are numerous publications about the geological and geomorphological mapping, physical and geochemical features of sediments, distribution and behavior of separated chemical elements in the different types of rocks (e.g. [3,25]), whereas the number of publications about the biological component of the soil erosion basin related to geomorphological formation seems to be limited [38]. To fill this gap, the present study was targeted to:

1. Determine the spatial distribution of soil microbial and nematode populations in the different types of soil formations (basalt, sandstone, limestone, granite and gypsum) taking place in the main types of rocks of the erosion basin.
2. Determine the spatial distribution and trophic diversity of the nematode population in each type of soil formation in the main types of rocks.

2. Materials and methods

2.1. Location and geo-climatic conditions

Makhtesh Ramon (40 km long, ∼9 km wide, 400 m deep), located within the Ramon Reserve National Park, southern Israel, is composed of many geological formations and large varieties of exposed rocks of various compositions [20]. Altitudes vary from 1020 m on the western rim to 420 m a.s.l. in the east near the outlet of Nahal (river) Ramon, which drains 90% of the Makhtesh area. Nahal Ramon is an ephemeral stream, 39 km long, which drains the central and western parts of the Makhtesh. Nahal Holit-Qamai drains the eastern part of Makhtesh Ramon. Nahal Neqarot, which flows east of the Ramon anticline, serves as the erosional base level of the Makhtesh valley [25].

The area is characterized by an arid to extremely arid climate. Mean multi-annual rainfall is 85 mm at the northern rim of the Makhtesh and 56 mm at the bottom, most of it coming from the west and northwest [20]. Mean daily temperature in July is 34 °C, and in January 12.5 °C; mean annual temperature is 17–19 °C [24]. Most of Makhtesh Ramon has a bare surface. The studied soils are immature, being actually non-lithified products of the initial stage of the weathering of parent rocks and, therefore, they partly inherit their structure. The thickness of soil does not exceed 20–30 cm. Due to arid climatic conditions, the processes of physical weathering prevail. Therefore the physical-weathered material contained no material finer than 30 μm [9]. The soils developed on Cretaceous basalts consist mainly of sand fractions mixed with approximately the same content of gravel and a minor amount of silt. The physical weathering of the friable Jurassic sandstones results in the accumulation of fine and medium sand with a strongly subordinated role of silt fractions. Coarse-grained soil developing on the Cretaceous granite consists mainly of coarse friable sand and fine gravel constitutes crystals of feldspar and quartz, almost without a fine matrix. The products of weathering on the Triassic gypsum strata along with the fine-grained composition partly preserve the structure of the parent rocks expressed as very thin blade-shape particles of granule size.

Vegetation cover is scarce and confined mainly to the stream channels. Trees are rare, and only two species, *Tamarix nilotica* and *Acacia raddiana*, are represented [26].

2.2. Sampling

Soil samples ($n = 25$) were taken from the 0 to 10 cm layer at five sampling sites having different types of rocks, stretching about 1000 m^2 each (Fig. 1). Five individual replicates of the soil samples were randomly collected from every site in the early hours at the end of the rainy season (in April 2004). Every soil sample consisted of five pseudo-replicates. Soil samples were collected at a distance from plants in the open area at: the lower Cretaceous basalt, belonging to the magmatic formation (station 1); the Jurassic marine limestone (sedimentary rocks, station 2); the Jurassic near-shore sandstone (sedimentary rocks, station 3); the Cretaceous granite, belonging to the magmatic formation (station 4), and the Triassic gypsum, belonging to the sedimentary formation (station 5).

Each soil sample (1 kg weight) was collected and placed in an individual plastic bag, which was then sealed. The samples were kept in insulated boxes for transport to the laboratory, where they were kept at 4 °C until biological and chemical analyses were performed. Before laboratory analysis, the soil samples were sieved through a 2 mm mesh sieve in order to remove organic remains.

2.3. Laboratory analysis

All collected samples of different types of soil formations were subjected to the following analyses:

1. *Soil moisture* was determined gravimetrically (105 °C, 48 h).
2. *Organic matter* was determined by oxidization with dichromate in the presence of H_2SO_4, without application of external heat [28].
3. *pH* was determined in H_2O (soil:solution ratio 1:2.5) with a potentiometric glass electrode.
4. *Soil salinity* was determined in soil extracts and expressed as electrical conductivity (μS m^{-1}).
5. *Total soluble nitrogen* (TSN) in soil was determined automatically [15] with a Skalar Autoanalyzer System [29].