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Landscape distribution of oribatid mites (Acari, Oribatida) in Kolkheti National Park (Georgia, Caucasus)*

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Abstract

The key subject of this investigation was to study distribution patterns of oribatid mites in the main habitats and ecosystems of Kolkheti National Park. Oribatida were studied in 1) sand dunes, 2) *Juncus* bogs, 3) flooded alder (*Alnus barbata* C. A. Mey) forests, and 4) humid alder forests. Sampling was conducted in November 2009 at 18 sites along three transects. For exploratory analysis, we applied clustering techniques. Correlation between species number, density and humus was calculated. Chao1 statistics were used to estimate the completeness of sampling. Forty six oribatid species were recorded. The highest Shannon diversity index was registered for alder forests, whereas the lowest index was observed for dunes. In sand dunes 16 species were found, three of which occurred only in this landscape. In *Juncus* bogs, 32 species were recorded, and 16 were unique to this landscape, including bog specific *Zetomimus furcatus* (Warburton & Pearce, 1905)*, Euzetes globulus* (Nicolet, 1855) and *Punctoribates manzanoensis* Hammer, 1958. Twenty two species were found in flooded forests, seven being exclusive. Ten species were recorded in humid forests, and *Metabelbella macerochaeta* Bulanova-Zachvatkina, 1965 and *Eremobelba geographica* Berlese, 1908, typical inhabitants of humid forest soils, appeared as exclusive species. Faunal comparisons among landscapes show high similarity between dune and bog oribatid mite communities, followed by flooded and humid alder forests. In dunes and bogs, total faunal density is determined by euryecological species, whereas in alder forests density was determined by high abundance of humid and extremely humid specific species.

Key words: Oribatida**,** dunes, *Alnus barbata*, Shannon's index of diversity, cluster analyses.

Introduction

Kolkheti National Park was created in 1999. It is located on the Kolkheti Lowland and is made up of three natural geographic regions: Anaklia-Churia (13,713 ha), Nabada (10,697 ha) and Imnati (19,903 ha). The Kolkheti Lowland area became the subject of international interest in 1997 when Georgia joined the Ramsar Convention on "Wetlands of International Importance Especially as Waterfowl Habitat" (The Ramsar Convention Manual, 2006). Kolkheti mires, first of all, are important for their relict origin (Denk *et al*., 2001; Kikodze & Gokhelashvili, 2007; Zazanashvili, 2009). This lowland is a remainder of the tropical and subtropical landscapes that stretched along the entire Eurasian continent as a continuous belt in the Cenozoic, about 10 million years ago. Some of the plants found in the Kolkheti are otherwise found only in swampy ecosystems of tundra and taiga of the far north of Europe (Kikvidze & Ohsawa, 2001). The Kolkheti Lowland area is also of international significance for another reason: the flooded ecosystems of Kolkheti National Park have a great importance for maintaining the biodiversity of the region (Management Plan of the Kolkheti National Park, 2003; Kikodze & Gokhelashvili, 2007). The boundaries between terrestrial and aquatic ecosystems are critical transition zones and generally support unique or diverse biota (Bardgett *et al*., 2001). Aquatic and semi-aquatic habitats of Kolkheti National Park create a refuge for many rare and endemic plant and animal species, including invertebrates (Arabuli *et al*., 2007; Denk *et al*., 2001; Kikodze & Gokhelashvili, 2007; Kikvidze

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& Ohsawa, 2001; Murvanidze & Kvavadze, 2010; Zazanashvili, 2009). The flooded habitats of these territories are necessary for migratory, wintering and nesting bird species (Kikodze & Gokhelashvili, 2007; Zazanashvili, 2009).

The first research on invertebrates in Kolkheti Lowland was carried out more than 60 years ago (Kobakhidze, 1943). The survey highlighted the reduction of the invertebrate fauna after drainage of *Juncus* bogs. Investigation of the invertebrate fauna of podzol-clay soils of Kolkheti Lowland carried out by Lagidze (1981) resulted in the report of 29 species of oribatid mites from alder (*Alnus barbata* C.A. Mey) forests, with three bog-specific oribatid species, *Nothrus palustris* C.L. Koch, 1839*, Minunthozetes pseudofusiger* (Schweizer, 1922) and an unidentified *Phthiracarus* sp.. Unlike the previous work, this publication highlighted an increase in the number of oribatid mites after bog drainage. The survey of the invertebrates of the Kolkheti Lowland published by Kurashvili (1984) showed the presence of 37 species of oribatid mites, with higher species diversity in drained habitats. These early publications unfortunately do not provide the very valuable information about how (methodologically) and exactly where the investigations were conducted. Research on the invertebrates of Kolkheti Lowland was not conducted between 1984 and 2000. In the Management Plan of Kolkheti National Park (2003), minimal attention is given to the invertebrates inhabiting this territory. It states that "only a few dozen species of the molluscs and crustaceans are there present", but it emphasizes the need for research on invertebrate fauna, establishment of bioindicators and conservation of these poorly known animals.

Recent work conducted by Arabuli *et al*. (2007) on nematodes, earthworms and oribatid mites of a flooded alder forest with boxwood (*Buxus cochica*) understory of a territory neighboring Kolkheti National Park showed the similarity of the oribatid fauna in this region with that of similar ecosystems of Kintrishi Reserve, located in subtropical region of Adjara, Western Georgia. The presence of boxwood at this altitude (H= 0–5m) was considered a surprising finding from a biogeographical point of view (Arabuli *et al*., 2007). In 2005, an inventory of oribatid mites of Kolkheti Lowland was done, resulting in the finding of 47 species from *Juncus* bog ecosystems, with *Punctoribates manzanoensis* Hammer, 1958 and *Zetomimus furcatus* (Pearce & Warburton, 1906) as new reports for Caucasian fauna, and 79 species for flood-plain alder forests (Murvanidze & Kvavadze, 2007, 2010)

The present work is part of a large spatial scale investigation of the invertebrate fauna of Kolkheti National Park, covering an area of 28,571 ha. The objective of this research is to evaluate the diversity of invertebrates in the park, determining unique, rare, endemic, or threatened species as the distribution patterns of oribatid mites in main habitats and ecosystems.

Materials and Methods

The study was conducted along the landscapes of the Anaklia-Churia and Nabada regions. The following major types of landscapes are found in these regions (Management of the Kolkheti National Park, 2003):

1 Coastal sands (beach). The vegetation of this habitat is poorly developed along the Black Sea coast and is represented by few plant species. The plant cover of the region of our investigation (from delta of Tikori River, to the delta of Churia River) is represented by the relic of tertiary age, sea daffodil (*Pancratium maritimum* L.).

2 Sand dunes. Here, xerophilous shrubs can be found associated with grass complexes. *Paliurus spina-christi* Mil. is the dominant plant species of this landscape.

3 Bogs. The vegetation of this landscape is distinguished by the rich flora. The dominant plant species are *Juncus* and cereals; in peat-bogs, the peat mosses *Sphagnum imbricatum* Hornsch. *ex* Russ., *S. papilosum* Lindb., *S. acutifolium* Schrad. and *S. palustre* L. are commonly found.

4 Alder forests. Both flooded and humid alder forests are located at 3–5 m above sea level, at the sea level or lower. Flooded alder forests are inundated twice a year (March–April and October-November) with water of the Rioni River. The humid alder forests are more intensively disturbed by anthropogenic action than the flooded alder forests. Both of these forests are remnants of once impenetrable liana forests (Denk *et al*., 2001); together with the animal population, they are also considered a relic. Together with subdominant Caucasian wingnut *Pterocarya pterocarpa* (Mchx) Knth, the alder trees are the main components of forests of Kolkheti National Park.

All above mentioned landscapes are characterized by high annual precipitation, 1,800–2,100 mm (Management Plan of the Kolkheti National Park, 2003).

Description of sampling sites

Samples were taken in November 2009 from three transects which were established to cover all types of landscapes mentioned previously; considering that the breadth of the stretches of Coastal sand and Sand dunes varies in the neighborhood of a few meters, these environments were in this study jointly referred to as Sand dunes. The length of transect 1 and transect three was 13 km each and the length of transect 2, 9 km (Fig. 1). On each transect we set up several sampling sites, for an overall total of 18 sampling sites, each corresponding to a predetermined area of about 20 m^2. The average distance between sampling sites was 2.4 km.

For most of the sites, soil humus content and pH was measured. Soil organic matter or humus is one of the major agents of soil structure (Coleman *et al*., 2004) and it can also be considered as a main factor in determining community structure of oribatid mites (Maraun & Scheu, 2000). In spite of the possible dependence of soil pH on the humus content it can be used as one of the important factor revealing structure of oribatid mite communities (Lebrun & van Straalen, 1995). For estimation of soil humus content three soil cores were collected per plot using a cylinder of 5 cm diameter to a depth of 10 cm. Soil samples were dried in an oven at 80°C for 48 hours; a

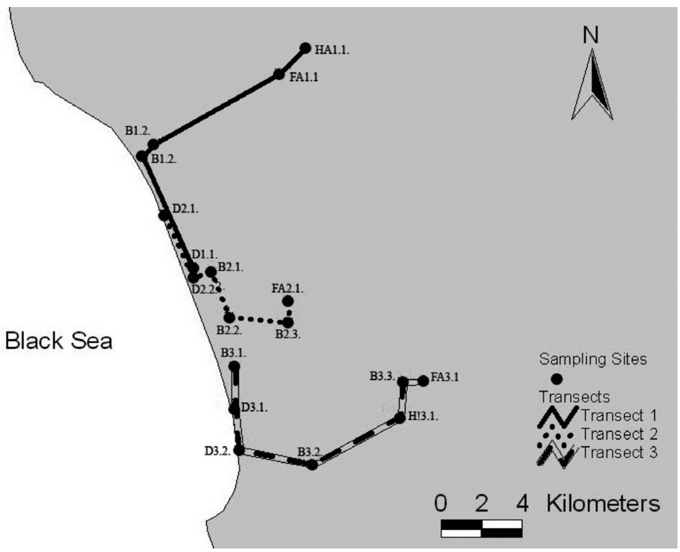

FIGURE 1. Distribution of sample sites in Kolkheti National Park, Georgia. Description of symbols are given in "Material and Methods".

subsample of 10 g of soil was then taken from each dried sample and placed in an oven at 500°C; 4 h later, the subsample was re-weighed. Mass differences between dried and burned contents were used as a measure of humus content.

Specific details of each sampling site are subsequently provided:

Sand dunes:

Transect I - Anaklia-Churia Region

D1.1. Left bank of Tikori River; 42.346612 N; 041.606233 E; beach sand; pH = 6; proportion of humus in dry matter= 0.9%.

Transect II

D2.1. 42.361433 N; 041.598317 E; with *P. maritimum*; sand; pH= 8.1; proportion of humus in dry mass= 1.2%.

D2.2. 42.346600 N; 041.606533 E; with *P. spina-christi*, *Asparagus* and *Ruscus ponticus*; sandy soil; pH = 6.5; proportion of humus in dry mass= 5.7%.

Transect III - Anaklia-Churia Region

D3.1. 42.286250 N; 041.629440 E; with *P. maritimum*; sand; pH= 8.9; proportion of humus in dry matter= 2.9%.

D3.2. 42.281383 N; 041.631267 E; with *P. spina-christi*; sandy soil; pH = 6.1; proportion of humus in dry matter= 5.4%.

***Juncus* bogs**

Transect I - Anaklia-Churia Region

B1.1. Left bank of Tikori River; 42.375250 N; 041.588050 E.

B1.2. Left bank of Tikori River; 42.375250 N; 041.591033 E; peaty soil.

Transect II - Anaklia-Churia Region

B2.1. 42.34665 N; 041.607017 E; peaty soil; pH = 4.5; proportion of humus in dry matter= 5.5%.

B2.2. 42.343594 N; 041.608158 E; with *Phragmites communis*; peaty soil; pH = 6.0; proportion of humus in dry matter= 7.0%.

B2.3. 42.342003 N; 041.617133 E; peaty soil; pH= 6.4; proportion of humus in dry matter= 34.1%.

Transect III - Nabada Region

B3.1. 42.297733 N; 041.630517 E; peaty soil; pH= 5.2; proportion of humus in dry matter= 6.7%.

B3.2. Kulevi oil terminal; 42.276149 N; 041.644835 E; peaty soil; pH= 7.9; proportion of humus in dry matter= 5.8%.

B3.3. Right bank of the Khobistskali River; 42.287092 N; 041.695895 E; peaty soil; pH= 5.4; proportion of humus in dry matter= 32.5%.

Flooded alder forests

Transect I - Anaklia-Churia Region

FA 1.1. 42.386467 N; 041.660760 E; clay soil; pH= 5.6; proportion of humus in dry matter= 6.5%.

Transect II - Anaklia-Churia Region

FA 2.1. 42.342514 N; 041.616980 E; with *Smilax excelsa*, *Rhamnus imeretina* and *Rubus* sp. Understory; clay soil; pH= 4.6; proportion of humus in dry matter= 58.5%.

Transect III - Nabada Region

FA3.1. Right bank of the Khobistskali River; 42.287634 N; 041.694417 E; clay soil; pH= 6.5; proportion of humus in dry matter= 21.4%.

Humid alder forests

Transect I - Anaklia-Churia Region

HA 1.1. 42.392733 N; 041.669533 E; with *Sambucus* sp., *Corylus* sp., *Periploca graeca*, *S. excelsa*, *Hedera* sp. and *Rubus* sp. Understory; clay soil; pH= 5.0; proportion of humus in dry matter= 8.4%.

Transect II - Nabada Region

HA3.1. Right bank of Khobistskali River; 42.282733 N; 041.691483 E; clay soil; pH= 7.9; proportion of humus in dry matter= 5.9%.

Sampling and processing of samples

Within each site, three soil samples were taken, each with a volume of 10 cm^3. The distance between the samples within a site varied from 3 to 5 m. In total, 54 soil samples were collected. Mites of all samples were extracted in the laboratory by means of a modified Berlese-Tullgren apparatus. Oribatids were collected every 24 hours during one week extraction and stored in Oudemans medium (87 parts of 70% alcohol, five parts of glycerol and eight parts of glacial acetic acid). Mites were sorted under a stereomicroscope; only adults were identified to species level. Identification was done examining mites on temporary and permanent slides. For temporary slides, lactic acid was used; permanent slides were made using Berlese fluid (200 g chloral hydrate, 20 mL glycerol, 30g gum Arabic and 50 mL water). Identifications were made using the keys of Weigmann (1981, 2006) and Ghilarov & Krivolutsky (1975). The identified material was deposited in the collections of Ilia State University.

Data analysis

Ecological peculiarities of oribatid mites were determined according to Schatz (2004), Weigmann (2006) and Behan-Pelletier & Eamer (2007). The evaluation of site-specific species leads to categories of ecotypes, "isovalent groups" of species with similar ecological valence. This method of evaluation was suggested by Knúlle (1957) and developed by Weigmann (1991, 1997a, b). The following ecological groups were created, according to the ecological data (Behan-Pelletier & Eamer, 2007; Weigmann & Krantz, 1981; Weigmann, 2006): euryecologic, xerophilous, humid and extremely humid and bog specific.

For exploratory analysis we applied clustering techniques. According to Fielding (2007), clustering based on *single linkage* algorithm binds clusters by finding minimal distances between cluster members. We used this method based on Sørensen distance matrix to reveal similarity pattern of oribatid communities using BioDiversity Pro (McAleece *et al*., 1996).

Correlation between species numbers, density and humus content was calculated using SPSS v.16.0 for Windows (SPSS Inc., Chicago, IL, USA). Shannon's Diversity Index (*H'*) was used to determine the faunal diversity of the oribatid community with Jackknifing procedure. For calculation we used Microsoft Excel 2003 (Magurran, 2004). We used software BioDiversity Pro (McAleece *et al*., 1996) to find out sampling completeness by computing Chao1 statistics for each site and sampling unit separately.

Results

Faunistic Studies

Forty six oribatid species were recorded, 15 in sand dunes, 32 in *Juncus* bogs, 22 in flooded alder forests and 12 in humid alder forests (Appendix).

Soils of dune landscape were very deficient in humus (0.9–5.7%). Concurrently, the density of the oribatid species collected in this landscape varied from 33 to 1,300 mites/m^2. Four species were recorded for the coastal sands and 15 for the sandy dunes with xerophilous vegetation. *Peloptulus phaenotus* (C.L. Koch, 1844), *Chamobates cuspidatiformis* (Traegardh, 1904) and *Zygoribatula exilis* (Nicolet, 1855) were found solely in the dunes with xerophilous vegetation. The xerophilous species (Weigmann, 2006) *Epilohmannia cylindrica* (Berlese, 1904) and *Peloribates longipilosus* Csiszar, 1962 were highly dominant. The abundance of *P. longipilosus* in the dunes reached 1,267 mites/m^2 (Fig. 2). It was much lower in transition area dune-bogs (B3.1: 33 mites/m^2) and absent from the soils of the other landscapes.

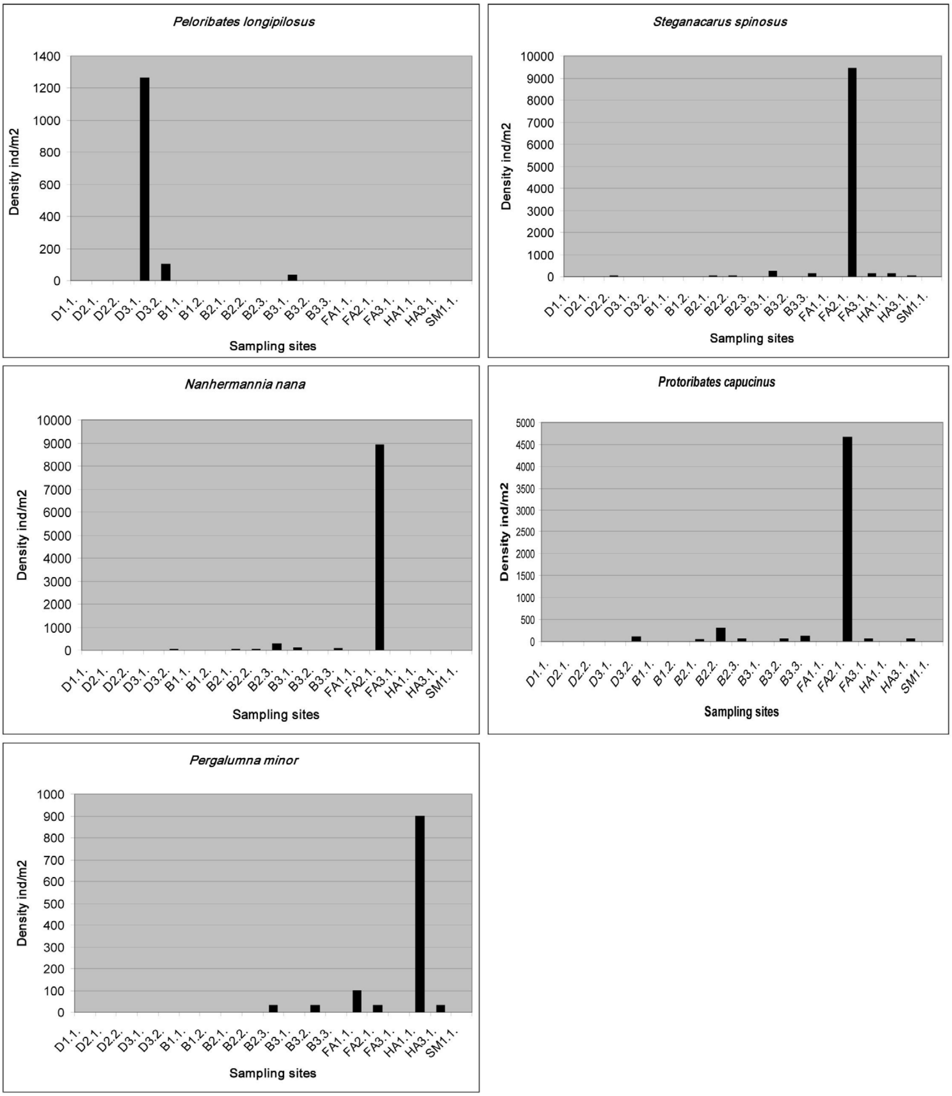

FIGURE 2. Densities of *Peloribates longipilosus*, *Steganacarus spinosus, Nanhermannia nana, Protoribates capucinus, Pergalumna minor* in the studied landscapes of the Kolkheti National Park, Georgia.

Soils of the *Juncus* bog landscapes were rich in organic matter (5.5–34.1%) Thirty two oribatid species were registered here, 16 being unique to this landscape, including the bog specific *Z. furcatus*, *Euzetes globulus* (Nicolet, 1855) and *P. manzanoensis.*

Soils of the alder forests showed high level of humus (6.5–58.48%). Twenty two species were found in the flooded alder forests, with the predominance of *Steganacarus spinosus* (Sellnick, 1920) (9,433 mites/m^2) and *Nanhermannia nana* (Nicolet, 1855) (8,900 mites/m^2) (Fig.2). These two species were also found in the humid alder forests and *Juncus* bogs in lower densities. *Protoribates capucinus* (Berlese, 1908) was also frequently found in bogs and in flooded and humid alder forest ecosystems (Fig. 2). Seven species were specific to flooded forests.

In the humid alder forests areas, two typical inhabitants of forest soils appeared as specific: *Metabelbella macerochaeta* Bulanova-Zachvatkina, 1967 and *E. geographica*. Among the species registered in humid forests, *Pergalumna minor* (Willmann, 1938) was found in high densities (900 mites/m^2) and constantly presented itself in the soils of *Juncus* bogs and flooded and humid forest landscapes (Fig. 2).

Data analyses

Cluster analyses showed that oribatid communities from sand dunes and *Juncus* bog are closer together, followed by humid and flooded alder forests (Fig. 3). Faunistic similarity between sand dunes, *Juncus* bogs and humid alder forests was indicated by the presence of *Phthiracarus ferrugineus* (C.L. Koch, 1841), *Platynothrus peltifer* (C.L. Koch, 1839), *Oppiella* (*R.*) *fallax* (Paoli, 1908), *Parachipteria punctata* (Nicolet, 1855), *P. minor* and *Scheloribates latipes* (C.L. Koch, 1840). Oribatids of flooded alder forests grouped next to them due to the presence of *S. spinosus, Rhysotritia ardua* (C.L. Koch, 1841), *N. nana, Oppiella nova* (Oudemans, 1902) and *P. capucinus* (Appendix 1).

Oribatid density was lowest in the dune areas and gradually increased from *Juncus* bog to flooded alder forests (Fig. 4). Determined numbers of species were slightly higher in *Juncus* bog and flooded alder forests. The Shannon Index of Diversity showed no significant fluctuations ($p > 0.05$), although determined value was slightly higher in bogs than in other landscapes.

There were no significant correlations of pH values with oribatid mite densities and species numbers, but significant positive correlations were observed between mite density and humus proportion in dry matter (Pearson 0.785, $p < 0.001$) and between density and number of species (Spearman's rho 0.621, $p < 0.005$). Although singletons and doubletons were relatively uncommon, the Chao1 estimator of species richness indicates that more oribatid species are yet to be collected from these habitats (Fig. 5) (Magurran, 2004).

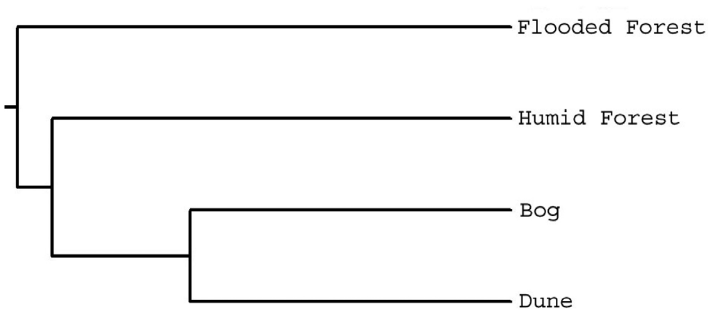

FIGURE 3. Cluster of faunistic similarities of oribatid mite faunas of Kolkheti National Park, Georgia, based on Sørensen distance matrix.

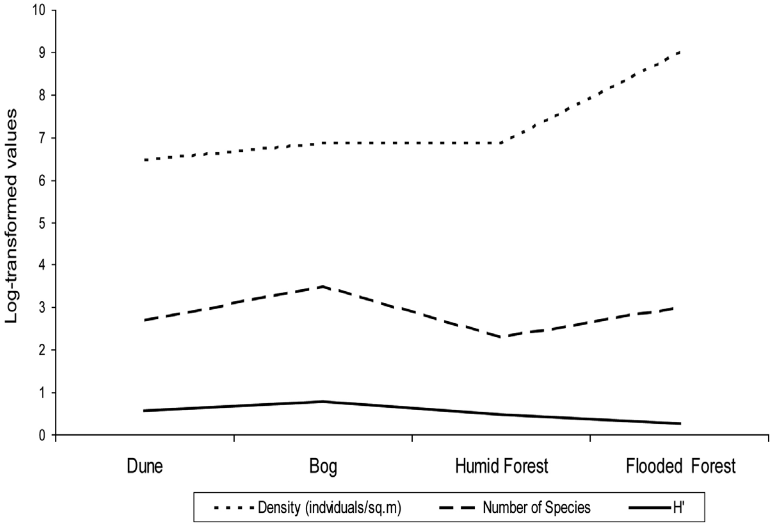

FIGURE 4. Log-transformed values of density (mites/m^2), Shannon index of diversity and number of species of oribatid mites in the studied sites in Kolkheti National Park, Georgia.

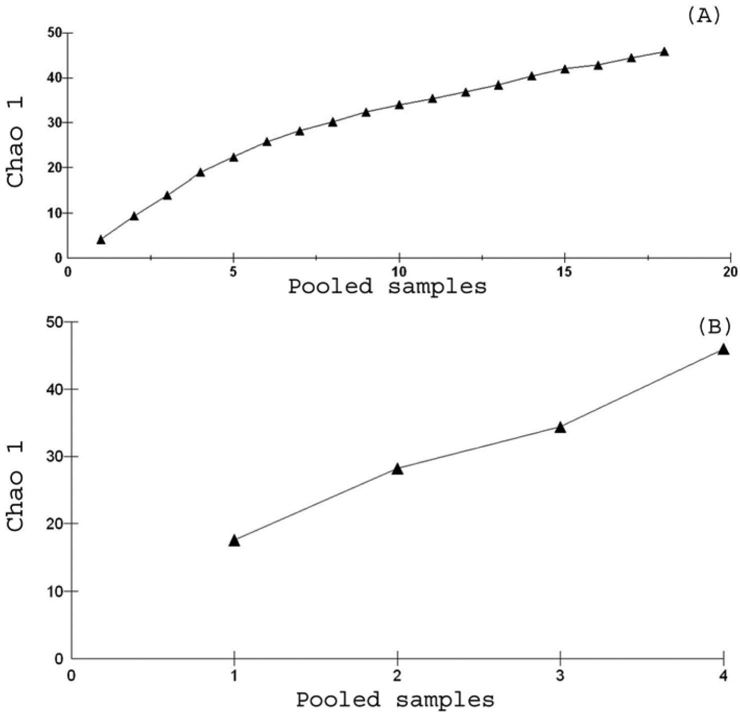

FIGURE 5. Densities of *Peloribates longipilosus, Steganacarus spinosas, Nanhermannia nana, Protoribates capucinus, Pergalumna minor* in the studied landscapes of the Kolketi National, Georigia.

Ecological groups

According to habitat preferences, the studied species were divided in four ecological groups: euryecological, xerophilous, humid and bog specific mites (Appendix 1). The first group includes ecologically ubiquitous species with the predominance of *R. ardua*, *O. nova* and *S. latipes.* Species of this group have a cosmopolitan or Holarctic distribution and thus we do not consider them as having ecological importance in this case.

The second group consists of xerophilous species. In general, they are found in sand dune soils. The high dominance of *E. cylindrica* and *P. longipilosus* characterize this group. These species can also be found in the margins of *Juncus* bogs but in lower densities compared to their preferred habitat (Appendix 1).

The third group includes humid soil specific species. *Protoribates capucinus* is the most frequently found species of this group, also indicating a high dominance. It is also present in the soil of xerophilous vegetation of the sand dunes but in low density (100 mites/m^2) compared to other landscapes (Appendix 1).

The fourth group includes extremely humid and bog specific species, with the predominance of *S. spinosus, N. nana* and *P. minor* (Appendix 1). This group is characterized by the presence of other bog specific species as well, but in lower densities: *Oppia nitens* C.L. Koch, 1836*, Z. furcatus, E. globulus* and *P. manzanoensis*

Discussion

The key subject of this work was to study distribution patterns of oribatid mites in main habitats and ecosystems of Kolkheti National Park. These territories are presented as dunes, bogs, flooded and humid alder forests.

In the early study of oribatid mites of Kolkheti National Park (Murvanidze & Kavavadze, 2007, 2010), the dominant species of the *Juncus* bog ecosystems of Kolkheti Lowland were *Z. furcatus, N. nana, P. peltifer, Nothrus pratensis* Sellnick, 1929 and *P. manzanoensis.* The aquatic species *Hydrozetes parisiensis* Grandjean, 1948 was found on the swampy shore of Nabada Lake (unpublished data), but in small numbers and it was absent from the fauna in our later research (Murvanidze & Kavavadze, 2010). In the current study, *P. peltifer* and *P. manzanoensis* were recorded in lower densities compared to the earlier study (Murvanidze & Kvavadze, 2010) and *N. pratensis* was not detected. The difference between the results of this and the previous study may be due to the corresponding sampling periods. While the first was conducted in June, the present study was conducted in November.

From the species having well developed habitat preferences, *Z. furcatus* is known to be most tolerant to aquatic habitats. This and all other species of Zetomimidae are associated with shallow, eutrophic water bodies such as marshes, wet meadows and wet moss (Behan-Peletier & Eamer, 2007). In our study, *Z. furcatus* was found only in *Juncus* bogs.

Nanhermannia nana was frequently found in humid and moist soils of bogs and swampy alder forests, usually in high numbers. This species is known to prefer biotopes with high relative humidity (Behan-Pelletier & Hill, 1983; Behan-Pelletier & Eamer, 2007; Irmler, 2004).

Oppia nitens has been repeatedly reported from humid ecosystems of the Kolkheti National Park (Arabuli *et al*., 2007; Murvanidze & Kvavadze, 2007, 2010). It is known as an ecologically ubiquitous species, preferring soils with high organic matter (Weigmann, 2006). Based on results of this and previous studies (Arabuli *et al*., 2007; Murvanidze & Kvavadze, 2007, 2010), it seems to prefer soils with extremely high humidity. In the present study, it was found in humus-rich soils of flooded alder forests.

In alder woodlands, 24 oribatid species were recorded, with the predominance of humidity tolerant species. Extremely humid and *Juncus* bog specific oribatid species, namely *N. nana, O. nitens, Z. furcatus, P. minor* and *E. globulus*, are usually found in high densities in flooded alder forests, but they are present in lower densities or are absent from sand dunes and humid alder forests. Forest species, *M. macerochaeta, E. geographica, Pergalumna nervosa* (Berlese, 1914) and *Parachipteria georgica* Murvanidze & Weigmann, 2003, were recorded in moderate abundance in humid alder forests and were totally absent from other studied landscapes. Irmler (2004) conducted an investigation in a similar gradient from a waterlogged site to a relatively dry site in alder woodlands at the margin of Lake Belau (Germany), showing that the density of humidity tolerant oribatid species decreased with increasing distances from the lake margin, whereas the density of species preferring drier habitats increased along the same gradient.

When the environment is saturated with water, a small variation in water level has no effect on mite distribution (Laiho *et al.*, 2001; Osler *et al.*, 2006). It is presumed that oribatid mites generally can survive the water-logged situation for a long time (Beck, 1976; Irmler, 2004). Their species richness decreases significantly with decreasing precipitation and moisture (Irmler, 2004). In bog ecosystems we found a larger number of species compared to the alder forest. High level of organic matter in soil (5.5–34.1%) seems to be favorable to support a diverse oribatid fauna. We found high number of common humid and extremely humid oribatid species in high densities in bogs, flooded and humid alder forests (Appendix 1). In general, number of humid and extremely humid species exceeded the number of both xerophilous and eueryecological species (Appendix).

Several works (Battigelli *et al.*, 2004; Maraun & Scheu, 2000; Schaefer & Schauermann, 1990) show the importance of humus content in composition of oribatid communities. In our study, except for dunes, the landscapes are characterized by high humidity and high humus content. However, the decrease in number of species from bogs to dunes and forests was not determined by soil humidity or lack of precipitation, but by humus content. Furthermore, oribatid mite diversity increased in a gradient from dunes to forests via bog ecosystems. Absence of the coincidence between the species number and diversity index in bogs is caused by high number of individuals of separate species compared to total faunal density.

In some cases, high abundance is a result of high dominance of a few widely distributed (euryecological) species, whereas species richness remains low (Arroyo *et al.*, 2005; Murvanidze *et al.*, 2009; Osler *et al.*, 2006). This is also supported by our results, e.g., oribatid density in dunes was supported by high dominance of euryecological species like *P. ferrugineus, R. ardua, O. nova* and *S. latipes.*

Oribatids of Kolkheti National Park can be regarded as landscape specific. In typical landscapes of Kolkheti National Park, humid and extremely humid species of oribatid mites are dominant. In dunes, total oribatid density was mainly determined by euryecological species, whereas in bogs, flooded and humid alder forests, total density was determined by high abundance of humid and extremely humid species [*Phthiracarus* (*A.*) *assimilis* Niedbala, 1983*, P. capucinus, N. nana, S. spinosus* and *P. minor*].

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References

Arabuli, G., Mosulishvili, M., Murvanidze, M., Arabuli, T., Bagaturia, N. & Kvavadze, E. (2007) The Colchic Lowland alder woodland with boxwood understory (*Alneta barbatae buxosa*) and their soil invertebrate animals. *Proceedings of the Georgian Academy of Sciences. Biological Series B*, 5, 35–42.

Arroyo, J., Inturrondobeitia, J.-C., Rad, C. & Gonzalez-Carcedo, S. (2005) Oribatid mite (Acari) community structure in steppic habitats of Burgos Province, central northern Spain. *Journal of Natural History*, 39, 3453–3470.

Bardgett, R.D., Anderson, J.M., Behan-Pelletier, V.M., Brussaard, L., Coleman, D.C., Ettema, C., Moldenke, A., Schimel, J.P. & Wall, D.H. (2001) The influence of soil biodiversity on hydrological pathways and the transfer of materials between terrestrial and aquatic ecosystems. *Ecosystems*, 4, 421–429.

Battigelli, J.P., Spence, J.R., Langor, D.W. & Berch, S.M. (2004) Short-term impact of forest soil compaction and organic matter removal on soil mesofauna density and oribatid mite diversity. *Canadian Journal of Forest Research*, 34, 1136–1149.

Beck, L. (1976) Zum Massenwechsel der Makro-Arthropodenfauna des Bodens in Überschwemmungswäldern des Zentralen Amazonasgebietes. *Amazoniana*, 6, 1–20.

Behan-Pelletier, V.M. & Eamer, B. (2007) Aquatic Oribatida: adaptations, constraints, distribution and ecology. In: Morales-Malacara, J.B., Behan-Pelletier, V., Ueckermann, E., Perez, T.M., Estrada-Venegas, E.G., & Badii, M. (eds) *Proceedings of the 11th International Congress of Acarology*. Merida, 71–82.

Behan-Pelletier, V.M. & Hill, S.B. (1983) Feeding habits of sixteen species of Oribatei (Acari) from an acid peat bog, Glenamoy, Ireland. *Revue d'Ecologie et de Biologie dul Sol*, 20, 221–267.

Coleman, D.C., Crossley Jr., D.A. & Hendrix, P.F. (2004) *Fundamentals of soil ecology, 2nd edition.* Elsevier Academic Press. Boston.

Denk, T., Frotzler, N. & Davitashvili, N. (2001) Vegetational patterns and distribution of relic taxa in humid temperate forest and wetlands of Georgia (Transcaucasia). *Biological Journal of the Linnean Society*, 72, 287–332.

Fielding, A.H. (2007) *Cluster and classification techniques for the biosciences*. University Press, Cambridge.

Ghilarov, M.S. & Krivolutsky, D.A. (1975) *Key to soil-inhabiting mites. Sarcoptiformes.* Nauka Publications, Moscow [in Russian].

Irmler, U. (2004) Long-term fluctuation of the soil fauna (Collembola and Oribatida) at groundwater-near sites in an alder wood. *Pedobiologia*, 48, 349–363.

Kikodze, A. & Gokhelashvili, R. (2007) *Protected territories of Georgia.* Tbilisi.

Kikvidze, Z. & Ohsawa, M. (2001) Richness of Colchic vegetation: comparison between refugia of south-western and East Asia. *BMC Ecology*, 1, 1–10.

Knúlle, W. (1957) Die Verteilung der Acari: Oribatei in Boden. *Zeitshrift der Morphologie und Oekologie der Tiere*, 46, 397–432.

Kobakhidze, D.N. (1943) Analyses of the terrestrial biocenoses of the central part of Kolkheti Lowland. *Trudi Zoologicheskogo instituta*, 5, 1–188 [in Russian].

Kurashvili, B. (1984) *The animal population of typical biocenoses of Kolkheti Lowland*. Tbilisi [in Georgian].

Laiho, R., Silvan, N., Carcamo, H. & Vasander, H. (2001) Effects of water level and nutrients on spatial distribution of soil mesofauna in peatlands drained for forestry in Finland. *Applied Soil Ecology*, 16, 1–9.

Lagidze, O.I. (1981) The fauna of podzol clay soils of Kolkheti Lowland and changes within drainage and usage. *Avtoreferat*. Moscow [in Russian].

Lebrun, P. & van Straalen, N.M (1995) Oribatid mites: prospects for their use in ecotoxicology. *Experimental and Applied Acarology*, 19, 361–380.

Magurran, A.E. (2004) *Measuring biological diversit*y. Blackwell, Oxford.

Management Plan of Kolkheti National Park (2003) *Project of integrative management of Black Sea cost of Georgia*.

Maraun, M. & Scheu, S. (2000) The structure of oribatid mite communities (Acari, Oribatida): patterns, mechanisms and implications for future research. *Ecography*, 23, 374–383.

McAleece, N., Lambshead, P.J.D., Paterson, G.L.J. & Gage, J.D. (1996) *Biodiversity Pro*. A program for analyzing ecological data. Available from http://www.sams.ac.uk/dml/projects/benthic/bdpro/index.htm

Murvanidze, M. & Kvavadze, E. (2007) The oribatid mites of flood plain alder forests of Central Colchic Lowland. *Proceedings of the Georgian Academy of Sciences, Biological Series B*, 5, 80–85.

Murvanidze, M. & Kvavadze, E. (2010) An inventory of oribatid mites, the main decomposers of bogs of Colchic Lowland (Caucasus, Georgia). In: Sabelis, M.W. & Bruin, J. (eds) *Proceedings of the 12th International Congress of Acarology*, Amsterdam, pp. 175–178.

Murvanidze, M., Kvavadze, E., Bagathuria, N., Eliava, I., Arabuli, T. & Mumladze, L. (2009) The invertebrate animals – bioindicators of urban environment. "*Universaly*" publ. 121pp. [in Georgian].

Osler. G.H.R., Osler, H.R., Cole, L. & Keith, A.M. (2006) Changes in oribatid mite community structure associated with the succession from heather (*Calluna vulgaris*) moorland to birch (*Betula pubescens*) woodland. *Pedobiologia*, 50, 323–330.

Schaefer, M. & Schauermann, J. (1990) The soil fauna of beech forests: comparison between a mull and a moder soil. *Pedobiologia*, 34, 299–314.

Schatz, H. (2004) Hornmilben (Acari, Oribatida) in Auwäldern an der Etsch und Tafler (Südtirol, Italien). *Gredleriana*, 4, 93–114.

The Ramsar Convention Manual (2006) *A guide to the convention on wetlands*. (Ramsar, Iran, 1971) 4th Edition. Ramsar Convention Secretariat. 114pp.

Weigmann, G. (1991) Oribatid communities in transects from bogs to forests in Berlin indicating the biotope qualities. *Modern Acarology*, 1, 259–364.

Weigmann, G. (1997a) Bioindication by means of isovalent species groups. *Abhandlungen und Berichte des Naturkundemuseums Gőrlitz*, 69, 59–65.

Weigmann, G. (1997b) Die Hornmilbenfauna (Acari, Oribatida) in Auenboden des unteren Odertals. *Faunistische und Őkologische Mitteilungen*, 7, 319–333.

Weigmann, G. (2006) *Hornmilben (Oribatida). Die Tierwelt Deutschlands*. 76 Teil. Goecke & Evers, Keltern.

Weigmann, G. & Kratz, W. (1981) Die deutschen Hornmilbenarten und ihre Őkologische Charakteristik. *Zoologische Beitrage*, 27, 459–490.

Zazanashvili, N. (2009) Territorial protection of globally threatened species in the *Caucasus*. In: Zazanashvili, N. & Mallon, D. (eds) *Status and protection of globally threatened species in the Caucasus*. CEPF Biodiversity Investment in the Caucasus hotspot 2004–2009, Tbilisi.

Appendix. Dominance values (%) and ecological groups of oribatid mites found in Kolkheti National Park.

Species	Dunes					Juncus bogs								Flooded alder forests			Humid alder forests	
	D1.1	D2.1	D2.2	D3.1	D3.2	B1.1	B1.2	B2.1	B2.2	B2.3	B3.1	B3.2	B3.3	FA 1.1	FA 2.1	FA 3.1	HA 1.1	HA 3.1
Euryecological																		
Phthiracarus ferrugineus	–	100	5	–	–	–	–	–	–	–	8	–	15	17	0.4	13	6	30
Rhysotritia ardua	100	–	–	–	22	86	–	–	–	–	–	–	4	8	–	–	–	10
Tectocepheus velatus sarekensis	–	–	5	–	–	–	–	23	–	–	–	–	–	–	–	–	–	–
T. velatus velatus	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	–	–	–
Oppiella nova	–	–	–	3	8	–	72	–	–	–	4	–	–	17	–	–	–	–
Oppiella fallax	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	–	21	–
Galumna lanceata	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–
Punctoribates punctum	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	–	–	–
Scheloribates laevigatus	–	–	–	–	–	–	–	31	–	–	–	–	–	–	–	–	–	–
Sch. latipes	–	–	69	–	32	–	14	–	–	6	–	22	–	–	–	–	–	–
Xerophilous																		
Epilohmannia cylindrica	–	–	–	–	3	1	14	–	–	–	–	–	–	–	–	6	–	–
Oxioppioides decipiens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–
Ramusella insculpta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	–
Peloribates longipilosus	–	–	–	97	8	–	–	–	–	–	4	–	–	–	–	–	–	–
Zygoribatula exilis	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–
Z. cognata	–	–	–	–	8	12	–	15	–	–	4	–	–	–	0.1	–	–	–

Species	Dunes					Juncus bogs								Flooded alder forests			Humid alder forests	
	D1.1	**D2.1**	**D2.2**	**D3.1**	**D3.2**	**B1.1**	**B1.2**	**B2.1**	**B2.2**	**B2.3**	**B3.1**	**B3.2**	**B3.3**	**FA 1.1**	**FA 2.1**	**FA 3.1**	**HA 1.1**	**HA 3.1**
Humid forest soil																		
Hypochthonius rufulus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.4	–	–	–
Phthiracarus (A.) assimilis	–	–	–	–	–	–	–	–	–	–	–	–	27	–	–	–	–	–
Nothrus palustris	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	–
Platynothrus peltifer	–	–	–	–	–	–	–	–	–	2	–	–	–	8	0.2	–	4	–
Metabelbella macerochaeta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
Eremobelba geographica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–
Cultroribula bicultrata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1	–	–	–
Gustavia microcephala	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Tectocepheus punctulatus	–	–	–	–	–	–	–	–	–	10	–	–	4	–	–	–	–	–
Scutovertex serratus	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–
Parachipteria georgica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	–
P. punctata	–	–	–	–	–	–	–	–	–	–	–	–	4	–	0.4	–	–	–
Pergalumna nervosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–
Trichoribates caucasicus	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–
Peloptulus phaenotus	–	–	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chamobates cuspidatiformis	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–
Minunthozetes pseudofusiger	–	–	–	–	3	–	–	–	–	–	12	–	–	–	–	6	–	–
Protoribates capucinus	–	–	–	–	8	–	–	3	82	4	–	22	15	–	20	13	–	20
Liebstadia pannonica	–	–	–	–	–	–	–	–	–	–	–	11	–	17	–	–	–	–
Steganacarus spinosus	–	–	5	–	–	–	–	3	9	–	27	–	15	–	40	25	8	10
Nanhermannia nana	–	–	–	–	3	–	–	3	9	17	12	–	8	–	38	–	–	–
Oppia nitens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	–
Ramusella clavipectinata	–	–	–	–	–	–	–	–	–	27	–	–	–	–	–	–	–	–
Eupelops occultus	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
Achipteria coleoptrata	–	–	–	–	–	–	–	–	–	–	19	–	–	–	–	–	–	–
Galumna obvia	–	–	–	–	–	–	–	*13*	–	–	–	–	–	–	–	–	–	–
Pergalumna minor	–	–	–	–	–	–	–	–	–	2	–	11	–	25	0.1	–	56	10
Zetomimus furcatus	–	–	–	–	–	–	–	–	–	2	12	–	–	–	–	–	–	–
Euzetes globulus	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–
Punctoribates manzanoensis	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–
Totals/ site	**1**	**1**	**5**	**2**	**11**	**4**	**3**	**10**	**3**	**10**	**9**	**7**	**10**	**7**	**11**	**8**	**8**	**6**
Density (mites/m2)	**100**	**33**	**632**	**1,300**	**1,233**	**2,533**	**233**	**1,299**	**366**	**1,599**	**867**	**299**	**864**	**400**	**23,533**	**534**	**1,598**	**332**