Postprint on Soil Mite Community Diversity in the Manas River Basin, Xinjiang

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Abstract

To investigate the community diversity and spatiotemporal characteristics of soil mites in different habitats of the Manas River Basin, field sampling and a modified Tullgren method were employed to collect soil mites for taxonomic identification and comparative analysis. A total of 33,208 soil mites were collected, belonging to 4 suborders, 86 families, and 140 genera. Among these, Ceratozetes and Oribatula were the dominant taxa. Significant differences ($P < 0.05$) were observed in both individual abundance and taxon richness among different vertical zone habitats, with individual numbers following the order: > > > > > > > > > > > . Vertical distribution revealed highly significant differences ($P < 0.01$) in individual numbers among different soil layers, with soil mites being primarily concentrated in the surface soil layer. Soil mites in different habitats showed significant seasonal differences ($P < 0.05$), with individual numbers following the order: September > April > July > November. Significant differences ($P < 0.05$) were found in all community diversity indices among the 12 different habitats, with the Shannon-Wiener diversity index (H) following the order: > > > > > > > > > > > , while the Margalef richness index (M) followed the order: > > > > > > > > > > > . Soil mite communities in different habitats exhibited moderate dissimilarity. The results indicate that soil mite community diversity in different vertical zone habitats of the study basin exhibits distinct habitat and seasonal variation characteristics.

Full Text

Preamble

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Community Diversity of Soil Mites in the Manas River Basin, Xinjiang

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Abstract

To investigate soil mite community diversity and its spatiotemporal characteristics across different habitats in the Manas River Basin, we conducted field sampling using improved Tullgren methods for collection, classification, and comparative analysis. A total of 32,308 soil mites were collected and identified, comprising four suborders, 86 families, and 140 genera. *Ceratozetes* and *Oribatula* were dominant groups, accounting for 10.14% and 11.18% of total individuals respectively. Eighteen genera were common groups, representing 55.89% of the collection, while the remaining 120 genera were rare groups comprising only 22.79% of total individuals. Significant differences existed in both individual and taxon numbers among different vertical zonal habitats ($p<0.05$). Soil mites were concentrated in the surface soil layer (0–5 cm), with individual numbers decreasing gradually with soil depth ($p<0.01$). Seasonal variation in community composition and individual numbers was significant across habitats ($p<0.05$), following the sequence: September > April > July > November. Diversity indices differed significantly among the 12 habitats ($p<0.05$). The Shannon-Wiener diversity index ranked: coniferous forest > mountain farmland > mountain shrubbery > shelter forest > deciduous forest > vegetable field > mountain steppe > vineyard > grassland > plain farmland > shrubbery > desert. The Margalef richness index ranked: coniferous forest > shelter forest > deciduous forest > vegetable field > shrubbery > grassland > mountain farmland > mountain shrubbery > plain farmland > mountain steppe > vineyard > desert. Community similarity among habitats was moderately dissimilar. Results demonstrate that soil mite community structure and diversity in this mountain-oasis-desert system exhibit distinct habitat-specific and seasonal variation characteristics.

Keywords: Manas River Basin; MODS; soil mites; community diversity; seasonal dynamics

1. Study Area Natural Overview

The Manas River Basin is located on the northern slope of the central Tianshan Mountains (43°05 -46°04 N, 84°56 -86°42 E) in the southwestern Junggar Basin. The landscape exhibits distinct vertical zonation with elevation changes, including alpine snow-ice zones, alpine and subalpine meadow zones, mid-mountain forest zones, low-mountain grassland zones, and desert zones. Since the founding of the People' s Republic of China, the basin has become Xinjiang' s largest artificial oasis and one of China' s four major irrigated agricultural regions, serving as a critical grain and sugar production base. Population growth and large-scale economic development have caused significant ecological changes, including severe soil salinization, pollution, and degradation. Vegetation shows clear vertical zonal distribution, land use types are complex and diverse, and biological communities exhibit distinct regional differences.

2. Sample Plot Setup

To ensure representativeness, we established two 150 km transects across the study area based on landscape patterns, soil types, and land use conditions. Twelve different habitats were selected: ( ) coniferous forest, ( ) mountain steppe, ( ) deciduous forest, ( ) mountain shrubbery, ( ) mountain farmland, ( ) shelter forest, ( ) plain farmland, ( ) grassland, ( ) vineyard, ( ) vegetable field, ( ) shrubbery, and ( ) desert.

3. Sample Collection and Processing

Sampling was conducted in mid-month during April, June, September, and November. At each habitat, three sampling points were selected, and soil cores were taken at 0–5, 5–10, 10–15, and 15–20 cm depths using soil augers. Samples were transported to the laboratory, and soil mites were extracted using the improved Tullgren method with continuous light. Mites were observed under a Leica stereomicroscope and identified to genus level using *The Oribatid Mites Genera of the World* (P. Balogh), *A Manual of Acarology* (Krantz 2009), and Chinese soil animal identification guides.

4. Main Environmental Factors Determination

Concurrent with soil mite surveys, we measured key environmental factors at each sampling point: soil temperature, pH, water content, bulk density, organic matter, total nitrogen, total phosphorus, total potassium, and total salt content. Soil temperature and pH were measured with a geothermometer and soil pH meter respectively. Water content was determined by oven-drying method. Bulk density was measured using the soil core method. Organic matter was analyzed via potassium dichromate-sulfuric acid oxidation. Total nitrogen, phosphorus, and potassium were measured following national standards (GB 7173—1987, GB 9836—1988, GB 9834—1988). Total salt content was determined by water-soluble salt analysis (GB 9837—1988).

5. Data Processing

We calculated the following ecological indices for soil mite community diversity analysis:

(1) Shannon-Wiener diversity index: H'

(2) Margalef richness index: M

(3) Pielou evenness index: J

(4) Simpson dominance index: D

(5) Jaccard similarity coefficient: $q = c/(a + b + c)$

(6) Sørensen similarity index:

Where N represents total individuals, ni represents individuals of taxon i, S represents number of taxa, a and b represent taxon numbers in communities A and B, and c represents shared taxa between communities.

One-way ANOVA and LSD tests were performed using SPSS 19.0 to compare differences among data groups. All data processing was conducted in Excel.

2. Results and Analysis

2.1 Community Composition and Quantitative Distribution Across Habitats

A total of 32,308 soil mite specimens were collected, belonging to four suborders: Oribatida (64.62%), Mesostigmata (31.47%), Prostigmata (3.19%), and Astigmata (0.72%). For the entire study area, *Ceratozetes* and *Oribatula* were dominant groups, together with *Epilohmannia*, *Trhypochthonius*, *Zygoribatula*, *Cosmochthonius*, *Eremaeus*, and *Allothrombium* as common groups, accounting for 77.21% of total captures.

Statistical analysis revealed significant differences in both individual numbers and taxon richness among the 12 habitats ($p<0.05$). Individual numbers ranked: (7,787; 24.10%) > (5,019; 6.23%) > (1,823; 15.53%) > (3,878; 5.64%) > (1,680; 12.00%) > (3,130; 5.20%) > (1,488; 9.69%) > (2,868; 8.88%) > (2,014; 4.61%) > (1,327; 4.11%) > (814; 2.52%) > (480; 1.49%). Taxon numbers ranked: (72; 51.43%) > (67; 47.86%) > (57; 40.71%) > (55; 39.29%) > (54; 38.57%) > (49; 35%) > (45; 32.14%) > (45; 32.14%) > (44; 31.43%) > (44; 29.29%) > (20; 14.29%) > (41; 31.43%). The high individual numbers in certain habitats correlated with diverse vegetation distribution.

2.2 Vertical Distribution of Soil Mite Communities

Soil mites showed pronounced surface aggregation, with 60.63% concentrated in the 0-5 cm layer, 22.56% in 5-10 cm, 11.53% in 10-15 cm, and only 5.28% in 15-20 cm. One-way ANOVA revealed significant differences in individual numbers among soil layers across habitats ($p<0.05$). This vertical pattern closely relates to the stratification of soil organic matter, temperature, and moisture.

2.3 Seasonal Dynamics of Soil Mite Communities

Seasonal surveys across four seasons showed that individual and taxon numbers varied significantly among habitats and seasons ($p<0.05$), following the pattern: autumn (15,146; 46.88%) > summer (6,682; 20.68%) > spring (6,041; 18.70%) > winter (4,439; 13.74%). This trend likely relates to increased litter accumulation in autumn and winter, providing abundant food resources.

2.4 Diversity Analysis Across Habitats

Diversity indices differed significantly among habitats ($p<0.05$). The Shannon-Wiener diversity index ranked: > > > > > > > > > > > . The Margalef richness index ranked: > > > > > > > > > > > . The Pielou evenness index ranked: > > > > > > > > > > > > . The Simpson dominance index ranked: > > > > > > > > > > > . Diversity metrics were generally higher in mountain habitats, likely due to diverse vegetation and minimal human disturbance.

2.5 Community Similarity Analysis

Jaccard and Sørensen similarity indices revealed considerable variation among habitats. Jaccard similarity coefficients ranged from 0.089 to 0.294, with the highest value between habitats and and the lowest between and . Most habitat pairs showed moderate dissimilarity (0.25–0.50), with 36 pairs showing extreme dissimilarity (<0.25). Sørensen indices showed similar patterns, with the highest value (0.836) between habitats and , indicating moderate similarity, and the lowest (0.164) between and , indicating extreme dissimilarity. These results demonstrate strong influence of elevation, vegetation composition, and human disturbance on community structure.

2.6 Relationships Between Community Indices and Environmental Factors

Correlation analysis revealed that individual density and diversity indices were significantly positively correlated with organic matter and total nitrogen content ($p<0.01$), and significantly negatively correlated with soil bulk density, total potassium, and total salt content ($p<0.05$). Richness and evenness indices showed significant positive correlations with temperature and organic matter ($p<0.05$). These findings indicate that soil temperature, organic matter, and moisture are key determinants of soil mite community structure and diversity in this region.

3. Discussion

3.1 Habitat-Specific Differences in Soil Mite Community Structure

Significant differences in individual numbers and taxon richness among habitats and seasons align with findings from other regions in China, though some variations exist due to local conditions. For the three major ecosystems in the Manas River Basin, individual density and taxon richness were highest in mountain habitats with diverse vegetation and abundant organic matter, moderate in oasis habitats with intensive human activity, and lowest in arid desert habitats. The vertical distribution pattern showing surface aggregation is consistent with international research and relates closely to vertical gradients in soil physicochemical properties, moisture, temperature, and organic matter. Soil bulk density, moisture, and organic matter are primary factors influencing vertical distribution. Studies show mite abundance correlates positively with soil nutrients, and soil temperature significantly affects community composition, with optimal ranges of 15-23°C promoting higher diversity, particularly for predatory mites.

3.2 Comparison of Community Diversity Across Habitats

Biodiversity indices reflect species richness and food web complexity. Our analysis revealed significant differences in diversity metrics among habitats, consistent with other studies. The Shannon-Wiener and Margalef indices were highest in coniferous forest and shelter forest habitats, indicating stable ecosystem structure. Soil moisture is a critical factor determining mite community composition and diversity, with higher biodiversity in moist environments. Soil pH also influences distribution, with most soil mites preferring slightly acidic to neutral conditions (pH 6.8-7.8). Similarity analysis showed moderate to extreme dissimilarity among habitats, reflecting substantial differences in environmental conditions, climate, and human disturbance regimes.

4. Conclusion

The Manas River Basin harbors rich soil mite resources with significant differences in species composition and diversity indices across the mountain-oasis-desert vertical zones. Dominant taxa varied by ecosystem: *Ceratozetes*, *Oribatula*, *Holaspulus*, and *Aleuroglyphus* in oasis ecosystems; *Passalozetes* and *Liacarus* in mountain ecosystems; and *Oppiealla* and *Eupelops* in desert ecosystems. Notably, *Passalozetes* is uniquely distributed in desert environments and serves as an important environmental indicator. These findings provide a scientific basis for biological assessment of soil environmental quality and systematic research on soil fauna in arid regions under global climate change.

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Note: Figure translations are in progress. See original paper for figures.