

A New Method to Evaluate Habitat Status Based on the Use of Data on Oribatid Mites (Acari: Oribatida)

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Abstract. Several indicators have been available for evaluating the coenological-ecological status of habitats. Of these, functions that are simple to use in a standardized way are of great importance in environmental biology. One such method involves listing the genera occurring in a given habitat with large abundance and species richness. In our study, the indication power of genus-level lists of Oribatid mites and the underlying effects behind the generation of similarity patterns were analysed using data on Oribatid mites collected by ourselves and derived from the literature. Our objective was to develop a method by which the distance between two Oribatid mite genus lists originating from any sources is evaluated for correspondence to spatial scales.

Keywords: Oribatid mites, genus list, family list, distance function, indication, pattern generation

Introduction

There have been only a few efficient tools to express objectively and numerically the current state and naturalness of a given habitat. This poses a huge problem in conservation practice since this information is essential for decision-makers to judge properly to what extent a habitat is disturbed and if it needs protection. To overcome this problem, suitable indicator groups of organisms and methods should be established.

The main goal of this study is to set up a comparison scale based on genus-level presence-absence data of Oribatid mite communities (Acari: Oribatida) from habitats examined at different spatial and temporal scales. The secondary goal – and this time the precondition as well - is to get a reliable picture on the indication power of the distances to be used.

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The use of Oribatid mites as indicators for describing the status of their habitat is justified by the special characteristics of the group. Oribatid mites can be found in almost all kinds of habitats: on land and in water; first of all in the organic horizons of soils. However, they have penetrated into different other microhabitats as well (e.g., lichens, bryophytes, bark etc.), which is mainly due to the great variability of their food sources (e.g. organic debris, fungi, other mites, etc.). In addition to the diversity of habitats, their high adaptation ability is also shown by their enormous abundance and species richness. The above features may be utilized by using coenological methods (Lebrun & van Straalen, 1995; Behan-Pelletier, 1999; Gulvik, 2007; Gergócs & Hufnagel, 2009).

The choice of the genus level is reasonable ecologically. Caruso & Migliorini (2006) have shown that there were no significant changes in the data on the anthropogenic disturbance on Oribatid mites when switching from species level to genus level. Our study has a similar objective: we would like to see how potential habitat changes are indicated based on genus level lists. Podani (1989) had a similar observation in case of plants, according to which switching to genus level did not cause significant change when comparing the examined habitats. Osler & Beattie (1999) carried out a meta-analysis, which confirmed our assumption that taxonomic levels above the species are suitable for comparing habitats. This research showed that habitats can be distinguished on family level as well in case of Oribatid mites, therefore our study also covers family level besides the genus level. There were also some other arguments in favour of this decision, namely that the number of databases used could be considerably extended in this way. In addition, taxonomical processing could become faster and more reliable in our field studies as well. Genus-level identification of Oribatid mites is solved on the basis of the work by Balogh & Balogh (1992) on a global scale, too. However, species-level identification is only possible for some zoogeographical regions and only some taxa on a global scale since the related literature is not synthesized yet properly (e.g. Balogh & Mahunka, 1983; Olsanowski, 1996).

By setting up the spatial and temporal scales, we expected that comparisons order of Oribatid mites' habitats based on the genus and family lists corresponds to actual spatial and temporal scales, i.e. the farther and qualitatively the more different habitats our lists originate from, the greater difference is found among similarities inside the given categories. However, if data originate from the same site, the difference among the examined samples should be greater in case of the lists which are more distant in time from each other.

The main goals of the present study are the following.

1. Developing a spatial and temporal scale reference based on the genus- and family-level taxon lists with the help of similarity functions.
2. Examining the degree of distances in the similarity order used for indication.
3. Utilizing the distances for comparing the habitats being under the effects of human perturbations with natural habitats measuring the extent of disturbance.

Materials and Methods

Categories and sources of the genus lists. In order to be able to determine to which spatial and temporal distance the Oribatid mite genus lists of two samples/sites correspond, different categories had to be defined (Gergócs et al. 2010). These categories were set up considering the combination of the given spatial and temporal scales the examined pair of genus lists originates from. These combinations were as follows.

First of all, some categories originate from the same zoogeographic kingdom, the same topographic position (i.e., country) and the same type of habitat, so we will not sign them in the codes of these categories. The first category originates from a homogenized, parallel sample collection (HPS- from own research). Also our own study from Hungary made it possible to set up categories on pattern levels meaning a distance of 2, 12, 24 and 52 weeks, in which substrate-microhabitat (S), habitat (H), topographicum and zoogeographic kingdom were the same (Sa). Regarding the time (Ti), we differentiated these categories: SaS/Ti-2, SaS/Ti-12, SaS/Ti-24 and SaS/Ti-52.

Samples were collected from three different places in Hungary to compare several habitat types and substrate types: 1) bank of the Danube: a floodplain forest, a meadow and a Black Locust (*Robinia pseudo-acacia*) plantation. 2) Velence mountains: a dry oak forest, a mossy thermophilous *Quercus pubescens* wood, a European hornbeam forest. 3) Órség district: a spruce plantation, a hornbeam-beech forest, a meadow.

Two categories were made from the data described above: SaS/Hu/close and SaS/Hu/far. These codes mean that the same type of substrates in the same type of sites were compared with the same type of substrates that belonged to a closer or a farther (being several kilometres far from the other site) site of the same type.

Data of the last category of the same substrates (SaS-trop) were collected from the tropics, by Janos Balogh. Data of Oribatid mite genus lists are from a moss forest in Costa Rica, a rain forest and a paramo in Brazil, and a rain forest in Papua New Guinea.

The next change in scale is the difference in substrate: DS. Two groups of these genus lists originate from our own database from the temperate zone (DS-temp) and from the above mentioned manuscripts by Balogh (DS-trop). The other two categories were made from the database of other sites in Hungary differentiating the distance in same types of sites: DS/Hu/close and DS/Hu/far.

Genus lists belonging to the same types of tropical and temperate habitats (SaH-trop, SaH-temp) were obtained from the manuscripts by János Balogh (Australia, Sri Lanka, Papua New Guinea, Costa Rica and Ecuador), the study by Migliorini et al. (2005) and the studies by Hammer (1958, 1961, 1962, 1966).

Sources of the categories of different habitats (DH-trop, DH-temp) are: studies by Noti et al. (1996), Migliorini et al. (2002), Osler & Murphy (2005), Skubala & Gulvik (2005), Arroyo & Iturrondobeitia (2006), Osler et al. (2006), manuscripts by János Balogh, published series by János Balogh (Balogh et al., 2008) and studies by Hammer (1958, 1961, 1962, 1966). A series belonging here originates from samples collected by Levente Hufnagel in Australia (2006, Australia: QLD, Cairns).

At this level, the genus lists from Hungarian habitats were examined as well. Accordingly, the following categories were made: SaH/Hu/far, DH/Hu/close, DH/Hu/far. SaH/Hu/close could not be created because of missing data.

In case of genus lists originating from different topographic positions (practically countries, DT), we considered the point if they originated from the same (SaK/DH/SaH) or different sites (SaK/DT/DH) and if the two topographic positions were in the same or different zoogeographic kingdoms (DK/DT/SaH, DK/DT/DH). These series came from studies by János Balogh and Marie Hammer.

In the last category, the complete genus lists of the six zoogeographic kingdoms were compared according to the work by Balogh & Balogh (1992) (DK).

Applying the reference list. Adaptability of our results will be demonstrated by showing some examples from other papers. In order to get genus lists from species lists we used five publications comparing natural mite assemblages with Oribatid mite communities destroyed by human disturbance. Hülsman & Wolters (1998) evaluated the effects of three tillage practices on soil mites in a replicated field experiment. Zaitsev & van Straalen (2001) made a study of Oribatid mite communities and their responses to metal contamination. Andrés and Mateos (2006) used soil mesofaunal bioindicators to evaluate four post-mining restoration treatments. Surveying the efficiency of treatments was carried out after 12 years by examination the soil mesofaunal responses. Berch et al. (2007) studied the responses of Oribatid mite species to site preparation treatments in high-elevation cutblocks. Déchene & Buddle (2009) tested how different experimental harvesting regimes affect the diversity, abundance and composition of Oribatida in a forest in Canada. Descriptions of the compared sites can be seen in Table 2.

The similarity values of the genus list pairs created from the above papers were obtained with the Ochiai function. On each occasion the genus list of control sites was compared with genus lists of treated sites. Finally, the distance data calculated in this way were confronted with the values of reference list checking which category suits the distance between control and treated sites. Sites in the studies mentioned above always originated from the same type of substrates and topographic positions (countries).

Data processing. From the databases we did not consider all possible list combinations which fit the category, only the ones having at least nine genera. After our complete genus list database was set up, the number of genera of the two lists and the numbers of the common genera were determined considering the genus list pairs in each category. As we had only presence-absence data and the value “d” of the contingency table was not considered in the case of the genus list pairs, the Ochiai and Jaccard functions were used as similarity functions (Podani, 1997). The similarities in each category were calculated from the means of the values of the similarity functions for the genus list pairs.

As our data were not always independent within a category, it was determined with a complex method to what extent the means of the categories differ from each other.

As there were few data in categories from Hungary we concentrated them with other adequate categories e.g. DS/Hu/close and DS/Hu/far with DS-temp. Since there was no SaD-temp category we made one from the categories SaS/Hu/close and

SaS/Hu/far for this examination. So, the original 24 categories reduced to only 18 categories. We had several distance function values within each category as we had 85 genus list pairs within one category on average. From among the distance function values of each category, fifteen values were chosen randomly with the help of a random number generator in the Excel software. It was carried out ten times in case of each category. In this way we got 10 series containing 15 values for each category. Series of the data table containing 10×15 values in case of each category were now independent and since normal distribution could not be observed within each category, the data were analysed with the Kruskal-Wallis statistical test using PAST software (Hammer et al., 2001). Each of the 18 series was analysed with the Mann-Whitney post hoc test as well, so we got ten tables containing 18×18 post hoc test results. One table (Table 1) was made out of these ten tables, which shows that how many times there are significant differences among the ten results at the 5% significance level. Based on this we were able to decide which categories differ from each other significantly.

The above analyses were carried out at the family level as well.

Results

Order of genus and family list categories. Figure 1 displays intervals with standard error around the Ochiai distance means in case of each category.

The category of homogenized parallel sampling (HPS) shows the outstanding largest similarity between the samples. This was followed by the samples originating from same (SaS) and different (DS) substrates. These two types of categories do not differ from each other because their orders are mixed. Similarities of genus lists originating from different times are the next: first the two-week-difference, then the 12-, 24- and finally the 52-week-difference. There is greater difference between genus compositions of Hungarian samples originating from the same type of habitat being in large geographical distance but originating from the same or different substrates (.../far) than in case of samples from closer habitats (.../close). Categories of tropical samples on substrate level are further back than the categories from the temperate zone comparing among each other with less geographical distances. The similarities of the ".../far" samples originating from different substrates are low so these categories have fallen amongst the categories differing in site level.

An opposing phenomenon can be seen on habitat level (SaH and DH). Habitats from the tropics are more similar to each other than the habitats from the temperate zone. The geographical distance has reduced the similarity between communities also on habitat level since the further habitats are more different from each other than the closer habitats. Same and different types of habitats have not been sharply separated from each other. Oribatid genus lists from different types of habitats in the same zone tend to be less similar to each other than the genus lists from the same habitat types.

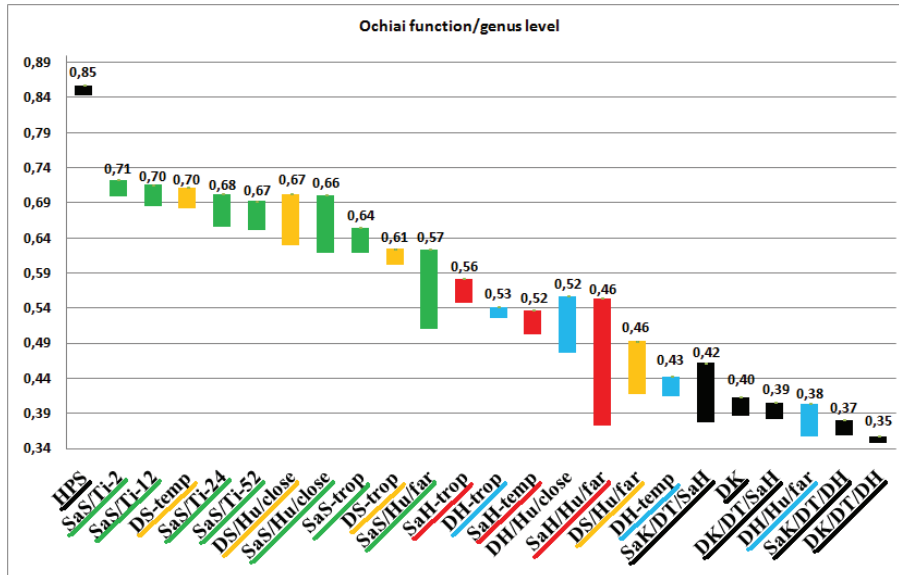


Fig. 1. The order of categories at the genus level. Similarity increases from right to left. For codes, see text.

In the last “block” showing the lowest similarities are categories measuring the difference of genus lists on habitat level between topographic positions (DT). The same type of habitat (DT/SaH) shows greater similarity than the different habitat (DT/DH) irrespectively of that the positions are either in the same zoogeographical kingdom or in different ones (SaK-DK). The category DK is among these categories. We got nearly the same results using both similarity functions (Ochiai and Jaccard), only the order of three pairs of categories has been inverted by the Jaccard function, but this condition does not cause inconsistency with statements mentioned above.

The results on family level largely correspond with the results on genus level. There is one notable difference from the results on genus level. The category DK has fallen amongst the categories of substrate level.

Significance of distances between genus and family list categories. The category of homogenized parallel sampling (HPS) is isolated from all the other categories (Table 1). The ten randomly chosen data often show different results for the separation of categories. The categories of same substrates (SaS) stand close to each other and to the categories of different substrates (DS). The uncertainties begin with the separation of categories of SaH and DH from the category groups of SaS, DH and DT. The categories of different topographic positions (DT) go together very much but they are uniformly separated from the categories of same and different substrates (SaS and DS). The categories of the same and different habitats (SaH and DH) fluctuate between the two large blocks, i.e. they vary if they are close either to the block of DT categories or to the block of SaS/DS. Distinction of tropical and temperate zones on the given habitat level is of importance only by different habitats

(DH), e.g. DH-temp and DH-trop often separate from each other significantly. We got the same results on family level as on genus level like in the case of orders. The DK category is significantly different from the block of different topographical (DT).

Table 1 The significance of differences between the 18 genus list categories according to Mann-Whitney tests. The numbers in the table mean that how many times there are significant differences between the categories among ten results at $p=0.05$.

18 categories	SaS/Ti-2	SaS/Ti-12	SaS/Ti-24	SaS/Ti-52	DS-temp	SaS-trop	SaS-temp	DS-trop	SaH-trop	DH-trop	SaH-temp	DH-temp	AB/ET/AS	DK	DK/DT/SaH	SaK/DT/DH	DK/DT/DH
HPS	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SaS/Ti-2		0	2	4	5	8	7	9	10	10	10	10	10	10	10	10	10
SaS/Ti-12			3	3	3	4	5	7	10	10	10	10	10	10	10	10	10
SaS/Ti-24				0	1	0	1	3	9	10	10	10	10	10	10	10	10
SaS/Ti-52					0	1	0	4	6	7	6	10	10	10	10	10	10
DS-temp						0	0	0	1	6	8	10	10	10	10	10	10
SaS-trop							0	1	3	5	5	10	10	10	10	10	10
SaS-temp								0	3	6	7	10	10	10	10	10	10
DS-trop									1	3	4	9	10	10	10	10	10
SaH-trop										0	2	7	6	10	9	9	10
DH-trop											1	5	4	10	10	9	10
SaH-temp												5	4	9	9	8	10
DH-temp													0	0	0	0	3
SaK/DT/SaH														0	0	1	7
DK															1	0	3
DK/DT/SaH																0	4
SaK/DT/DH																	1

Applying the created reference list. Dissimilarities for the genus lists of the five publications are shown in Table 2. It can be seen that how much change was caused by several human perturbations in the composition of Oribatid community in a given habitat. Several human interventions examined by Hülsmann and Wolters (1998), Déchéne and Buddle (2009) and Zaitsev and van Straalen (2001) did not cause much change in the composition of Oribatid communities since the differences between the analyzed habitats are as much as the differences between the communities from the same habitat and the same substrate (SaS).

However, Déchéne & Buddle (2009) found that clear cut and burning after harvest have large effects on Oribatid mite communities. In this case the distance between the communities are up to the distance either in case of between same habitats or in case of between different types of substrates. We could find similar results by the perturbations in (Berch et al. 2007) namely not only burning but mounding and scalping the soil have important effects on Oribatid communities. The greatest differences could be measured in case of succession in a post-mining restoration some years after the beginning in the study of Andres and Mateos (2006). In this study, samples originating from adjacent natural habitats differ as much from the Oribatid genus lists of post-mining habitats as the habitats from the same or different topographical differ from each other.

Table 2. Ochiai dissimilarities between the genus lists from the five publications. Table shows the attributes of the compared sites and the categories having the same values of distances.

Sources	Control sites	Treated sites	Ochiai function values	Categories correspond to values
Hülsman & Wolters (1998)	no soil cultivation	conventional tillage with a mouldboard plough	0,84	HPS
	no soil cultivation	soil cultivation with a chisel plough	0,84	
	no soil cultivation	minimum tillage with a springtine cultivator	0,84	
Zaitsev & van Straalen (2001)	at a distance of 10 km from the smelter*	at a distance of 3 km from the smelter *	0,83	HPS
	at a distance of 10 km from the smelter*	at a distance of 2 km from the smelter *	0,73	
	at a distance of 10 km from the smelter*	close to the smelter*	0,78	
Andrés & Mateos (2006)	neighbouring unexploited forest area	soil spreading	0,44	SaK/DT/SaH, DH-temp, DS, SaH/Hu/far
	neighbouring unexploited forest area	soil-spreading+ grass and herb sowing	0,54	DH-trop, SaH-temp, DH/Hu/close
	neighbouring unexploited forest area	soil spreading + tree planting	0,56	
	neighbouring unexploited forest area	soil spreading+ sowing+ plantation	0,52	
Berch et al. (2007)	untreated forest floor	burned	0,63	SaS, DS, SaH-trop
	untreated mineral soil	burned	0,55	
	untreated mineral soil	mounded	0,61	
	untreated mineral soil	scalped	0,55	
Déchéne & Buddle (2009)	control site (leaf litter)	one-third partial cut	0,88	SaS ; HPS
	control site (leaf litter)	two-third partial cut	0,89	
	control site (leaf litter)	clear cut	0,87	
	control site (leaf litter)	controlled burn-after-harvest	0,84	
	control site (soil)	one-third partial cut	0,69	SaS, DS
	control site (soil)	two-third partial cut	0,71	
	control site (soil)	clear cut	0,61	
	control site (soil)	controlled burn-after-harvest	0,53	

Discussion

Order of the genus list categories. Prominent similarity of the homogenized samples is not extraordinary, but it is important that they do not show the maximum (i.e., 1). Consequently if there is no difference between two samples there can be some deviation caused by sampling or by accident. It can be assessed that two

samples are different only when the distance between them is less than the value of the HPS category.

It can be clearly seen that genus lists differed only in substrates are more similar to each other than comparing whole sites or sites differing in topographica with each other. We would have expected that the distance between different substrates (DS) would be larger than between same substrates (SaS). This result was shown at the order of the categories but it was not significant. Karasawa and Hijii (2004) showed that the species composition of Oribatid communities in mangrove forests is more likely to be affected by factors responsible for microhabitat diversity than by geographical distance between the examined islands. It means that the same type of microhabitats on two distant sites may be more similar to each other than two different substrates on the same site.

We did not see large changes in Oribatid mite community composition living in a given substrate type after a year. The result met our expectation but the separations of the categories were not significant. In our study, we could examine a period of not more than a year difference between genus lists but when an Oribatid mite community was monitored in a beech forest for 6 years by Irmeler (2006), he found more than 75% similarity in the communities of various years.

In the tropics, substrates are more different from each other than in the temperate zone. At the level of habitats tropical sites are more similar to each other than the sites in the temperate zone. According to these two results in the temperate zone the Oribatid genus lists of microhabitats are more homogeneous than in the tropics, as in the tropics the genus lists of habitat types are more uniform. But since the differences are not significant between the results of tropical and temperate zone, this can signify only a trend.

Categories of different topographica (DT) were unambiguously separated from the categories of substrate level. Data of substrate and habitat levels from different sites in Hungary showed that geographical distances can cause large differences between Oribatid genus compositions. Zaitsev and Wolters (2006) studied the impact of climate across Europe on the structure and diversity of Oribatid communities. They found that at the chosen scale climate had moderate impact on abundance and biomass of Oribatida communities showing that some other important factor(s) cause(s) larger difference between species and as we could see between genus compositions in larger level of geographical distance.

On genus level, distance between zoogeographic kingdoms means the same difference as it is between genus lists originating from different countries (topographica). It is remarkable that zoogeographic kingdoms were mainly differentiated based on vertebrate groups and if an invertebrate group, in this case Oribatid mites are regarded, difference between zoogeographic kingdoms on vertebrate level can cover smaller topographica and not continents in case of Oribatid mites. On family level, distance between zoogeographic kingdoms means the same difference as between family lists originating from the same or different types of substrate. In case of Oribatid mites, zoogeographic kingdom is not a reasonable unit of differentiation on family level, while it is one of the units of differentiation in case of vertebrates, which is most likely due to the fact that

separation of Oribatid mite families historically preceded the separation of continents.

Analyzing different topographica we found that the Oribatid communities living in the same type of habitats resembled each other much more than in case of communities living in different habitats when genus lists were compared between different zoogeographical kingdoms. This confirms our previous assumption that the type of a habitat may play a greater role in pattern formation than the zoogeographical kingdoms. Balogh et al. (2008) obtained the same results.

The order of assay on family level often differs from the order on genus level, but these differences are mostly by categories where distances are not significant so the differences are not considerable. Similarities between results of family and genus level point out that it is possible to use the family level instead of the genus level from a taxonomical point of view in the comparisons suggested by us. This corresponds to the results of the meta-analysis by Osler and Beattie (1999) – similar to ours – in which it was found after the analysis of 25 studies that habitats were mainly chosen on family level and they suggested that the family level could be enough to quickly estimate the diversity of an area.

We could observe that certain human disturbances would not cause big changes in Oribatid communities as if we repeated sampling from the same substrate. Increasing perturbation by tillage practices (Hülsman and Wolters, 1998), effects of metal contamination in different distances from a smelter on Oribatid communities (Zaitsev and van Straalen, 2001), and at last the effects of experimental harvesting regimes after eight years on Oribatid mites in a mixed boreal forest (Déchéne and Buddle, 2009) are cases which point to the above mentioned small changes. By the other cases we could be allowed to examine larger distances caused by perturbation: burning after clear cut harvest in a temperate deciduous forest (Déchéne and Buddle, 2009), burned, mounded and scalped forest floors (Berch et al. 2007) and an inchoative stage succession of post-mining restoration (Andrés and Mateos, 2006).

By means of the standardized reference list shown in this study we can count how much spatial distance is equivalent to the similarity of genus or family lists of Oribatid communities originating from two unknown samples. Our results show that measures of human disturbance can be correlated with spatial differences by means of our reference list, namely expressing the effect of perturbation on the composition of Oribatid communities.

Examining Oribatid mites is important because of their special properties, but their usefulness in describing the stage of habitats has not yet been exploited. Data about them are being assembled but often in an uncoordinated way and they cannot be compared properly. Using Oribatid mites suitably requires effective and systematic data recording which is standardized and coordinated. Integrated processing and interpretation of huge databases should be performed in a way the present study demonstrated.

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