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# The use of predatory soil mites in ecological soil classification and assessment concepts, with perspectives for oribatid mites

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**Abstract**

Gamasina are the main predators among the soil mesofauna and, therefore, have a crucial position in the soil food web and contribute significantly to energy and matter turnover. Ecological concepts including predatory mites in soil assessment have not yet been established, while standardized sampling, extraction, and conservation methods are available. There are reliable keys for Europe that cover most families. Few species in low dominance ranks correlate well with soil properties like soil texture and pH. Meaningful endpoints for soil assessment are community parameters that are based on the life history of the species (e.g., Maturity Index). It has been shown that the predatory mites, as well as the oribatids as a second common and widespread group of mites, fit well into a soil assessment concept comparable to RIVPACS, which was established for aquatic systems. Perspectives for future research are the development of a computer-aided identification key and the creation of a database with information on the ecology and biogeography of important species.


*Keywords:* Predatory mites; Gamasina; Mesostigmata; Oribatida; Soil assessment; Reference state; Soil quality; Maturity Index; Expectation value; Habitat function

## 1. Introduction

### 1.1. Aim of the article

In an integrative biological soil quality assessment system, soil has to be recognized as a platform of interactions in a tremendously complex ecological system, including a huge variety of organisms. In the German Soil Protection Act (BBodSchG, 1998), this is addressed as the habitat function. Because it is almost impossible to investigate each of the soil organisms groups, a choice of taxa has to be made when trying to assess the habitat function. One important criterion is the position of a certain group in the soil food web. Among the macrofauna, the species-rich taxa are predators (spiders, staphilinids); saprophagous groups like earthworms and woodlice contain only a few species (Ellenberg et al., 1986). Among the mesofauna, the situation is reversed: Most microarthropods and soft-bodied mesofauna groups like enchytraeids are fungivores, bacterivores, or saprophages. There are few predatory species among oribatids and in Collembola, but among the mite taxa Prostigmata and Mesostigmata, the majority of species are predators. Under temperate climate conditions the Mesostigmata by far outnumber the other predatory mite groups in species number, abundance, biomass, and contribution to energy turnover (Persson and Lohm, 1977; Luxton, 1982). Within the Mesostigmata, Gamasina are the most important and frequently encountered group. Their outstanding importance is reflected in the fact, that in many articles on soil ecology, Gamasina are referred to as "predatory mites," ignoring the other less abundant

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taxa. In addition, a gamasid mite species (*Hypoaspis aculeifer*) was selected as "typical" predator in soil ecotoxicology (Bakker et al., 2003).

Gamasina have been involved in few soil ecological studies, e.g., Koehler (1984, 1999), Christian (1995), Osler and Beattie (2001), and, before all others, Karg in his 1960 publications (Karg, 1961a, b, 1967). Most investigations define a control site with which an experiment or a site of interest is compared. Approaches to soil quality assessment that involve predatory mites are scarce. However, Karg and Freier (1995) introduced a concept for indicating the "biological activity" of soils that is based on the presence of mites in three ecological groups and on the frequency in which predatory mites occur in replicated samples (Table 1). This method could work in arable land, where the abundance is generally low and dispersion is highly patchy, but it has not been applied in the field of soil ecology yet. In grassland or even forest samples there are usually predatory mites present in each replicated sample. Therefore, this concept does not allow separation of disturbed from undisturbed sites.

An alternative to defining general properties is classifying sites according to land use practices or soil properties and defining baseline values for each site class. Such a concept would basically follow the RIVPACS system, an approach developed in the United Kingdom for the assessment and classification of surface waters (Wright et al,. 1998; Wright, 2000). Similar concepts have also been established in Canada (Reynoldson et al., 1995) and Australia (Wells et al., 2002). A comparable procedure should be established for biological soil quality assessment (for details on RIVPACS, see Breure et al., 2005). As soils are distributed all over the terrestrial landscape, the classes defined by the faunal communities can be displayed on topographical maps. These classes can be used to illustrate rare situations, centers of diversity, and natural gradients in a landscape. Diversity can be displayed on two levels: first, on the level of a site class, and second, on the landscape level. Site classes are diverse if they contain a species-rich community, whereas landscapes can be diverse if they are composed of a variety of sites with different communities.

Table 1
Karg and Freier's (1995) proposal for assessing toxic effects on soils (5–30 samples, 0–15 cm in depth)

| Proportion of samples with predatory mites (%) | Assessment |
|---|---|
| 80–100 | High biological activity, no effect |
| 60–80 | Slightly disturbing effects on biological activity |
| 40–60 | Alarming disturbing effects on biological activity |
| <40 | Massive disturbing effects on biological activity |

Biological site classification means that sites are grouped according to their soil fauna communities. Best suited for that purpose is a battery approach in which multiple taxa are included. In doing so, many ecological pathways and possible interactions can be covered. The position of predatory mites in the food web and both the high diversity and moderate specificity give them the potential to be good indicators for the ecological state of a soil. This article aims to provide insights into how predatory mites could be used in a battery approach for assessing biological soil quality and to point to specific examples where predatory mites contributed valuable information on the quality of the habitat function of soils. The potential contribution of oribatid mites is also discussed.

### 1.2. Predatory soil mites are important regulators of soil meso- and microfauna

Predatory mites within the order Mesostigmata are small (200 to ca. 2000 μm) microarthropods dwelling in the air-filled pore space of soils, in the litter layer, and for a few species, even on plants. They are voracious predators of other microarthropods, nematodes, enchytraeids, insect larvae, and eggs. Some species are even cannibalistic, preying on their own juveniles or males. Their specific meaning in an ecological framework is that they function as top predators in the mesotrophic system (Heal and Dighton, 1985) and combine the three main energy flow pathways in the soil: the primary production, fungal, and bacterial energy channel (Fig. 1). Calculations based on the food web model of Berg et al. (2001) give estimates on the contributions of different components to element cycles. The estimates for C and N mineralization of two mite groups are given in Fig. 2. It is obvious from the model calculations that predatory mites play a major role in mineralization of nitrogen in natural ecosystems like forests.

### 1.3. Reasons for including predatory mites in a soil classification and assessment concept

In addition to their ecological role in soil ecosystems, there are also practical reasons to include predatory mites in soil classification and assessment concepts. They are relatively species rich; Karg (1993) lists about 800 species for Central Europe. Nevertheless, diversity and number of specimens at a given site are quite limited; rarely are more than 60 species recorded at a single site. The abundance can reach 20,000 individuals/$m^2$, though the average lies between 4000 and 10,000 individuals/$m^2$ (Ruf in Römbke et al., 1997). Some species are typical of specific habitat types like forests and grasslands (Buryn and Hartmann, 1992); others are