Korean J. Ecol., 24(4): 239 ~ 243, 2001

Stability Analysis of Soil Oribatid Mite Communities (Acari: Oribatida from Namsan and Kwangreung Deciduous Forests, Korea

Jung, Chulue* and Joon-Ho Lee

Entomology program, School of Agricultural Biotechnology, Seoul National University, Suwon 441-744, Korea

ABSTRACT: One of the most important justifications of conservation of ecosystem and biodiversity is that diversity begets stability. Impact of biodiversity on community and ecosystem function has long been debated in science. Here we report the stability analysis of soil oribatid mite communities from environmentally stressed habitat (Namsan) and relatively well preserved habitat (Kwangreung) with the perspective of consistency as a primary criteria of stability. Stability of oribatid mite communities were evaluated with turnover rate, constancy analysis, b diversity index, and absolute abundance, abundance ranking, and the presence or absence of species over time. Out of 6 criteria, three consented that oribatid community from Kwangreung was more stable than that from Namsan. Those are turnover rate in litter layer, constancy analysis, and absolute abundance. Feasibility of stability analysis using oribatid mites was further discussed, rendering further study.

Key words: Constancy, Diversity-stability, Ecosystem health, EDS, Persistence

INTRODUCTION

Ecosystem health is frequently exposed to mass media and public in many disciplines even out side of science sectors. However, defining 'Ecosystem Health' is very difficult and complex. Some (Rappot *et al.* 1998) proposed criteria to assess the ecosystem health (Ecosystem Distress Syndrome; EDS) as follows; [1] reduced biodiversity, [2] reduction in primary production that includes shift in biotic composition resulting in increased dominance by exotics and opportunistic r strategist, reduced size distribution or increased production per unit biomass, and increased amplitude of oscillation of component species, and [3] change in energy flow caused from structural distortion. The convention holds that the healthier systems have higher biodiversity and more stability against disturbance. However, the relationship between diversity and stability has been a hot subject of ecological debates (Price 1997). Krebs (1998) defined stability of community as the capacity of recovery from disturbance, and considered community change as number one priority by defining community as non-equilibrium, open system. To understand biotic system, biotic and abiotic components must be studied in concert (Moore *et al.* 1988, Cepeda and Whitford 1989).

Recently soil microarthropod communities have been extensively analyzed focusing on soil oribatid mites from two characteristic forest systems within and outside of Seoul in Korea, where Namsan forest soil was considered as heavily environmentally stressed system whereas Kwangreung forest as relatively less stressed (Jung *et al.* 1996, Park *et al.* 1996a, 1996b, Jung *et al.* 1998, Lee *et al.* 2000, Park *et al.* 2000). The oribatid mites play important roles in forest soil system such as decomposer of organic materials, modifier of microbial communities related to decomposition process and physical and chemical properties of soil, and food source of other macroarthropods as well (Butcher *et al.* 1971, Wallwork 1983, Seastedt 1984, Hagvar 1988, Crossly *et al.* 1992a, 1992b, Choi 1996), and the structure and function of soil microarthropod community is closely related to total health of forest ecosystem (Moore *et al.* 1988, Curry and Good 1992). Jung *et al.* (1998) reported higher atmospheric pollutant deposition and less primary production indicated by the depth of fresh litter layer. Also Jung *et al.* (1998) documented low diversity and abundance of soil inhabiting oribatid mites in environmentally stressed forest, Namsan compared to Kwangreung system. Then the next question is "Is soil oribatid mite community in Namsan less stable than that in Kwangreung?" We view community persistence as a stability criterion in this study, and tried to understand the diversity-stability relationship. Even though no definite measure of community stability has been developed to test soil microarthropod community, we tried to evaluate the stability of forest soil oribatid mite communities using several proposed criteria such as Tischler (1949), Stalton (1979), Rahel (1990), and Tokeshi (1993). Feasibility of stability analysis was further discussed with forest health and soil mites.

* Author for correspondence; Phone: 82-31-290-2467, Fax: 82-31-296-1650, e-mail: chuleuijung@yahoo.com

MATERIALS AND METHODS

Study site, sampling and extraction of oribatid mites

In the central area of Seoul, the biggest metropolitan in Korea, Namsan, a small mountain offering shelter, refuge for wildlife and human being is located in 37°32°'N and 125°58'E. The deciduous forest sampled in Namsan is in the southeastern slope from the Namsan Tower (200-300 m altitude), dominated by *Quercus mongolica, Sorbus alnifolia* and *Acer* spp. Kwangreung is located in Pocheon-gun, Kyunggi-do, 37°45'N and 127°10'E. The deciduous forest sampled in Kwangreung is located in the southeastern aspect of the Soribong-peak, dominated by *Carpinus laxiflora, Q. aliena, Q. mongolica*, and *Acer* spp. The direct distance from Namsan to Kwangreung is ca. 25 Km. Thus this relatively small geographic scales was intended to minimize the effect of local weather variation on target animal community.

Five soil core samples (5 cm dia. and 5 cm h. each) and ca. 300 ml litter sample was taken with 3 replicates in each plot, and 6 plots per each forest sampling area. Samples were taken every season except winter for two years (1993 and 1994). Further detail is in Jung *et al.* (1998) and Lee *et al.* (2000). Then the soil microarthropods were extracted using modified Berlese-Tullgren funnel (Jung 1996, also refer Wallwork 1970, Choi 1996). Oribatid mites were sorted out and identified by Wallwork (1970), Ehara (1980), Balogh and Mahunka (1983) and Choi (1985).

Stability analysis

Jung *et al.* (1998) reported distinctive difference in soil conditions between Namsan and Kwangreung deciduous forest; more acidity (low pH) in Namsan soil and litter layers relative to Kwangreung, lower acidity of precipitation, high concentration of total N and soluble sulfur, and lower primary production of forest in Namsan compared to Kwangreung. Jung *et al.* (1998) also reported lower diversity and abundance of soil oribatid mites (32 families 53 genera 89 species with 5,194 individuals in Namsan vs. 40 families 67 genera 114 species with 7,856 individuals in Kwangreung) and higher portion of endemic species in Kwangreung. Similar associations of oribatid mites with environmental qualities have been reported mostly focused on acid rain (Paoletti *et al.* 1991, Koehler 1992).

For stability analysis, four criteria were used; turnover rate (Tokeshi 1993), constancy analysis (Tischler 1949), β diversity index (Stanton 1979) and Rahel's three-scale analysis (1990). Turnover rate (Eq. 1) measures the independency of density change at each consecutive sampling event (Tokeshi 1993). Thus, from the scope of density change of each species, the community stability is estimated and compared. Seasonal sampling data were used for estimating the turnover rates. In Eq. 1, $S\tau$ is the turnover rate, Pi is the proportion of ith species over total number of individuals, s is the total number of species, and t, t+1 is the sampling event per se.

$$S\tau = 0.5 \sum_{i=1}^{s} i=1 \mid Pi(t) - Pi(t+1) \mid \quad \text{---------- Eq. 1}$$

Tischler (1949) devided species occurrence frequency (=constancy) in each sampling site at each sampling time into 4 levels; absolute species having constancy of 75-100%, constant species having constancy of 50-75%, accessory species having constancy of 25-50% and accidental species having constancy lower than 25%. Tischler (1949) and Wallwork (1973) considered the absolute species and the constant species being the constitute species of that target community and playing important roles in stability of that system. β diversity measures the difference in diversity of two different habitats (Pielou 1984). In this study, we estimated the β diversity as the dividend of mean number of species per sampling plot to the total number of species in each sampling plot following Stalton (1979). The last criterion for community stability analysis is so-called three-scale stability measure following Rahel (1990), which are in short absolute abundance, abundance ranking and the presence or absence of species over time. Those are expressed as mean variance coefficients of absolute density change in a habitat, correlation coefficient of rank correlation analysis, and Jaccard similarity index that is proportion of common species from both sites over total species (for further detail, refer Mountford 1962, Magurran 1984).

RESULTS AND DISCUSSION

Community stability was assessed using turnover rate (Tokesh 1993), constancy analysis (Tischler 1949), β diversity (Stalton, 1979), and Rahel's approach (1990). Each approach had been developed and suggested from the different biotic community studies such as marine, fresh water and soil biotic communities. But those have their own strength to evaluate the stability of biological community. Turnover rate measures density fluctuation between subsequent sampling events. Turnover rates between sampling data for two years of oribatid communities in soil layer was not different, 0.55 and 0.53 in Namsan and Kwangreung, respectively (Fig. 1). In litter layer, turnover rate from Kwangreung community was lower meaning more stable with the values of 0.47 vs. 0.57 in Kwangreung and Namsan, respectively (Fig. 1). However, because of high variation of turnover rate within group, statistical inferences are limited. Overall, turnover rates of this study were much higher than the value Tokeshi (1993) proposed as a stable criterion, 0.2 at which a community can be considered having low fluctuation of each species density and composition. Constancy analysis showed similar shapes of distribution, but higher portion of level 2 and 3 species from Kwangreung (Fig. 2). Species belonging to these levels are considered as ones could respond and function as

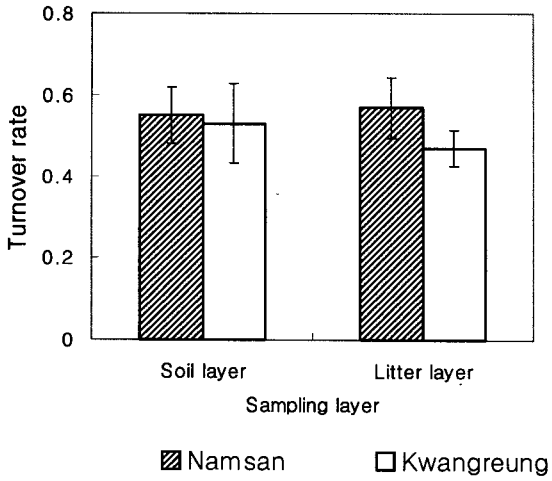

Fig. 1. Turnover rates (mean ± S.E.) of oribatid mites in Namsan and Kwangreung deciduous forests on soil and litter layer.

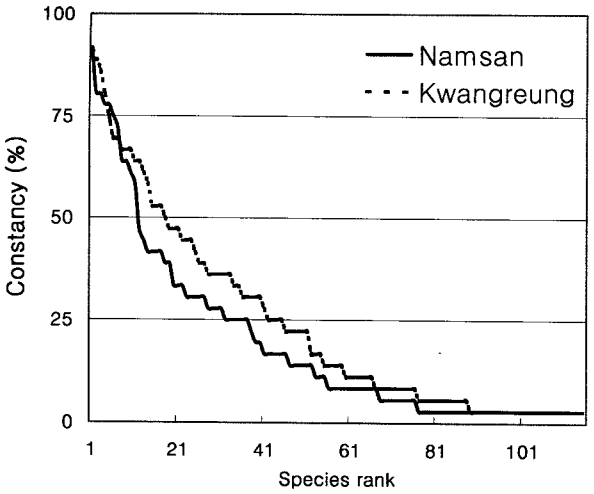

Fig. 2. Constancy plots of oribatid mite communities in Namsan and Kwangreung deciduous forest soil.

constitutes of dominant species in some case where drastic community change occurs (Wallwork 1973, Paoletti *et al.* 1991, Koehler 1992), thus indirect inference that Kwangreung oribatid community could be more stable than Namsan may be possible. Within larger area of habitats, to compare the habitat stability β diversity has been used by several ecologists (see Pielou 1984). Estimating β diversity, there was no difference in β diversity indices between Namsan and Kwangreung, 3.83 and 3.95, respectively (Table 1). Harrison *et al.* (1992) and Stanton (1979) considered the value above 4.0 as a stable community. Thus according to Stanton (1979) and Harrison *et al.* (1992), oribatid communities from both of Namsan and Kwangreung are close to the stable communities. Following Rahel's approach (1990), mean variance coefficient of absolute density was lower, but similarity of species composition was higher in Kwangreung (Table 2). Correlation of abundance ranking was higher in Namsan, meaning less fluctuation of abundance ranking.

Overall, each stability criterion provides somewhat contradictory results and making a consistent inference difficult. Even though soil environments was considered better, and species richness, diversity and abundance were higher in oribatid mite community from Kwangreung deciduous forest soil, three out of six stability criteria consented that oribatid mite community from Kwangreung was more stable than that from Namsan. The effect of biodiversity on stability has been contradictory debated (Pickett *et al.* 1989, Rodriguea and Gomez 1994, Tilman and Downing 1994). One view hold that species diversity promotes resistance to disturbance thus stability. Other asserts that many species are so similar that ecosystem function is independent of diversity if major groups are in function (Tilman and Downig 1994). Also, caution should be applied on assessing biotic community with certain indices. Facing increasing demand of formulating judgment and evaluation of community or ecosystem, scales of study system, extensiveness of sampling and evaluation, and other environmental quality as well as statistical problems are to be considered as a whole (Magurran 1988, Freedman 1993, Price 1997, Krebs 1998). In detail, the importance of spatial and temporal scales in evaluating community stability has received considerable attention (Dayton and Tegner 1984, Wiens *et al.* 1986). For example, some communities may

Table 1. Three-scale stability analysis of oribatid mite communities in Namsan and Kwangreung deciduous forest soil

	Stability		
	Absolute abundance[a]	Abundance ranking[b]	Similarity[c]
Namsan	0.676 **	0.636 **	0.606
Kwangreung	0.598	0.588	0.652 **

[a] mean coefficient of variance

[b] rank correlation coefficient

[c] Jaccard similarity index

** denotes the statistical difference within a column ($P < 0.001$)

Table 2. Mean number of oribatid mite species per sampling plot (S ± S.E.), mean number of individual per species (I/S), total number of species per each sampling habitat (Namsan and Kwangreung *per se*, S_T) and β diversity index (β)

	Habitats	
	Namsan	Kwangreung
S ± S.E.	23.2 ± 3.52	28.83 ± 1.65
(I/S)	14.71	18.02
S_T	89	114
β	3.83	3.95

fluctuate at short time scales may be cyclic and thus more stable over long time scale (Allen *et al.* 1977). The level of taxonomic resolution can be influential (Rahel *et al.* 1984). Also the hierarchical level of analysis could be important; analyzing guild structure or higher taxonomic categories may provide better understanding of the target system. The other point is the statistical or numerical resolution of community stability. As noticed on this study by non-consensus of the results, selecting a particular measure is not merely a statistical concern but more of viewpoint of the system. Further study on animal community is demanded focused on defining and evaluating community stability.

LITERATURE CITED

Allen, T. F. H., S. M. Bartell and J. F. Koonce. 1977. Multiple stable configurations in ordination of phytoplankton community change rates. Ecology 58: 1076 - 1084.

Balogh, J and S. Mahunka. 1983. Primitive oribatids of the palaearctic region. Elsevier. Amsterdam. 372 pp.

Butcher, J. W., R. Snider and R. J. Snider. 1971. Bioecology of edaphic collembola and acarina. Annu. Rev. Entomol. 16: 249 - 288.

Cepeda, J. G. and W. G. Whitford. 1989. The relationships between abiotic factors and the abundance patterns of soil microarthropods on a desert watershed. Pedobiologia 33: 79 - 86.

Choi, S.-S. 1984. Studies on the analysis of soil-microarthropod community on Gwangreung area. Wonkwang Univ. 18: 185 - 235.

Choi, S.-S. 1996. Soil Zoology. Wonkwang Univ. press. 488 pp.

Crossley, D. A., D. C. Coleman and P. F. Handrix. 1992. The importance of the Fauna in agricultural soils: Research approaches and perspectives. Agriculture, Ecosystems and Environment 27: 47 - 55.

Crossly, Jr. D. A., B. R. Mueller and J. C. Perdue. 1992. Biodiversity of microarthropods in agricultural soils: relations to processes. Agri. Ecosys. Environ. 40: 37 - 46.

Curry, J. P. and J. A. Good. 1992. Soil faunal degradation and restoration. Advances in Soil Science. 17: 171 - 215.

Dayton, P. K. and M. J. Tegner. 1984. The importance of scale in community ecology: a kelp forest example with terrestrial analogs. pp 457-482. in P. W. Price, C. N. Slobodchikoff and W. S. Goud, eds. A new ecology: novel approaches to interactive systems. Wiley, New York.

Ehara, S. 1980. Illustrations of the mites and ticks of Japan. Jenkoku Noson Kyoiku Kyokai. 562 pp.

Hagvar S. 1988. Decomposition studies in an easily-constructed microcosm : Effects of microarthropods and varying soil pH. pedobiologia 31: 293 - 303.

Harrison, S., S. J. Ross and J. H. Lawton. 1992. Beta diversity on geographic gradients in Britain. J. Anim. Ecol. 61: 151 - 158.

Jung, C., H. H. Park, J.-H. Lee, S.-S. Choi and B.-Y. Lee. 1996. Faunal list of oribatid mites (Acari: Oribatida) in Mt. Namsan, Korea. Korean J. Soil Zool. 1: 89 - 94.

Jung, C., J.-H. Lee, Y.-H. Bae, and S.-S. Choi. 1998. Diversity of oribatid mites (Acari: Oribatida) in Namsan and Kwangreung deciduous forests. Korean J. Soil Zool. 3: 91 - 105.

Kaneko, N. 1995. Community organization of Oribatid mites in various forest soils. *In* Structure and function of soil communities. (eds.), C. V. Edwards, T. Abe and B. R. Striganova Tokyo University Press. Japan. pp 21 - 33.

Koehler, H. H. 1992. The use of soil mesofauna for the judgement of chemical impact on ecosystems. Agri. Ecosys. Environ. 40: 193 - 205.

Krebs, C. J. 1998. Ecological methodology. Addison Wesley Longman Inc. New York. 620 pp.

Lee, J.-H., H. H. Park, B. H. Kang, C. Jung and S.-S. Choi. 2000. Comparison of oribatid mite (Acari: Oribatida) communities among city, suburban, and natural forest ecosystems: Namsan, Kwangreung, and Mt. Jumbong. Korean J. Ecol. 23: 107 - 112.

Magurran, A. E. 1988. Ecological diversity and its measurement. Cambridge University Press. 179 pp.

Moore, J. C., D. E. Walter and H. W. Hunt.. 1988. Arthropod regulation of micro- and mesobiota in below-ground detrital food webs. Annu. Rev. Entomol. 33: 419 - 439.

Mountford, M. D. 1962. An index of similarity and its application to classificatory problems. in eds. Murphy, P. W., D. Phil and B. Agr. Sc. Butterworths. Progress in soil zoology. London. 43 - 50.

Paoletti, M. G., M. R. Favretto, B. R. Stinner, F. F. Purrington and J. E. Bater. 1991. Invertebrates as bioindicators of soil use. Agri. Ecosys. Environ. 34: 341 - 362.

Park, H. H., C. Jung, J.-H. Lee and B.-Y. Lee. 1996a. Soil microarthropods fauna at the Namsan and Kwangreung, Korea. Korean J. Soil Zool. 1: 37 - 47.

Park, H. H., C. Jung, J.-H. Lee, S.-S. Choi and B.-Y. Lee. 1996b. Faunal list of oribatid mites (Acari: Oribatida) at the 44th (deciduous) and 45th (coniferous) compartment in Kwangreung, Korea. Korean J. Soil Zool. 1: 95 - 101.

Park, H. H., J.-H. Lee, Y.-H. Bae and S.-S. Choi. 1998. Diversity of oribatid mites (Acari: Oribatida) in Namsan and Kwangreung coniferous forests, Korea. Korean J. Soil Zool. 3: 78 - 90.

Park, H. H. and J.-H. Lee. 2000. Community analysis of oribatid mites (Acari: Oribatida) in Namsan and Kwangreung coniferous forests, Korea. Korean J. Ecol. 39: 31 - 41.

Pickett, S. T. A., J. J. Armesto and S. L. Collins. 1989. The ecological concept of disturbance and its expression at various hierarchical levels. Oikos 54: 129 - 136.

Pielou, E. C. 1984. The interpretation of ecological data. A primer on classification and ordination. John Wiley and Sons. Singapore. 263 pp.

Price, P. W. 1997. Insect ecology. 3rd ed. John Willey and Sons. New York. 873 pp.

Rahel, F. J. 1990. The hierarchical nature of community persistance: A problem of scale. Am. Nat. 136: 328 - 344.

Rahel, F. J., J. D. Lyons and P. A. Cochran. 1984. Stochastic or deterministic regulation of assemblage structure? It may depend on how the assemblage is defined. Am. Nat. 124: 583 - 589.

Rapport, D., R. Constanza, P.R. Epstein, C. Gaudet and R. Levins. 1998. Ecosystem Health. Blackwell Science Inc., Malden, MA.

Rodriguea, M. A. and S. A. Gomez. 1994. Stability may decrease with diversity in grassland communities : Empirical evidence from the 1986 Cantabrian Mountains (Spain) drought. Oikos 71: 177 - 180.

Seastedt, T. R. 1984. The role of microarthropods in decomposition and mineralization processes. Ann. Rev. Entomol. 29: 25 - 46.

Stanton, N. L. 1979. Patterns of species diversity in temperate and tropical litter mites. Ecology 60: 295 - 304.

Tilman, D. and J. A. Downing. 1994. Biodiversity and stability in grasslands. Nature 367: 363 - 365.

Tischler, M. 1949. Grundzuge der terristrischen Tierokologie. Braunschweig. (cited from Wallwork, 1976)

Tokeshi, M. 1993. Species abundance patterns and community structure. Ad. Ecol. Res. 24: 111 - 186.

Wallwork, J. A. 1970. Ecology of soil animals. Mcgraw-Hill. London. 283pp.

Wallwork, J. A. 1972. Distribution patterns and population dynamics of the micro-arthropods of a desert soil in southern California. J. Anim. Ecol. 41: 291 - 310.

Wallwork, J. A. 1976. The distribution and diversity of soil fauna. Academic Press. 331pp.

Wallwork, J. A. 1983. Oribatids in forest ecosystems. Annu. Rev. Entomol. 28: 109 - 130.

Wiens, J. A., J. F. Addicott, T. J. Case and J. Diamond. 1986. Overview: the importance of spatial and temporal scale in ecological investigations. *In* J. Diamond and T. J. Case (eds.), Community ecology. Harper & Row. New York. pp 145-153.

(*Received June 15, 2001, Accepted July 20, 2001*)