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THE CASE STUDY ON SOIL FAUNA DIVERSITY IN DIFFERENT ECOLOGICAL SYSTEM IN SHILIN NATIONAL PARK, YUNNAN, CHINA

PRIMER PREUČEVANJA RAZNOVRSTNOSTI TALNE FAVNE V RAZLIČNIH EKOLOŠKIH SESTAVIH V NARODNEM PARKU SHILIN (YUNNAN, KITAJSKA)

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Abstract UDC: 574:551.44(510)

Xiang C. & Song L. & Zhang P. & Pan G.: The case study on soil fauna diversity in different ecological system in Shilin national park, Yunnan, China

A preliminary study of the distribution and diversity of soil fauna in a sequence of ecosystem degradation in the Shilin National Park, Yunnan, China has been made. The degraded ecologic system includes 5 types of vegetation cover: (1) natural bush; (2) human planted cypress forest; (3)natural grass; (4)secondary grass and (5) bared red earth. A quadrate of 1m×1m in each eco-tessera was sampled for soil fauna collection. The animals were obtained either by picking up or by heat-removing. The soil fauna were dominated by Acarina, Collembola, Nematode, Coleoptera,and Opistopora in these soils. However, Erchytraeidae, Araneida, Lepidoptera and Diptera were also common groups. The diversity index H turned to be less than 1.5, drastically decreasing with the vegetation degradation trend. In the karst soils, Parholaspidae was one of the most populous among the mites. The biomass of Trhypochthoniidae and Ologamasidae was very concentrated in the natural bush ecosystem, showing high sensitivity of mites to vegetation degradation. The biomass ratio of Acarina to Collembola in the studied soils ranged from 0.70 to 1.50, which was in great discrepancy to the results reported of the natural soils at similar latitude. The small soil fauna biomass and less diversity indicated that the studied soil was in a state of deterioration of soil fauna habitats and, in turn, the soil ecosystem health. The results also evidenced that the soil fauna in the karst soil was definitely vulnerable as regarded to the sustainable development of the Shilin Park.
Keywords: Stone Forest; karst soils; fauna diversity; vegetation cover; ecosystem degradation.

Izvleček UDC: 574:551.44(510)

Xiang C. & Song L. & Zhang P. & Pan G.: Primer preučevanja raznovrstnosti talne favne v različnih ekoloških sestavih v narodnem parku Shilin (Yunnan, Kitajska)

Predhodno sta bili preučevani razporeditev in raznovrstnost talne favne v vrsti degradiranih ekosistemov v narodnem parku Shilin. Ti ekosistemi vključujejo pet tipov rastlinskega pokrova: 1. naravno grmišče, 2. umetno nasajen cipresov gozd, 3. naravni travnik, 4. drugotni travnik, 5. golo rdečo prst. Na vsakem izmed njih je bila talna favna nabrana s kvadrata velikosti 1 krat 1 m. •ivali so bile nabrane ročno ali pa izločene s pomočjo segrevanja. V talni favni so prevladovale acarina, collembola, nematoda, coleoptera in opistopora. Toda razmeroma pogoste so bile tudi skupine enchytraeidae, araneida, lepidoptera in diptera. Indeks raznovrstnosti H je manjši od 1,5 in se močno zni•uje vzporedno z degradacijo rastlinstva. V kraških prsteh so med najpogostejšimi parholaspidae. Biomasa trhypochthoniidae in ologamasidae je najbolj zgoščena v naravnem grmišču in ka•e veliko občutljivost teh skupin na degradacijo rastlinstva. Razmerje biomase acarina v primerjavi s collembola je v razponu 0.7 do 1.5, kar je veliko odstopanje od podatkov za naravne prsti podobnih geografskih širin, znanih iz literature. Majhna biomasa talne favne in manjša raznovrstnost ka•eta, da se habitati v preučevanih prsteh slabšajo in se torej slabša tudi zdravje celega ekosistema. Izsledki tudi ka•ejo na ranljivost talne favne v prsteh z vidika sonaravnega razvoja parka Shilin.
Ključne besede: kraška prst, biodiverziteta, rastlinski pokrov, degradacija ekosistema, Shilin, Yunnan, Kitajska.

The relationship between soil fauna diversity and ecological system has been broadly noted and researched by many scientists (Griffiths et al., 2001; Filip, 2002; Mikola et al., 2002) . Soil fauna are the main consumers and decomposers of organic matters in the soil. Lal (1988) recognized that the soil fauna affected the soil property in the tropical ecosystem. Five years later the variations of the soil fauna groups in the ecosystem degradation and recovery processes were clearly understood (Curry & Good, 1992). Bauble et al. (1997) pointed out that soil large animals could be the biomarker of the soil environmental change. In recent years more researchers show that the number and diversity of the earthworm groups can be used as the biomarker of the ecosystem health, which responds immediately to the soil environmental pollution and ecosystem degradations. The studies showed that carbon transportation produced by the organisms was the basic characteristics in the epi-karst zone (Pan & Cao, 1999; Cao & Yuan & Pan, 2001), so the living and activity of soil animals is very important for the form and transformation of the soil organic matter. The fragile and stability of the karst ecosystem can be explained by the function of the soil fauna diversity as well as the soil carbon transformation effect on the karstification. The karst areas are the main fragile ecology system area, the karst ecology system in Southwest China has been seriously degraded and the environment is getting worse and worse; it even appeared rocky desertification (Song, 1999; Yuan, 2000;). Many researches have focused on the soil microbial biomass and its dynamics in the karst areas. But there is little knowledge about the structure and change of the soil animal group in the karst area. This paper deals with the relationship between the soil fauna diversity and karst ecosystem and the soil fauna as the index of the karst ecosystem changes in the Shilin National Park.

BRIEF INTRODUCTION OF STUDIED AREA AND RESEARCH METHODS

The studied area was chosen in the Naigu Scenic spot of Shilin National Park at the altitude of 1820m. It belongs to the subtropical monsoon climate with a mean annual precipitation of 970 mm and temperature 15.6!. The *shilin* (stone forest) karst landscape develops in the Lower Permian limestone. The *shilin* landscape has been created by subsoil solution and subaerial solution in the long term (Liang & Song, 2000). The natural vegetation in the area is bush; the steady plant community is fitted to the ecosystem with much stone and little soil. Since the scenic spot was opened for visitors in 1991 the original vegetation was partly reformed including replanting of some species of tree and grass, and some farmland has been retired. The soil is mainly calcareous eluvial soil resulted from limestone weathering, which suffered unfair erosion in the ecosystem degradation.

There are 5 representative ecosystems in Naigu Spot according to the vegetation:

1. Natural bush with 120~150cm high and area covered nearly 100%;
2. Cypress with 20 years old, 5~6m high, 2.5m row spacing, 1.5m tree spacing, covered 100%.
3. Natural grass with much couch grass, 80~100cm high, 70~100% covered.
4. Secondary grass with sparse couch, 60~80cm high, less than 70% covered.
5. Bared red earth with sparse couch.

The standard sampled plot with acreage of 1m×1m was established randomly in each ecosystem. In every plot the soil was sampled from 0~10cm, 10~20cm, 20~30cm and 30~40cm below soil surface. The macroscopic soil fauna were collected by hand and identified visually; little or micro soil fauna were gathered by the method of Tullgren (dry funnel) and Baormaun (wet funnel) and identified by microscope. The inactive larva and protozoan were not determined by these methods. The taxonomy and statistics of the gathered soil fauna were mainly dependent on the methods brought forward by Yin et al. (1992, 2000).

RESULTS AND DISCUSSION

The composition and number of the soil fauna community of in the Stone Forest

935 samples of animals were obtained. They belong to the 28 species: Arthropoda such as Insecta, Arachnida, Chilopoda, Malacostraca, Diplopoda, Symplyla; Annelida, such as Oligochaeta, Hiradinea; Nemata, such as Nematoda; Rotatoria, such as Rotatoria; Turbellaria, such as Turbellaria (Table 1). The dominant communities of the soil fauna are Acarina, Collembola, Nematoda, Coleoptera and Opistopora,

Table 1. The species and amounts of the soil fauna in the various ecosystem in the Forest Stone Park

Species	natural bush	cypress	high grass	scarce grass	bared soil	total individuals	percentage of total samples(%)
Acarina	117	57	24	6	6	210	22.46
Collembola	58	40	27	9	4	138	14.76
Nematoda	35	38	25	8	2	108	11.55
Enchytraeidae	6	4	1	1	0	12	1.28
Opistopora	140	26	14	3	0	183	19.57
Hymenoptera	9	2	9	5	1	26	2.78
Coleoptera	21	79	8	2	5	115	12.30
Araneida	9	4	23	0	1	37	3.96
Lepidoptera	8	6	1	3	0	18	1.93
Diptera	7	4	5	1	0	17	1.82
Diplura	3	1	4	0	0	8	0.86
Symphyla	3	0	3	2	0	8	0.86
Orthoptera	2	0	4	0	0	6	0.64
Scolopendromorpha	2	1	3	0	0	6	0.64
Geophilomorpha	2	0	1	1	0	4	0.43
Protura	3	1	0	0	0	4	0.43
Isoptera	1	0	3	0	0	4	0.43
Isopoda	4	0	0	0	0	4	0.43
Rotatoria	0	3	2	1	0	6	0.64
Hemiptera	5	0	0	0	0	5	0.53
Diplopoda	3	1	0	0	0	4	0.43
Thysanoptera	0	2	0	0	0	2	0.21
Turbellaria	1	1	0	0	0	2	0.21
Palpigradi	0	0	1	0	0	1	0.11
Blattaria	0	0	2	0	0	2	0.21
Dermaptera	2	0	0	0	0	2	0.21
Opiliones	1	0	0	0	0	1	0.11
Pseudoscorpionida	1	0	0	0	0	1	0.11
Hirudinea	1	0	0	0	0	1	0.11
Biomass (individuals/m^2)	444	270	160	42	19	935	100.00
Percentage of total samples	47.49	28.88	17.11	4.49	2.03	100.00	

the common community includes Traeidae, Hymenoptera, Araneae, Lepidoptera and Diptere, others are scarce community. The number of the soil fauna is similar to the well protected forest at the same latitude, but there is difference among the number of dominant community of the sampled soil. The biomass of the forest soil fauna at the same latitude is higher with the individuals density of 1000 per square meter. The large scale soil fauna decreased obviously when the individual density is below 200 per square meter, which means the biomass of soil fauna tends to decrease because of the vegetation degradation and human disturbance.

Effect of various vegetation and soil depth on structure and number of soil fauna

There are significant effects of various vegetation on the structure and number of soil fauna in the Shilin area. The individual number of the soil fauna in the natural bush amounts 47.6% of the total number and 89.3% of all species in the studied area. While the individual number and species in the soil without vegetation covers are 2.1% of the totals. The biomass of soil fauna is strongly affected by the vegetation degradation. The dominant communities of soil fauna changes with the variation of vegetation. The dominant communities are Acarina and Opistopora in the natural bush soil, but are Collembola and Nematoda in the soil under the planted cypress. The gross biomass of soil fauna decreased sharply with the destruction of vegetation as well as with the soil depth. There are abundant soil fauna at the 40cm depth in the soil of natural bush, however only few soil fauna at the 40cm depth in the cypress and grass soil. Wang et al. (1999) described that the gross soil fauna biomass and their distribution in the different depth are relation to the depth of A layer and the content of organic materials (OMC) in the ecosystem degradation despite the fauna epi-accumulative is very clear in the forest of Hengshan Mountain. The A layer is 20 cm down in the soil of natural bush but only about 10cm in the cypress or grassland soil. The A layer with little soil fauna number and community is very thin in the bared red soil. The OMC in the A layers are 44.4g/kg, 25.0g/kg, 20.97g/kg and 19.48/kg in the natural bush, secondary cypress, natural grass and secondary grass, respectively. There is a logarithmic positive correlation between the density of the gross soil fauna and OMC in the A layer.

The decrease of soil fauna biomass under the various vegetation conditions is caused by the degradation of the vegetation resulting in the reduction of organic matter inputting into the soil. In this case, the smaller food and nutrients supply restrict the soil fauna development.

Table 2. Distribution of the soil fauna in soil depth under different vegetation

	total individuals				total communities			
Soil depth (cm)	0-10	10-20	20-30	30-40	0-10	10-20	20-30	30-40
natural bush	307	109	19	11	16	16	3	3
secondary cypress	184	74	9	1	15	4	1	1
Original grass	107	3	10	1	15	4	3	1
Secondary grass	25	16	2	0	10	5	1	0
Bared soil	15	5	0	0	6	2	0	0

The distribution of the Acarina and Collembola

Acarina and Collembola are the common dominant community. As Acarina is very sensitive to delicate environmental change, it is often employed to indicate the evolution of the environment (Yin & Zhang et al, 2000; Yin & Yang 1992).

The ratio values of the individual numbers of the Acarina and Collembola are decreased with the increase of heat energy. In the ecosystem of natural forest to the south of Changjiang River, the ratio values are less than 0.55. The results show that most Acarina cannot live well and even disappear in the condition of vegetation degradation. The ratio values under the different vegetation covers are between 0.3 and 1.5 (Table 3).

Table 3. The density of the acarina and collembola in the sampled soil (individuals/m^2)

Species	natural	cypress	high grass	sparse grass	bared earth
Trhypochthoniidae	20	2	not detected	not detected	2
Bdellidae	20	14	not detected	not detected	not detected
Gustaviidae	16	6	2	no detected	no detected
Ologamasidae	7	not detected	not detected	not detected	not detected
Veigaiidae	11	not detected	not detected	2	not detected
Stigamaeidae	14	10	5	not detected	not detected
Phthiracaridae	15	12	not detected	not detected	not detected
Acaridae	3	12	no detected	no detected	2
Lohmanniidae	not detected	not detected	13	2	not detected
Parholaspidae	11	1	4	2	2
Total	107	57	24	6	6
Isotoma	30	17	12	not detected	not detected
Onychiurus	15	not detected	2	5	2
Cryptopygus	13	11	not detected	not detected	1
Sphaeridia	not detected	12	not detected	1	1
Hypogastrura	not detected	not detected	13	3	not detected
total	68	40	27	9	4
Acarina/Collembola	1.6	1.4	0.9	0.7	1.5

Table 3 shows Acarina, Trhyprochthonisdae and Ologamasidae are the most sensitive to the ecosystem changes, Painolaspidae is much adaptive to various vegetation. Onychiurus in the Collembola cannot live in the soil covered by cypress.

The biodiversity of the soil fauna

The soil fauna abundance index (D), diversity index (H) and uniformity (J) can be calculated by the following equation:

$$D = (s-1)/\ln N$$

Here s is the gross number of community and N is the gross number of individuals.

$$H = -\sum_{I=1}^{s} Pi \ln Pi$$

In which $Pi = Ni / N$, where N is the gross quantity of individuals and Ni is the amount of the individuals of i community.

$$J = \frac{H}{H\max}$$

Here *H* is the diversity index and *Hmax* is the maxium biodiversity index.
The results are showed in Table 4.

Table 4. Change of soil fauna diversity under the various vegetation

index	natural bush	cypress	tall grass	sparse grass	bared earth
total communities	25	16	19	12	6
total individuals	444	270	160	42	19
abundance (D)	3.94	2.68	3.55	2.94	1.70
biodiversity (H)	1.34	0.93	0.72	0.24	0.11
uniformity (J)	0.212	0.225	0.135	0.188	0.290

The study results gave all the community amounts under the degradated vegetation as less than 20, except that under natural bush, which accords with the results of the sub-tropical ecosystem (Yin & Yang et al, 1992; Liao & Li & Huang 1997). The soil faunal biodiversity index H is 1.34 under natural bush but 0.11 under bared red earth. Under natural bush the indexes of abundance, diversity and uniformity are higher than those under other vegetation, but the uniformity under bared red earth is obviously higher than that under other vegetation, that might be caused by the structure of soil fauna rather simplified. These results showed that under the natural vegetation the abundance and diversity of the soil fauna is higher and that under the seriously degraded bared earth is lower, but the uniformity higher with the vulnerable soil fauna ecosystem.

CONCLUSION

The Acarina, Collembola, Nematoda, Coleoptera and Opistopora are the dominant communities, Onchytraeidae, Opiliones lepido, Diptera are the normal community; others are the scarce community.

Painolaspidae is adaptive in any environmental vegetation. Gross biomass amounts of community and the index of biodiversity in the soil of natural bush are much higher than those in the soil of other degraded vegetation, which show that the natural bush is the ecological screen protecting the soil fauna from deterioration. The gross biomass of soil fauna is less than those in the forest of the same latitude and the diversity of soil fauna decreased sharply in the various degraded vegetation, which indicate the deterioration of the soil ecosystem.

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