Diversity Variation of Ground-dwelling Beetle (Insecta: Coleoptera) Communities in Jiaozi Mountain, Yunnan, China*

WANG Jun[1,2], LIANG Xing-Cai[1]**
(1. Kunming Institute of Zoology, Chinese Academy of Sciences, Kunming 650223, China;
2. Graduate University of Chinese Academy of Sciences, Beijing 100049, China

Abstract: Jiaozi Mountain, the nearest nature reserve away from Kunming, is one of the famous low-latitude-jokuls where the environmental balance affects the whole Kunming area. However, data about biodiversity in Jiaozi Nature Reserve were still unknown. In this paper, the composition and seasonal diversity variation of ground-dwelling beetle communities in Jiaozi Natural Reserve were estimated. The results showed that: (1) through the three-month study in 4 typical microhabitats (grassland, shrub, coniferous forest and farmland), 2 451 beetles which were collected and analyzed belonged to 24 families. The carabids (family Carabidae) were the dominant group, which accounted for 62.10% of total individual number; the second common group was Staphylinidae (12.77% in total). It was indicated that the beetles´activeness period last short due to the high altitude and low temperature; (2) by comparing the biodiversity indices of 4 microhabitats, it was found that there were migrating activities among different sites. It was indicated that beetles over-wintered in shrubs and migrated with the season variation. The beetles' migrating activities probably accorded with the food source.

Key words: biodiversity; beetle; Jiaozi Mountain; Yunnan; China
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云南轿子雪山自然保护区土壤甲虫生物多样性变化调查

王 君[1,2]，梁醒财[1]**
（1. 中国科学院 昆明动物研究所，云南 昆明 650223；2. 中国科学院 研究生院，北京 100049）

摘要：对云南轿子雪山自然保护区地表甲虫物的种组成及生物多样性季节变化进行了连续跟踪调查。调查结果如下：（1）通过对4种典型微环境样地（草地、灌丛、林地以及农田生态系统）连续3次跟踪连续调查，共获得标本2 451头，分别隶属于24科。其中步甲科（Carabidae）为优势类群，占总数的62.10%；隐翅虫科（Staphylinidae）其次，占12.77%。可能由于海拔、气温等因素影响，该地区昆虫活动高峰期较短。（2）通过对4种典型微生态环境中地表甲虫的生物多样性的比较，表明不同生境内甲虫的多样性指数存在动态变化，在不同生境片区内甲虫存在迁移活动，甲虫多在灌丛中越冬，并随季节及食物源迁移。

关键词：生物多样性；甲虫；轿子雪山；云南；中国

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作者简介：王君（1982 - ），女，河北保定人，硕士研究生，主要从事昆虫学方向研究。
E - mail：wangj126@yahoo.com.cn **通讯作者 Corresponding author E - mail：liangxc@mail.miz.ac.cn

1 Introduction

Biodiversity could be used as means to value sustainability of certain area[1] and are commonly used in conservation studies[2~4]. Insects have great potential as indicators for biodiversity conservation[5], and it is known that habitat characters and environmental stress often affect beetle diversity in ecosystems. There are various environmental types and microenvironments distributing in China; the mainland spans from tropical area to frigid zones. Nevertheless, most previous studies focused on temporary biodiversity conditions at a certain landscape and time period.

Jiaozi Nature Reserve locates in the north of Yunnan Province, in southwest China (E: 102°48′ ~ 102°57′, N: 26°1′ ~ 26°8′). This area, with altitude ranging from 700 m to 4 221 m, is one of the rare jokuls in low latitude area[6]. Locating in "the kingdom of animals and plants", this mountain is the nearest Nature Reserve from Kunming, the capital city of Yunnan Province; thus it is also assumed that Jiaozi Natural Reserve affects the environmental balance of Kunming area. Previous researches focused on the investigations of biological species[7,8] and the economical value[9]. Information on the biodiversity and its relationship with environment factors about Jiaozi Mountain area was unknown.

In the present study, the beetle community of the different landscapes at Jiaozi Nature Reserve was chosen as the subjects to investigate the relationship and the change according to microhabitats and seasons.

2 Materials and Methods

2.1 Study area

This study was executed in Jiaozi Nature Reserve, and all the sample plots were located in an area within 26°00707′ ~ 26°01544′ N, 102°56864′ ~ 102°57650′ E. The annual mean temperature in 2007 was 19.7 ℃, and annual precipitation was 806 mm (data from Kunming Meteorological Bureau). This study was carried out throughout the summer season, when insect activities were considered the most active. We focused on 4 different microhabitat types according to their distinct plants, altitudes and other relative factors.

Site Ⅰ was once farmland but had been desolated for more than 40 years. It located at a large mild slope, which was covered by various weed. Dominant plants belonged to Leguminosae, Gramineae and Labiatae. Site Ⅱ was a typical shrubbery, mostly covered by *Fargesia orbiculata*, *Rhododendron* spp. and Gramineae grasses; the slope was much steeper than site Ⅰ. Because of the protection of some thorny plants, there was little grazing activity here. Site Ⅲ was a coniferous forest, which located on the top of a hill. The ground was almost without grass but covered with thick leaf litters and moss. Site Ⅳ was a piece of farmland, which was used for cultivating. The 4 sites were distinguished as Tab. 1:

Tab. 1 Description of 4 sites in Jiaozi Mountain

code	site	primary plants	plant hight /m	degree of disturbance	longitude	latitude	altitude/m
Ⅰ	Daxingchang	grass	0.1 ~ 0.2	high, with grazing	102°56864′	26°01494′	2 880
Ⅱ	Dengjiashan Puerto	*Rhododendron spp.*, *Fargesia orbiculata*, *Potentilla fulgens*	1 ~ 2	medium, no grazing	102°57193′	26°00707′	2 953
Ⅲ	Shazipo Forest	*Abies georgei*, *Pinus yunnanensis*	thick humus layer	low, no grazing	102°57197′	26°00898′	3 078
Ⅳ	Dahengshan	wheat, potato	May: 0.5 – 1 June: > 1 August: 0.1	high, no grazing	102°57650′	26°01544′	2 806

2.2 Data collecting and sampling

Environmental data (temperature and precipitation) were obtained from the record of Kunming Meteorological Bureau, which provided detailed weather data of this area for each month. Other environmental data were obtained by field observing.

Ground-dwelling beetles were sampled at 4 different sites simultaneously, using pitfall traps during the main activity season. Fifty pitfalls were set in each site, and the investigation was carried out in early May, late June and early August in 2007, making up a total sampling effort of 600 pitfall traps. The intervals between two investigation seasons were about 40 days. Traps were made of plastic cups (diameter: up, 6.5 cm; bottom, 4.5 cm. height: 9 cm). Each cup was filled with 50 mL mixed solution, including vinegar, sugar, 75% ethanol and water; the proportion of each ingredient was 2∶1∶1∶20; and a tiny whole was made on the wall of each cup in order to drain excessive rainwater. Trap lines were set as straight as possible, with the distance of 1 m between each to reduce potential sample dependency. In June and August, traps were relocated at the same place as in May, in order to measure the diversity variation. The traps were buried flush with the soil and operated 3 days each time.

All trapped individuals were counted; trapped beetles were collected and identified to the species level.

2.3 Data analysis

Samples of 50 traps at each site were pooled and analyzed to evaluate the changes of beetle activity level, richness and diversity in response to different habitats and seasons. Beetle abundance (the number of individuals per trap) at each site was calculated to assess beetle activity level. The number of species per site assessed species richness. The diversity of beetles was described by indices as follows:

Shannon – Winer index H′[10]:

$H' = -\sum_{i=1}^{s} P_i \ln P_i$, ($p_i = n_i/N$, where n_i is the number of ith species, and N is the total number of individuals).

Simpson's index C

$C = \sum (P_i)^2$

Camargo's indices of evenness E'[11]

$E' = H_s/\ln S$, (where S is the number of species).

3 Results

3.1 Species composition and beetles activity

A total of 2 451 beetles, which belonged to 24 families, were trapped, including 322 individuals trapped in May, 1 435 individuals in June and 694 individuals in August. The carabids were the dominant group (62.10% of total beetles, and 83.23% in May, 60.98% in June, 54.61% in August); family Staphylinidae was relatively common group (12.77% of total beetles, and 3.42% in May, 13.45% in June, 15.71% in August). The number of individuals and species at each site were listed in Tab. 2. The overall capture rates varied from 0.25 (site I, May) to 4.69 (site IV, June) individuals / (trap · day).

Overall beetle abundance was the highest in June (28.70/trap), the medium in August (13.88/trap) and the lowest in May (6.44/trap). As for patches, the change in sites I, II and IV accorded with the overall activity rank, except site III. The order of total beetle activity at each site was: III > IV > II > I in May, IV > III > I > II in June and IV > III > II > I in August (Fig. 1a). For the dominant groups, the beetle activities of carabids were III > IV > II > I in May and IV > III > II > I in June and August (Fig. 1b).

3.2 Richness

For all of the 4 sites, the total species richness was the highest in June (211 species), intermediate in August (133 species) and the lowest in May (65 species). In May, the richness of 4 microhabitats was similarly low, then rose much higher in June and fell in early August (Fig. 2a). For carabids, the species changed greatly during the months on site I, III and IV; but remained nearly the same on site II (Fig. 2b).

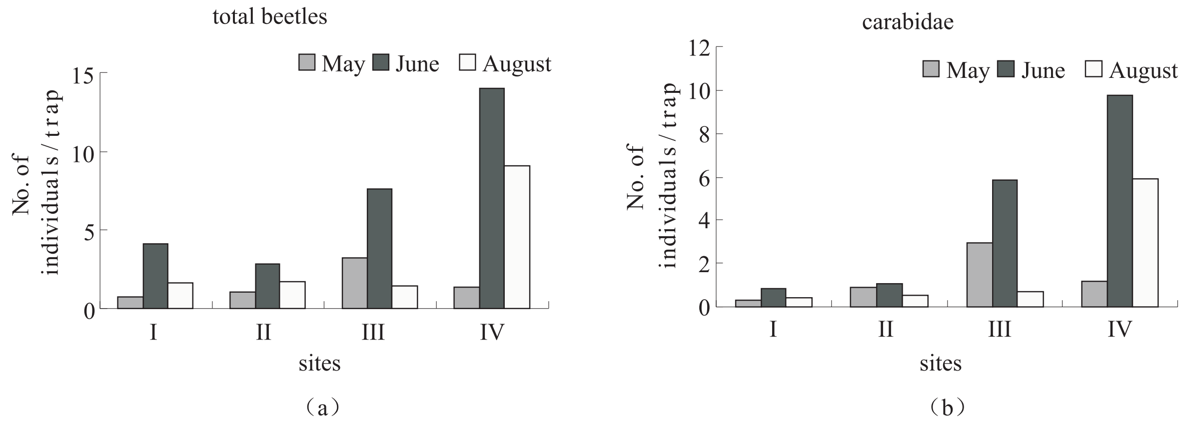

Fig. 1 Abundance of overall beetles (a) and carabids (b)

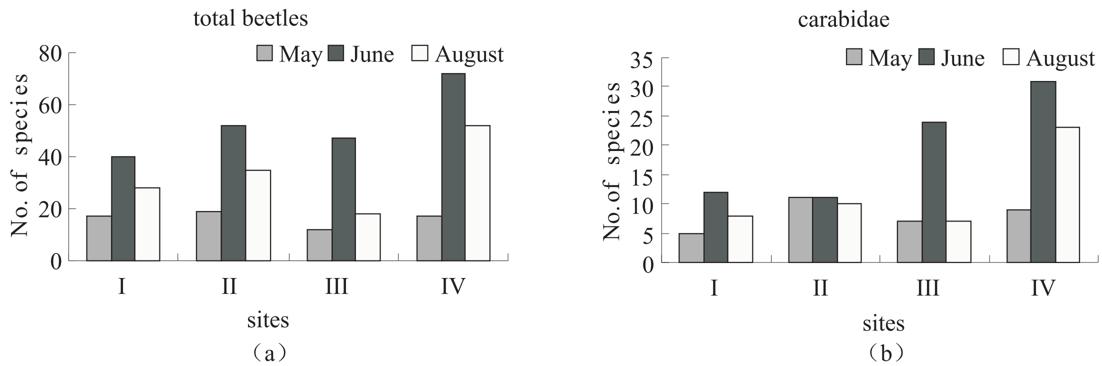

Fig. 2 Richness of overall beetles (a) and carabids (b)

3.3 Diversity

Three diversity indices were calculated to compare the biodiversity change of overall beetles and the dominant group. The Shannon-Winer index (Fig. 3a) showed that for all the beetles, the indices of site II were the highest and the indices of site III were much lower both in May and August, while in June, the indices among I, III and IV varied slightly. As for carabids (Fig. 3b), the situation came different. The diversity indices of sites I and III in June were much higher than in May and August, and for site II and IV, the indices in June were lower than in May and August.

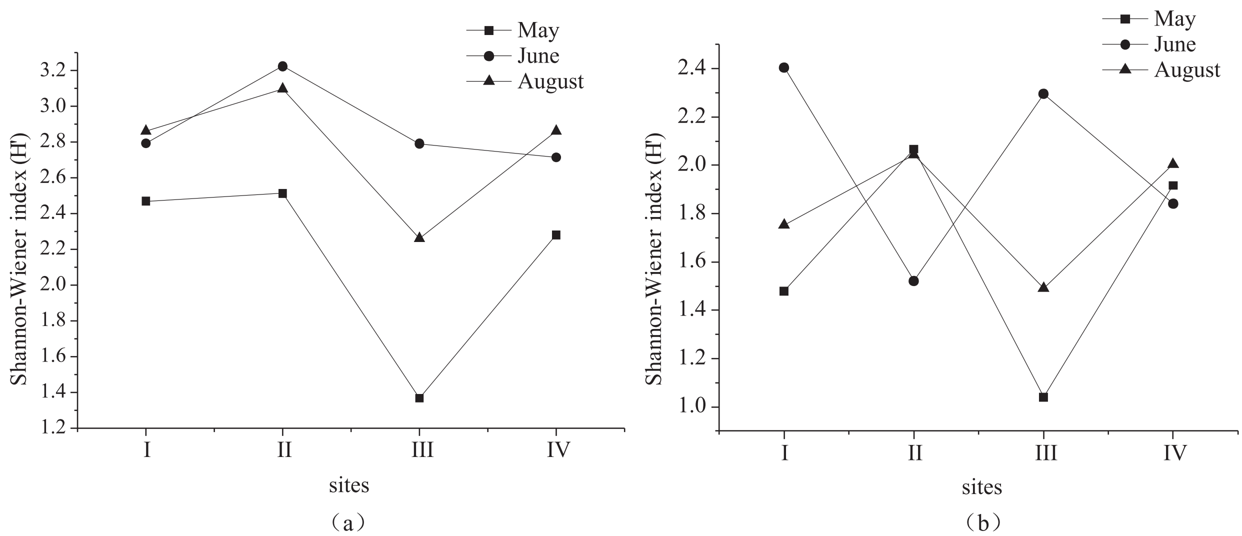

Fig. 3 Shannon-Winer index of overall beetles (a) and carabids (b)

Camargo's indices of evenness showed that for all the beetles (Fig. 4a), the order of indices in June and August was II > I > III > IV; while in May, the index at site III was much lower than sites I, II and IV. For carabids (Fig. 4b), the changes in May and August almost accorded with the indices of overall beetle; in June, the index was the highest at site I, then came site III and site II, and the lowest at site IV.

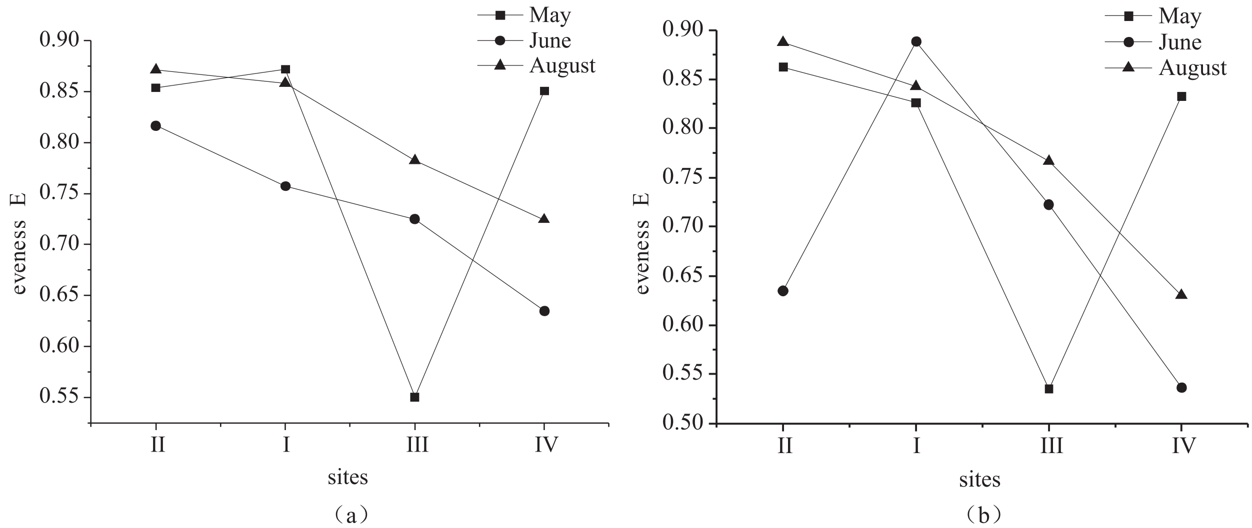

Fig. 4　Camargo's evenness of overall beetles (a) and carabids (b)

The Simpson's index (Fig. 5) showed that both in May and August the indices for overall species were highest at site III, then came site IV, I and II. While in June, the index was the highest at site IV, the lowest at site II. As for carabids, it was much higher at site II and IV in June than in May and August; while lower at sites I and III in June than in May and August.

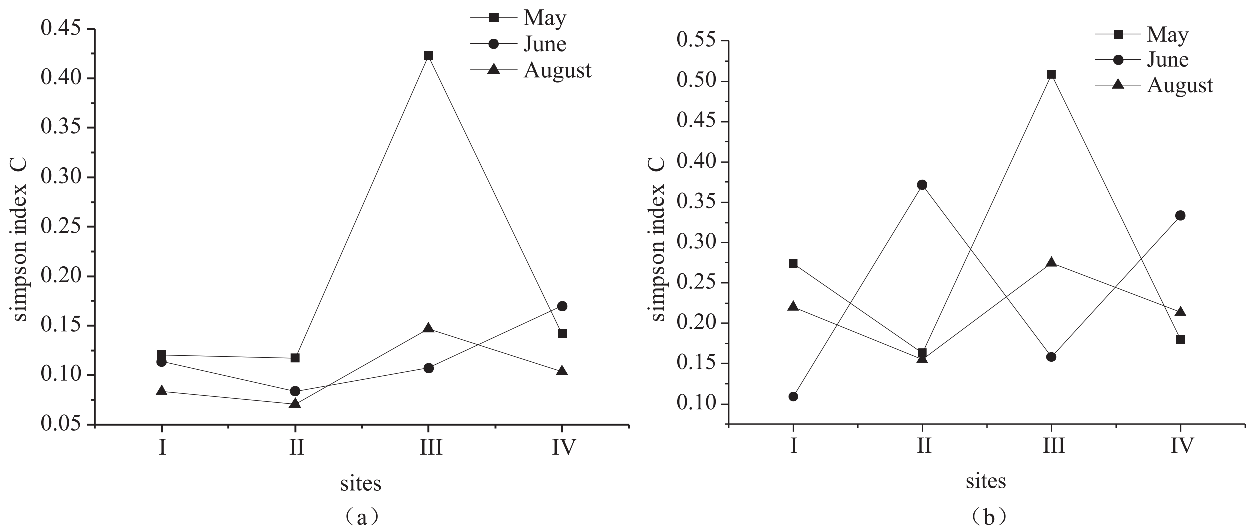

Fig. 5　Simpson's index of overall beetles (a) and carabids (b)

4　Discussion

The study showed that the insect abundance and richness were much lower in early May, then rose during early summer, and fell down before early August. Carabids were more adaptive in high altitude and low temperature areas. In Jiaozi Mountain, they are the dominant groups. The phenomenon may all due to higher altitude and lower temperature in Jiaozi Mountain area.

The biodiversity indices of the beetle community varied through different seasons and microenvironment. With the same air temperature and precipitation degree, the indices of 4 landscapes varied significantly. Compared to the indices of overall beetles, the carabids varied almost reversely in June. It indicated that there were migrating activities among beetles, especially carabids.

Site III was covered by tall arbor, which contributed to the rareness of ground plants (shorter than 1m); it held more individuals of beetles but less numbers of species; both abundance and richness of site IV were much lower in May but grew quite high in late June. It was assumed that this phenomenon was related to the species and heights of plants at such sites. The plant height should be an important impact factor for the richness and abundance of insects.

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Tab. 2　Total individual number and species number

Family	Ⅰ			Ⅱ			Ⅲ			Ⅳ			total	%
	May	June	August	May	June	August	May	June	August	May	June	August		
Carabidae	16(5)	40(12)	21(8)	45(11)	53(11)	27(10)	149(7)	294(24)	36(7)	58(9)	488(31)	295(23)	1522	62.10
Tenebrionidae	1(1)	0	0	1(1)	0	6(1)	7(1)	8(2)	1(1)	0	1(1)	0	24	0.98
Elateridae	7(1)	16(3)	0	0	5(3)	2(2)	1(1)	3(3)	0	1(1)	12(3)	2(2)	50	2.04
Coccinellidae	0	2(2)	0	0	0	0	0	0	0	0	0	0	2	0.08
Curculionidae	3(2)	15(4)	8(4)	0	3(2)	16(1)	1(1)	10(5)	8(2)	2(2)	29(4)	16(5)	111	4.53
Cicindelidae	1(1)	0	0	0	0	0	0	0	0	0	0	0	1	0.04
Cantharidae	1(1)	0	0	0	0	0	0	1(1)	0	0	1(1)	1(1)	4	0.16
Chrysomelidae	2(1)	1(1)	23(4)	1(1)	11(7)	3(3)	0	8(1)	0	1(1)	29(6)	80(9)	158	6.45
Melolonthidae	0	22(2)	0	1(1)	8(4)	1(1)	0	0	0	1(1)	5(2)	0	38	1.55
Rutelidae	0	0	0	1(1)	0	0	0	0	0	0	0	0	1	0.04
Aphodiidae	2(2)	1(1)	1(1)	1(1)	25(4)	3(2)	0	0	0	0	3(3)	1(1)	35	1.43
Geotrupidae	0	0	1(1)	0	0	1(1)	1(1)	0	0	0	0	0	2	0.08
Scarabaeidae	1(1)	1(1)	0	0	0	0	0	1(1)	1(1)	0	0	0	7	0.29
Staphylinidae	0	15(8)	16(3)	3(2)	29(15)	22(11)	5(1)	55(7)	25(5)	3(2)	94(12)	45(5)	313	12.77
Silphidae	0	0	1(1)	0	1(1)	0	0	0	0	0	0	0	2	0.08
Trogossitidae	0	0	0	0	1(1)	2(1)	0	1(1)	1(1)	0	0	0	5	0.20
Languriidae	0	1(1)	0	0	0	0	0	0	0	0	0	0	1	0.04
Oedemeridae	0	21(1)	0	0	0	0	0	0	0	0	0	0	21	0.86
Pselaphidae	0	0	2(2)	0	0	0	0	0	0	0	0	0	2	0.08
Sphaeritidae	0	0	0	0	0	0	0	0	1(1)	0	5(2)	3(1)	9	0.37
Trogossitidae	0	2(2)	3(2)	0	0	0	0	1(1)	0	0	6(2)	3(3)	15	0.61
Bostrychidae	0	0	0	0	1(1)	0	0	0	0	1(1)	1(1)	0	3	0.12
Anthicidae	1(1)	57(1)	6(1)	0	0	1(1)	0	0	0	0	24(2)	6(1)	96	3.92
others	2(1)	12(1)	1(1)	1(1)	6(3)	1(1)	0	1(1)	0	0	5(2)	1(1)	29	1.18
total	37(17)	206(40)	83(28)	54(19)	143(52)	85(35)	164(12)	383(47)	73(18)	67(17)	703(72)	453(52)	2451	100.00

Note: The numbers in brackets showed the number of species