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Study for the Temporal and Spatial Variation of the Ant Assemblages as the Biological Indicator in National Parks

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Abstract: In recent years, with the rapid economic growth and the increase of people's income, intellectual ecological tours have been enjoyed by many people. The protection of natural resources and traditional culture in National Parks has been highly valued. In order to avoid causing damage to the environment, disappearance of precious resources and harm to the original ecological system, it is very important to establish a monitoring inventory to understand the environmental changes caused by human at an ecological tourist spot. Therefore, ant assemblages have been used as biological indicators of environmental condition to represent the impacts of ecotourism to the ecosystem of the Longluantan Scenic Area in Kenting National Park. From the monitoring practices of ant community composition, we can found that the temporal and spatial variation of abundance indices, was significantly sensitive to the extent of human disturbances and recreation intensity.

Key words: Biological diversity, Monitoring, Ant

Introduction

With the economical fastest growing, tourism had been paid much attention to many people. Recently, ecotourism is a widely welcome travel because ecotourism not only helps to promote the idea of in situ preservation of environment, but it also educates the general public on conservation issues for ecological system (Newsome *et al.*, 2002). Among these ecotourism, the National Parks offer the highly valued tourism such as ecological, biological, cultural, environmental factors, environmental friendly, green, natural-oriented, resource-based and sustainable. However, the prevailing of ecotourism causes some serious impacts and treats on the national parks, such as destroy of environment, degradation of habitats, visitor dissatisfaction because of limited access or crowding, the disturbance of wildlife and so on. Therefore, it is very important to protect of natural resources and environmental conservation to avoid causing damage to the environment, disappearance of precious resources and harm to the original ecological system at an ecological tourist spot.

In 1872, the United States gave birth to the world's first national park-Yellowstone National Park, in order to protect Wyoming's remarkable geological curiosities and today, there are nearly one thousand national parks located in more than a hundred countries on this planet. The Kenting National Park is Taiwan's first national park, which located at the southern tip of Taiwan. With warm climate, spectacular landscape, seascape, cultural heritage, pleasant scenery, and easy access. It is one of the most popular resorts, attracting millions of both domestic and foreign tourists every year. Among the popular scenic spots in the national park, Longluantan Scenic Area is the largest artificial wetland. It is not only a water reservoir for irrigation, but also a paradise for migratory birds during autumn and winter. During birding season and holidays, numerous tourists bring some unavoidable impacts and destroy on the land ecosystem of the area. Therefore, it is necessary to establish a monitoring survey to understand the environmental changes caused by human at an ecological tourist spot.

In general, to establish a long term monitoring survey for an ecological tourist spot is still a complex work, such as which biology can be selected as the biological indicators. In the past, many method had been used for the consideration of the relatively simple classification, collection, the sensitively reaction to ecosystem changes and their diverse ecological function roles in varied ecosystems. Ant species distributed over a wide range of habitats. The ant assemblages have been used as biological indicators of environmental condition and management practices in many different ecosystems (Yeatman and Greenslade, 1980; Peck *et al.*, 1998 and Andersen, 1998).

Therefore, we hypothesize that assemblages of ants in Longluantan Scenic Area will show significant differences depending on human impacts, and they are capable of providing an assessment over a wide range of stresses. So, they may have potential as a biological indicator of conditions and fluctuations in Longluantan Scenic Area. To assess this hypothesis, the monthly field survey in Longluantan Scenic Area from April 2003 to March 2004 will be conducted. There are four transecting lines according to the different plantation and different recreation stresses will be set. Associations between ant species with human impacts were analyzed and to clarify the roles of ants at Longluantan Scenic Area.

This paper is aimed to understand the diversity and composition of the ants at the Longluantan Scenic Area in Kenting National Park. We were trying to define the human interferences, especially leisure and recreation activities, on biodiversity so that we can evaluate the impact of human manipulation on Longluantan Scenic Area. Based on the analysis of the biodiversity indices of ants, the suitability of using ant community as biological indicators to represent the impacts of ecotourism to the ecosystem of national park will be evaluated.

Materials and Methods

Study Area: The study was performed at Longluantan Scenic Area in Kenting National Park in Taiwan (Fig. 1). As the largest artificial wetland in Kenting National Park, Longluantan Scenic Area is not only a water reservoir for irrigation, but also a paradise for migratory birds. During birding season and holidays, the area attracts a huge amount of tourists for bird watching and other recreation activities, but there are only scattered visitors in other periods. The daily visitation also varied at Longluantan Scenic Area. The majority of tourists taking tour bus visiting before sunset, and just stay about one hour. Since there are temporal variations of recreation intensities and environmental pressures, the application of ecological monitoring survey would make it possible to understand the impacts of different recreation intensities and environmental pressures on ecosystem of the area.

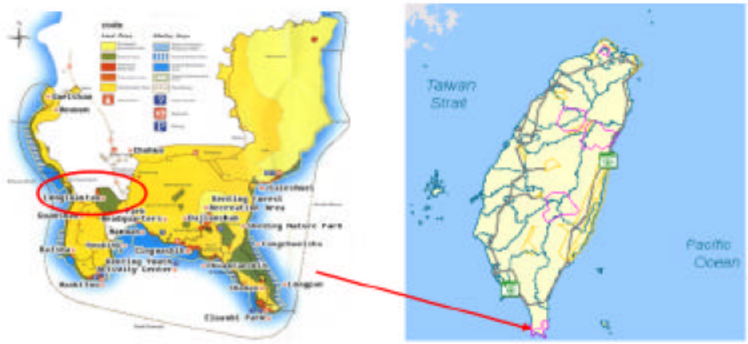

Fig. 1: Location of the Longluantan Scenic Area in Kenting National Park, Taiwan

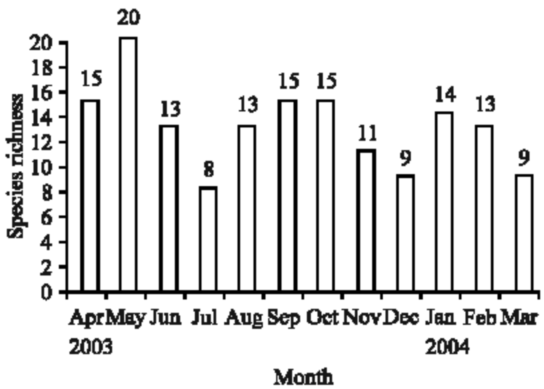

Fig. 2: Monthly fluctuations of species richness of ants collected during April 2003 to March 2004 at Longluantan Scenic Area in Kenting National Park

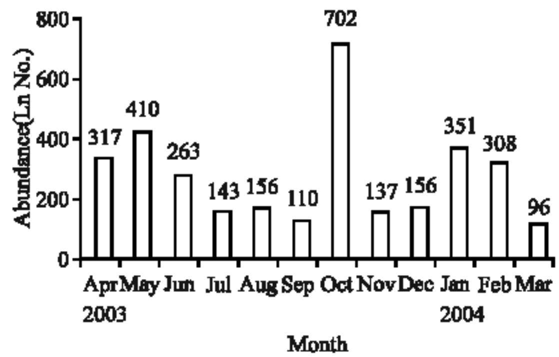

Fig. 3: Monthly fluctuations of abundance of ants collected during April 2003 to March 2004 at Longluantan Scenic Area in Kenting National park

Sampling: According the different vegetation cover distributed at Longluantan Scenic Area, we chose two sites for the study. One site is open grassland located in front of the natural center; the vegetation was a mainly low herb. The other is a shrubland planted native shrubs and trees for many years. Within each site, we established two transects (grassland: Gr 1 and Gr2, and shrubland: Sr1 and Sr2) of ten pitfall traps, with five to ten m between traps.

Pitfall traps were constructed of plastic vials with four cm mouths filled half with detergent liquor. Samplings took place monthly, and in each transect, traps were left out for 24 hrs. and then collected. After collecting the traps, ants were counted and identified to morphospecies and species where possible.

Besides the pitfall traps, we also collected leaf-litter (1m × 1m, 5 cm deep) at proximity near trees of each transect and set Berlese's funnel device for collection the ants. After collection, ants were also counted and identified.

Data Analysis: To describe the structure of each ant community, the two components of species diversity, species richness and evenness, were estimated for each transect and for each month.

The evenness index of Pielou (J) was estimated:

$$J = H / \ln S \qquad (1)$$

Where S is species richness and H is the Sannon index of diversity

$$H = - \sum (p_i \times \ln p_i) \qquad (2)$$

in which p_i is the proportion of workers of the ith species in traps during the period of time considered.

In addition, we also calculated an abundance index that expresses the abundance of the most common species as a fraction of the total number of individuals collected in traps, and are a measure of numerical dominance.

Results and Discussion

There were four subfamilies, 19 genera 34 species of ants sampling by pitfall traps and leaf-litter collection conducted at Longluantan Scenic Area in Kenting National Park during April 2003 to March 2004 (Table 1). Over the entire collection, the predominant subfamily was the Myrmicinae (12 genera, 23 species), followed by the Formiciane (two genera, five species), predatory Pronerinae (three genera, four species), and the Dolichoderinae only one species, *Technomyrmex albipes*.

Temporal Variation of Ant Community Structure: There were significant differences of ant community structure among months (χ^2, $p<0.0001$). Ant species richness varied monthly from eight (July, 2003) to 20 species (May, 2003) (Fig. 2), and abundance from 96 (March, 2004) to 702 (October, 2003) (Fig. 3). The decreases of ant diversity during summer months (June and July, 2003) may be related to the higher temperatures.

Table 1: List and number of ant species collected monthly during April 2003 to March 2004 at Longluantan Scenic Area in Kenting National Park

Species	Apr	May	Jun	Jul	Aug	Sep.	Oct.	Nov.	Dec.	Jan	Feb	Mar	Total
Myrmicinae													
Myrmica													
Myrmica sp.	7	3									1		11
Myrmecina													
Myrmecina strigis			1	3	1			1		1	1		8
Aphaenogaster													
Aphaenogaster tipuna		25	25		2								52
Aphaenogaster lepida						1	338	22	103	320	266	35	1085
Aphaenogaster takahashii			1										1
Cardiocondyla													
Cardiocondyla sp. 1	2	4								2			8
Cardiocondyla sp. 2		10	8			6	1	1				3	29
Cardiocondyla sp. 3		2				1	1						4
Cardiocondyla sp. 4		74											74
Cardiocondyla wroughtonii		2		1	2	1	4						10
Tetramorium													
Tetramorium pacificum	24	41	16		5	3	2	7	2	1	1		102
Tetramorium nipponense	1	3			1				2				7
Tetramorium simillimum		3	67		1		2	2					75
Solenopsis													
Solenopsis sp.	9	2	3		2			1			1		18
Crematogaster													
Crematogasterdohrni fabricans	1				1					1			3
Pheidologeton													
Pheidologeton yanoi	5	8				1			3	1	2	2	22
Pheidole													
Pheidole formosensis										1			1
Pheidole megacephala										1			1
Monomorium													
Monomorium sechellense			25	8	10		1					1	45
Monomorium intrudens			1			1	2				1		5
Pristomyrmex													
Pristomyrmex formosae		6			1	2	1	1		1			12
Pristomyrmex pungens	197	161	106	114	128	73	263	71	37	17	25	43	1235
Strumigenys													
Strumigenys formosensis		2											2
Formicinae													
Paratrechina													
Paratrechina longicornis	21	5					76	8					110
Paratrechina formosae	10	3	2	1		10	4		1	2	2	6	41
Camponotus													
Camponotus devestivus	6	31		9		1	1	2			1		51
Camponotus quadrinotatus	15	18		3		4	4		2		2		48
Camponotus monju	2					1							3
Ponerinae													
Hypoponera													
Hypoponera gleadowi			1										1
Leptogenys													
Leptogenys kitteli	2				1	2		21	4				30
Pachycondyla													
Pachycondyla javanus										1		1	2
Pachycondyla luteipeu					1	3				1			5
Dolichoderinae													
Tapinoma													
Tapinoma melanocephalum											3	4	7
Technomyrmex													
Technomyrmex albipes	15	7	7	4			2		2	1	2	1	41

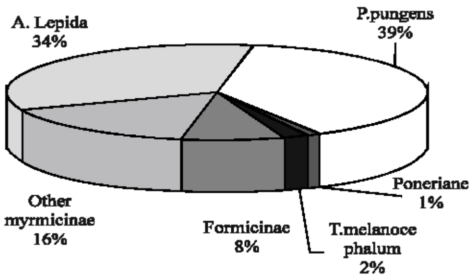

Fig. 4: The %age of different ant subfamily collected during April 2003 to March 2004 at Longluantan Scenic Area in Kenting National park, respectively (n= 3149)

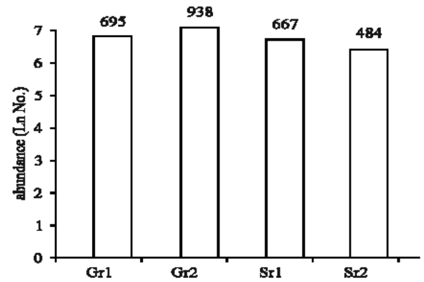

Fig. 5: Abundance of ants collected at four Tran-sects during April 2003 to karch 2004 at Longluantan Scenic Area in Kenting National Park

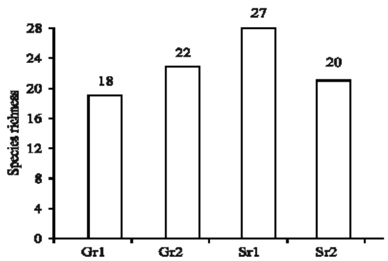

Fig. 6: Species richness of ants collected at four transect during April 2003 to March 2004 at Longluantan Scenic Area in Kenting national Park

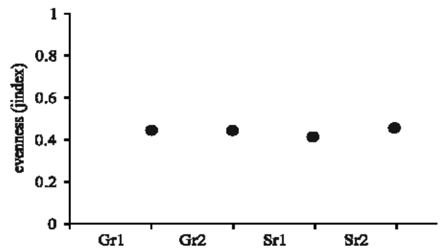

Fig. 7: Evenness index of ants collected at four transect during April 2003 to March 2004 at Longluantan Scenic Area in Kenting national Park

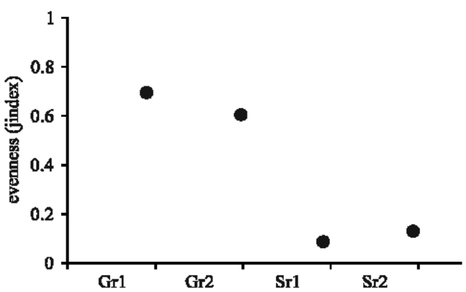

Fig. 8: Abundance index of ants collected at four transect during April 2003 to March 2004 at Longluantan Scenic Area in Kenting national Park

The environmental stress of high temperature caused reducing of ant activities (Andersen, 1998), and the species richness and abundance both declined. The abundant tourists of summer vacation during July to September might also attribute to the deceases. The most abundant of ants in October, was due to the abnormal occurrence of a single species *Aphaenogaster lepida* at transect Sr1. A total of 3149 individuals were sampled in this study. Most of the ant abundance was *Pristomyrmex pungens* (39%), followed by other species (21 species) belonged to the Subfamily Myrmicinae (16%), Formicinae (five species, 8%), predatory Poneridae (four species, 2%), and Dolichoderinae (one species, 1%) (Fig. 4). The composition of ant community was different from montane areas which the Formicinae had highest percentage at middle and high elevation in Taiwan (Wei *et al.*, 2002). It was possible that weather condition and vegetation affected the ant community structure, and the differences also might be related to succession stages and frequency of human interferences

Spatial Variation of Ant Community Structure: There were differences among four transects for ant community structure (Table 2). The majority of ants sampled at the two transects (Gr 1 and Gr 2) set in the grassland in front of natural center were middle and small size, such as *Cardiocondyla*, *Tetramorium* etc. Besides most of species belonged to the subfamily Formicinae only sampled in the two transects. As to the other two transects (Sr1 and Sr 2) set in native shrubland, were the sites the ants belonged to the genus *Aphaenogaster* (three species) and Ponerinae (two genera, three species) and *T. albipes* sampled only. The species found in only one habitat type may be good indicators of the effects of habitat disturbance if a certain level of disturbance restricts their range. In the absence of data addressing qualitative differences in diversity, it may be useful to use these species as indicators of disturbance (Roth *et al.*, 1994). It was showed that less disturbed sites may favor more specialized species, on the contrary, generalist may be more prevalent in modified habitats since they usually are more disturbance-tolerant or more to recolonized after disturbance.

In addition, there were significant differences of ant abundance among different transects (÷^{2}, $p < 0.0001$). The transect Gr 2 had the highest abundance (n = 938), followed by Gr 1 (n = 695), Sr 1 (n = 667), and Sr 2 (n = 484) (Fig. 5). The monthly abundance of Sr1 and Sr 2 were similar before July. The difference of total number of ants in Sr 1 and Sr 2 was due to the extraordinary increase of *A. lipida*. The number of species at each transect showed much higher richness in Sr 1 (n =27), than other three transects. The species richness of Gr 2 was 22, Gr1 was 18 and Sr 2 were both 20 (Fig. 6).

However, the spatial variation of evenness index showed little differences among Gr 1 (0.448), Gr 2 (0.443) and Sr 1 (0.413), and the highest in Sr 2 (0.45) (Fig. 7). Ant diversity decreased in more heavily disturbed areas (Roth *et al*., 1994). Accordingly, the human disturbances of Sr 2 may be relatively lower than the other three transects. The trend of abundance indices was not the same as evenness indices. The lowest value was 0.061 in Sr 1, followed by Sr 2 (0.08), Gr 2 (0.636), and Gr 1 (0.694) (Fig. 8). It revealed that the dominant

Table 2: List and number of ant species collected in four transects April 2003 to March 2004 at Longluantan Scenic Area in Kenting National Park

Species	Gr 1	Gr 2	Sr 1	Sr 2
Myrmicinae				
Myrmica				
Myrmica sp.	10		1	
Myrmecina				
Myrmecina strigis	2	1	3	2
Aphaenogaster				
Aphaenogaster tipuna			52	
Aphaenogaster lepida	2		461	325
Aphaenogaster takahashii			1	
Cardiocondyla				
Cardiocondyla sp. 1	3	1	1	1
Cardiocondyla sp. 2	15	1	1	8
Cardiocondyla sp. 3	2		2	
Cardiocondyla sp. 4		73	1	
Cardiocondyla wroughtonii		2	4	7
Tetramorium				
Tetramorium pacificum	65	33	15	36
Tetramorium nipponense		2	5	
Tetramorium simillimum	4	68	2	
Solenopsis				
Solenopsis geminata	8	1	1	1
Crematogaster				
Crematogaster dohrni fabricans		1	1	1
Pheidologeton				
Pheidologeton yanoi	16	2	2	2
Pheidole				
Pheidole formosensis		1		
Pheidole megacephala				1
Monomorium				
Monomorium sechellense	10	1	1	25
Monomorium intrudens			2	2
Pristomyrmex				
Pristomyrmex formosae	2	3	7	
Pristomyrmex pungens	482	597	41	41
Strumigenys				
Strumigenys formosensis				2
Formicinae				
Paratrechina				
Paratrechina longicomis	3	103	2	2
Paratrechina formosae	3	21	11	1
Camponotus				
Camponotus devestivus	40	7	4	
Camponotus quadrinotatus	25	14		9
Camponotus monju		3		
Ponerinae				
Hypoponera				
Hypoponera gleadowi		1		
Leptogenys				
Leptogenys kitteli			30	1
Pachycondyla				
Pachycondyla javanus			2	
Pachycondyla luteipeu	3		2	
Dolichoderinae				
Tapinoma				
Tapinoma melanocephalum				7
Technomyrmex				
Technomyrmex albipes		2	12	10

species *P. pungens* had more influences on spatial fluctuations of the ant community structure in Gr 1 and Gr 2 (grassland), rather than Sr 1 and Sr 2 (shrubland). Hence, abundance index of different sites would be used to judge the extent of human disturbances at Longluantan Scenic Area in Kenting National Park, respectively.

Conclusions

The community structure, biodiversity indices and species richness of ants were varied temporally and spatially. The two sites we chose in the survey, the grassland located in front of natural center faced more intensive human disturbances and higher recreation intensity. According the ant community structure, the two transects in the grassland had more commonly disturbance-tolerant species. However, the native shrubland community structure seemed to be more stable, except for the recorded disturbances of power line construction.

The temporal and spatial variation of abundance indices, which used the relative abundance of the most common species in this area, showed that the index was more sensitive to the extent of human disturbances and recreation intensity.

Due to the relative short-term survey of this study was not specific for the chosen sites, the preliminary analysis of the study needs further research programs to unveil the relationships between ant biodiversity indices and the extent of human disturbances.

The monitoring program of Longluantan Scenic Area in Kenting National Park should including the periodical survey and update the data of ecological factors (vegetation cover, ant biodiversity, soil erosion, etc.), the long-term monitoring of environmental factors (meteorological factors, air and water quality), and the inventory conducted to understand the requirements of tourists and their behavior, the opinions and understanding of local people for the differences between the dual roles of Longluantan Scenic Area (traditional reservoir and popular scenic spot) in Kenting National park, and the willingness for the locals to involve the management of the sites.

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