E-1.3 Studies on community structure of animals in tropical forests

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Abstract We carried out 4-year continuous monitoring of the community and populations of small mammals in the Pasoh Forest Reserve. The species diversity of small mammals was low in the secondary forest than in the primary one. This may be due to 1: undeveloped vertical structure of the forest, 2: low horizontal heterogenity, 3: reduction of food supply, and 4: reduction of nesting sites. Spiders were collected with a beating method in March and July 1994. Salticidae and Theridiidae were common on trees and the number of spiders was more abundant in the middle height of the forest. Number of land snail species and population density in lime stone area were lager than granite area and most of them appear to depend on Ca from lime stone.

Key Words tropical forest, small mammal, spiders, land snail, community, population

1. Features and roles of small mammal communities in a tropical rain forest.

(1) Introduction

Small mammal communities of the tropical forests have higher species diversity and complexity than that of the other climate regions. In South-East Asia, rough sketches of their ecology have been reported on food habits and habitat utilization (Harrison, 1954, 1957, 1961, 1962; Lim, 1970; Medway, 1978; Kemper, 1988; Payne et al., 1985). There are also some detailed studies on habitat preference (Kemper & Bell, 1985) and social organization (Kawamichi & Kawamichi, 1979, 1982; Langham, 1982). However, long term and large scale studies have been scarcely done in the tropics, though such studies are indispensable to provide necessary information for conservation and management of the tropical rain forest ecosystems (Pimm, 1991). We have carried out monthly trapping study of small mammals over two years at a 10 ha site in a tropical rain forest of West Malaysia. Here, we report on the community structure of small mammals and their habitat preference among three adjacent forest types; namely primary, secondary and swamp forests.

(2) Study site and methods

Study site: The study was carried out in the Pasoh Forest Reserve in Negri Sembilan, Malaysia. A 10 ha (500 m x 200 m) study site was established in the boundary area between a virgin forest and a regenerated forest that selectively logged in 1960s. The study site consisted of primary forest (51.2 % of the area), secondary forest (29.6 %) and swamp forest (19.2 %). The swamp area includes streams and an area whose forest floor was periodically covered with water during the rainy seasons. Most part of the swamp area dries up during dry seasons when the precipitation is less than 100 mm/month,

Tree survey: Tree survey in the three forest types was carried out from September to October I 994 to describe the vegetation structure. We mapped the location and measured the diameter of all large trees (dbh>5 cm) within five 20 m x 20 m quadrates in each forest type, and of all trees (dbh>60 cm) in the whole 10 ha study site. The existence of canopy gaps was also recorded at every 5 m x 5 m quadrate in the study site.

Monthly trapping of small mammals: Two hundred and fifty live-traps were set systematically as a grid pattern on the forest floor. The distance between traps was 20 m. The size of the trap was 17 cm x 17 cm x 44 cm (W x H x D). Oil palm fruit was used as baits. Trapping has been carried out once a month around the middle of each month since June 1992. One trapping session included four consecutive days. The ratios of traps in the primary, secondary and swamp forest were 43.2% (108 traps), 22.4% (56 traps) and 34.4% (86 traps) respectively, since we regarded the trap located within 10 m away from the swamp as a trap in swamp area. Captured animals were marked individually by using both methods of finger-clipping and colored-ear-tag after anesthetized with the ether. At every capture, animals were identified and measured the body dimensions and examined the reproductive condition before releasing.

(3) Results

(i) Forest structure

Judging from the size distribution of large trees (dbh > 60 cm) that compose the emergent or main canopy layer, the secondary forest had fewer trees over 100 cm in dbh and more of 60 - 70 cm than the primary forests. Since the Malaysian logging law provides that one can cut only the tree whose dbh is more than 60 cm, it seems that large trees were mostly logged in this area. It is notable that the trees of 60 - 70 cm in dbh have grown up from the trees that were in smaller size classes and escaped from the logging. Because of the existence of these trees, the spatial distribution of large trees was uniform throughout our study site, although dbh of most trees was under 70 cm in the secondary forest.

Including small to middle sized trees (dbh > 5 cm), tree densities in the primary, secondary and swamp forests were 1415, 1740 and 1820/ha, respectively. Basal areas were 1.29, 1.76 and 1.43 m^2, respectively. Comparing between the primary and secondary forests, the latter had more trees of 5 - 10 cm and 10 - 15 cm classes. Trees in these classes made a continuous uniform canopy layer at 15 - 25 m in height as contrast with the primary forest whose canopy layer was more horizontally discontinuous. Moreover, one can look through further in the secondary forest than in the primary forest, because of fewer saplings.

The gap ratios of the primary, secondary and swamp forests were 4.9%, 1.9 % and 9.8 %, respectively. The gap ratio of the secondary forest was less than half of the primary forest. This suggests that there are fewer fallen trees that provide nesting, resting and hiding sites for terrestrial animals. Tree size distribution of the swamp forest was similar to that of the primary forest rather than that of the secondary forest. This suggests that this area might suffer little disturbance by logging. However, this forest had more trees but less basal area than the primary forest. It was bushy with small trees of less than 10 cm in dbh that made dense crown layers at 1 - 10 m in height with high gap ratio. In sum, the secondary forest in our study site has gradually recovered from the damage of selective logging in terms of the vegetation coverage, but was characterized by the biased size distribution as more pole-sized trees and fewer large trees, a continuous canopy layer, and fewer tree falls and gaps. This forest may supply an environment with low heterogeneity to animals, not only vertically but also horizontally. In the swamp forest, the water condition at the forest floor may be critical for terrestrial animals as well as its forest structure.

(ii) Species composition of small mammals

Twenty species belonging to 7 families and 5 orders of Mammalia were recorded during two-year trapping from June 1992 to May 1994. Sixteen species were small mammals which here we define as the mammal whose mean weight of adult is less than 1 kg. Rodentia was the most dominant order, and 13 spp. containing 8 spp. of sciurid and 5 spp. of murid were recorded. The most dominant species were *Tupaia glis, Lariscus insignis* and *Callosciurus notatus* among diurnal animals, and *Leopoldamys sabanus, Maxomys surifer* and *Maxomys whiteheadi* among nocturnal ones in terms of number of captures. The animal densities in the primary, secondary and swamp forests were 13.2, 10.1 and 7.2 captures/ha/month, respectively.

(iii) Distribution of small mammals

Numbers of captures on some species were less in the swamp forest than in the others. There were some traps with no captures in the central part of the swamp area. *Rhinosciurus laticaudatus* was caught more frequently in the primary habitat, while *Leopoldamys sabanus* occurred in both virgin and regenerated forests. *Rattus tiomanicus* occurred in any forest types.

(4) Discussion

(i) Comparison of species diversity among habitats

Shannon-Weaver Index H' in the primary and swamp forests (3.01 and 2.83, respectively) were higher than in the secondary forest (2.21). This index is known as an indicator of the species evenness in a community. Thus, it is suggested that the secondary forest has greater tendency to be occupied predominantly by one or a few species in comparison with the other habitats.

The species unevenness was made up by the following two factors. First, populations of both arboreal and terrestrial squirrels were quite small in the secondary forest. The captures of squirrels accounted for only 6.5 % of the total in the secondary forest, while 27.7 % in the primary forest and 20.1 % in the swamp forest. One species of arboreal squirrel, *Callosciurus prevostii* and one species of flying squirrel, *Hylopetes spadiceus* did not occur in the secondary nor swamp forests, while all of 16 spp. were recorded in the primary forest. Secondly, populations of murids in the secondary forest were remarkably higher (79.5 %) than in the primary forest (61.6 %) or swamp area (52.2 %). *Leopoldamys sabanus* and *Maxomys surifer* predominated in the secondary forest. This tendency reduced the species evenness in this habitat.

(ii) Habitat preference of small mammal species

We could categorize small mammal species into three categories. The first, namely the primary forest species group, consists of *Maxomys rajah, Rhinosciurus laticaudatus, Lariscus insignis, Maxomys whiteheadi, Sundasciurus lowi, Callosciurus notatus,* and *Tupaia glis* which were captured more frequently in the primary forest than in the other habitats (G-test, $p < 0.01$ for all species, rejection region is 9.210). This suggests that these seven species prefer non-swamp and undisturbed forests. This category includes 43.5% of small mammal species and all of the arboreal and terrestrial squirrels whose G-value can be calculated are in this category.

The second, namely non-swamp forest species group, consists of *Maxomys surifer* and *Leopoldamys sabanus,* which were frequently captured in the secondary forest as well as in the primary forest, but fewer in the swamp area (G-test, $p < 0.01$ for both species). These two species would not be influenced by the disturbance of logging any more after the vegetation recovered. More precisely, *Leopoldamys sabanus* seemed to prefer the disturbed forest rather than the virgin forest, since G-value of the secondary forest is larger than the other. It was found that *Maxomys surifer* and *Maxomys rajah* behave differently. These species are closely related each other and had been systematized as subspecies. Their body morphology is quite similar and they are considered to occupy the same ecological niche. However, *Maxomys rajah* showed strong preference to the primary habitat, but *Maxomys surifer* did not show such tendency. Probably, *Maxomys rajah* is strictly confined to the undisturbed environment through its food habits or some other factors that were not revealed in this study.

The third group is represented by *Echinosorex gymnurus* and *Rattus tiomanicus*. Their occurrences seem not to associate with disturbed habitat nor water condition. Though Medway (1978) said that *Echinosorex gymnurus* prefers swamp forest or streams, such tendency was not found in this study. According to a telemetric study, this species prefers to nest under the ground at dry place, often in an old discarded termite nest (Yasuda, unpublished data). Thus we may be able to say that *Echinosorex gymnurus* occurs anywhere including the swamp area. Regarding *Rattus tiomanicus*, we captured 28 individuals in total for two years. Most of them (89 %) were caught only once (Yasuda, unpublished data). This suggests that this species wanders extensively in the forest and be caught occasionally.

(iii) Factors influencing to the animal distribution

According to Lim (1970), the food of *Leopoldamys sabanus* consists of insect (40%), fruits and seeds (36%), leaves and shoots (14%) and other plant materials (10%). *Lariscus insignis* and *Tupaia glis* eat plant and animal materials (Harrison, 1962). Generally, most small mammals are thought to be omnivorous, except some arboreal squirrels that are considered frugivores. The distribution and abundance of fruits could affect the population density of some animals to a certain extend. Therefore, further study in future must be planned from this point of view.

There were fewer gaps and fallen trees in the secondary forest. Fallen trees would supply insects as a food for small mammals, and the potential food resources might be more abundant in the primary forest than in the secondary forest. Fallen trees also supply nesting, resting or hiding sites to terrestrial animals through decomposing process, if trees arc large enough. Especially for the species that do not dig their nest by themselves, large fallen trees are quite important. This might be one of the reasons why some terrestrial squirrels, such as Lariscus insignis and Rhinosciurus laticaudatus, were more abundant in the primary forest. Forest structure including the distribution of canopy layers would be a critical factor for arboreal animals. For example, it is reported that *Callosciurus* spp. separate their habitat vertically by height of the canopy (MacKinnon, 1978; Tamura, 1993). It implies that species diversity of arboreal squirrel might be low where the forest structure is simple and homogeneous . In conclusion, the diversity of small mammal community was higher in an intact forest than in an adjacent thirty-years old regenerated forest. This clearly suggests that thirty years are not enough to recover from the damage of selective logging. The effect of logging was still easily seen in the small mammal community as well as in the plant community. Thus, it is considered that the plant community gives strong influences on the small mammal community in many aspects through its structure and function. Small mammals are believed to take an important role in seed dispersal in the tropical forest ecosystems (Becker et al., 1985; Emmons, 1980; Foget, 1990; Foget & Milleron, 1991; Gautier-Hion et al., 1985). The next step is to reveal how such an important role would be changed as a consequence of disturbance in a tropical rain forest.

(5) References

Becker, P., Leighton, M. & Payne, J. B. (1985) Why tropical squirrels carry seeds out of source crowns? J. Trop. Ecol., I : 183-186.

Emmons, L. H. (1980) Ecology and resource partitioning among nine species of African rain forest squirrels. Ecol. Monogr., 50 : 3 1-54.

Forget, P-M (1990) Seed-dispersal of *Vouacapoua americana* (Caesalpiniaceae) by caviomorph rodents in French Guinea. J. Trop. Ecol., 6 : 459-468.

Forget, P-M & Milleron, T. (1991) Evidence for secondary seed dispersal by rodents in Panama. Oecologia, 87 : 596-599.

Gautier-Hion, A., Duplantier, J.-M., Quris, R., Feer, F., Sourd, C., Decoux, J.-P., Dubost , G., Emmons, L., Erard, C., Hecketsweiler, P., Moungazi, A., Roussilhon, C. & Thiollay, J.-M. (1985) Fruit characters as a basis of fruit choice and seed dispersal in a tropical forest vertebrate community. Oecologia, 65 : 324-337.

Harrison, J. L. (1954) The natural food of some rats and other mammals. Bull. Raffles Mus., 25 : 157-165.

Harrison, J. L. (1957) Habitat studies of some Malayan rats. Proc. Zool. Soc. Lond., 128 : 1-21.

Harrison, J. L. (1961) The natural food of some Malayan mammals. Bull. National Mus., 30 : 5- 18.

Harrison, J. L. (1962) The distribution of feeding habits among animals in a tropical rain forest. J. Anim. Ecol., 31 : 53-63.

Kawamichi, T. & Kawamichi, M. (1979) Spatial organization and territory of tree shrews (Tapaia glis). Anim. Behav., 27 : 381-393.

Kawamichi, T. & Kawamichi M. (1982) Social system and independence of offspring in tree shrews. Primates, 23 : 189-205.

Kemper, C. & Bell, D. T. (1985) Small mammals and habitat structure in lowland rain forest of Peninsular Malaysia. J. Trop. Ecol., I : 5 - 22.

Kemper, C. (1988) The mammals of Pasoh forest reserve, Peninsular Malaysia. Malay Nat J., 42: 1-20.

Lim, B. L. (1970) Distribution, relative abundance, food habits, and parasite patterns of giant rats (Rattus) in west Malaysia. J. Mammal., 51: 730-740.

Langham, N. P. E. (1982) The ecology of the common tree shrew, *Tupaia glis* in peninsular Malaysia. J. Zool., Lond., 197 : 323-344.

MacKinnon, K. S. (1978) Stratification and feeding differences among Malayan squirrels. Malay. Nat. J., 30 (3/4): 593 - 608.

Medway, Lord (1978) The wild mammals of Malaya (Peninsular Malaysia) and Singapore (2nd ed.), xxiii + 131 pp., Oxford Univ. Press.

Payne, J. , Francis, C. M. & Phillipps, K. (1985) A field guide to the mammals of Borneo, 332 pp. , The Sabah Society with World Wildlife Fund Malaysia, Kuala Lumpur, Malaysia.

Pimm, S. L. (1991) The Balance of Nature?, 434 pp. The University of Chicago Press.

Tamura, N. & Yong, Hoi-Sen (1993) Vocalizations in response to predators in three species of Malaysian Callosciurus (Sciuridae). J. Mamm., 74(3) : 703-714.

2. Community Structure of Spiders in Tropical Rain Forest in Peninsular Malaysia

(1) Introduction

Spiders are distributed all over the world and have adapted to various terrestrial environments. They are ubiquitous predators in terrestrial ecosystems and play an important role in tropical rain forests. To clarify the structure and the function of tropical rain forest ecosystem, the role of spiders in tropical rain forest ecosystem should be studied. However , there has been few studies concerning ecological aspects of spiders, such as community structure, in the tropical rain forest in Malaysia. Though many species of spiders are distributed in the tropical rain forests, even a inventory of spider species in tropical rain forest in Malaysia is lack. In this research, we collected specimen of spiders in Pasoh forest reserve, which is a typical lowland tropical rain forest in Peninsular Malay, and analyze the pattern of community structure.

(2) Methods

Research were conducted in the Pasoh forest reserve in Peninsular Malaysia. Pitfall trapping was the methods of collecting wandering spiders. The trap consisted of a plastic cup (6 cm diam, 10 cm depth) buried in the soil, the open end flush with the soil surface. Ethylene glycol was placed at the bottom of the cup to a depth of about 2 cm as a preservative. Traps were located within each 40 pre-selected quadrates of the 1 m grid system. Traps were set for 48 hours at monthly intervals from February to April I 992 in Pasoh forest reserve. We collected spiders on trees by beating methods in March and July, 1994 by using the tower constructed in the forest reserve. Sampling were conducted from 8:00 to 11:00 from the undergrowth to canopy. All specimens were preserved in 70% alcohol and brought to the laboratory in Japan.

(3) Results

Spatial distribution of spiders The number of specimens of spiders collected by pitfall traps were not different in between the peripheral and the center of Pasoh Forest
Reserve. The family compositions was not different in between the periphery and the center of Pasoh Forest Reserve.

Vertical distribution of spider families A total of 101 specimens were collected by the pitfall method. Clubionidae and Zodariidae were especially abundant in the collection. These family seems to be main component of ground wandering spiders in Pasoh forest reserve. However Lycosidae, which is common in temperate forest, was lack in samples. A total of 287 specimens were collected on the trees. Salticidae and Theridiidae were common on trees. The number of spiders were more abundant in the middle height of the tropical rain forest.

(4) Discussion

Edge effect is suggested for the distribution pattern of organisms in the tropical rain forest. However, we could not detect any difference of the family composition of spiders between the center and the peripheral of the forest. It is possible that the edge effect is lack in spider distribution, because heterogeneity of microhabitat in tropical rain forest would determine the distribution of small invertebrate, such as spiders. However , we have only limited information about the analysis of species level, because of the difficulty of identification of larva specimen, and it needs further consideration about the edge effect of spiders. For this problem, detailed identification of all specimens is under process. Contrary to the edge effect, vertical distribution of family composition is different between the height above the ground. Especially, Salticidae and Theridiidae were abundant on trees, but rare on the ground, and Zodaridae was abundant on the ground, but lack on the trees. These pattern was determined by the hunting habits of each family, . The number of spiders in canopy is not so abundant as that of the middle height, but the most spiders in the middle height consisted of two families, Salticidae and Theridiidae. These family usually catch insects wandering on trees. To clarify the factors affecting the number of spiders on trees, we need information about the abundance of insects on tropical trees.

3. Community Structure of Molluscs in a Tropical Rain Forests

(1) Introduction

Land snails are a large group of animals: More than 140,000 species of molluscs have been described, with about 40,000 of these living on the land, mostly in the tropics. Although substantial number of descriptive and taxonomic studies have been made on tropical land snails, few have been directed to studies on community and population ecology. Community structure of land snails in tropical forests may exhibit few characteristics. for example; (1) Each species may have a particular microhabitat preference; (2) The distribution of land snails may strongly influenced by soil types and water quality; (3) They can easily respond to human-induced environmental changes. for example, change in soil structure, water quality. habitat simplification, etc.; (4) There are remarkable intraspecific differentiation between snail populations inhabiting various limestone areas.

(2) Study area and Methods

The land snail community was investigated in two tropical forests around lime stone hill in Malay peninsula from 1993 to 1994. One study site was Bukit Takun hill and another was Batu Cave hill. These hills were composed of lime stone rock and isolated in Granite soil area. To investigate the snail fauna. the quadrate was settled from the foot of lime stone rock to the depth of the forest. The belt transect method was conducted in the forest edge between Bukit Takun forest and grass field to investigate the change of density of snail species.

(3) Results and Discussion

The number of land snail species were gradually decreased with the distance. The distribution of most land snail species depend on the distribution of lime stone. The number of species was relatively high at the distance of 2 to 3m from the forest edge. This area corresponds to the location where shrubs grow. The number of land snail species was larger at forest area than at forest edge and at grass field. The densities (30 X 30 cm) of *Subulina octana* and *Diplommatina* sp. in relation to the distance from the forest edge showed the difference in site preference bwteen these two species. In contrast to *Diplommatina* sp., *Subulina octana* was only distributed in grassy area and not in the forest area. The density of S. octana was apparently high at the grass field, which suggested that *Subulina octana* is distributed only in disturbed area.