## F-2.1 Conservation of Wetland Biodiversity in Tropical Asia

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**Abstruct** We studied of mangrove animals, and analyzed the geographical change, physicochemical condition of water and growth line of shell to clarify the present condition of Matang mangrove forest in Malaysia during 1992-1994. We also surveyed benthic animals and physicochemical factors in mangrove forest of Iriomote Island to compare with Matang. Diversity of animal species and/or abundance of the animals on and around cutover area were less than that in matured mangrove forest. Sedimental study in Matang mangrove forest showed that the mangrove stratum accumulates to 2.8 m underground. The northern and southern parts of Matang area are expanding in contrast to the central area which is shrinking in recent years, and about 0.5 % of total mangrove area was lost during the last decade. Physicochemical analysis of water suggested that $NH_3$-N was supplied from mangrove forest to river and $NO_3$-N was flowed from river to the mangrove forest , and several nutritive substances flowed out from cutting area to river. Investigation of stable isotope showed that animals inhabiting the mangrove forest mainly depend on terrestrial ecosystem, whereas the mud flat animals depend on aquatic ecosystem, and some fishes migrate from the other specific area to channels in mangrove forest. Measurement of growth line of shells showed that about 50 % of *Anadara granosa* collected in the area were less than 1 year old and the rest were 1 year old. The shells had some obstacle rings from January to March, which suggested the weather condition affected growth of the shell. As the mangrove felling gives various effects on animals depending on the wetland ecosystem, we preliminarily discussed conservation of the wetland biodiversity; i.e., allocation and size of areas harvested, and the designation of a protected area.

**Key Words** Malaysia, mangrove, biodiversity, benthos, stable isotope, diatom

1. Introduction

Wetlands have been considered barren and unhealthy area for long time. However, recent studies have showed that wetlands are highly productive and biologically rich area. Also, wetland provides various biological resources to local inhabitants. Thus wetland conservation of wetlands has great importance to sustain biodiversity and resources for human beings. In Southeast Asia there are various types of wetland, and wildlife communities are found in the areas. Also, some wetlands are particularly important as wintering sites for shorebirds and migratory birds between Southwest Pacific and Japan. However, a large part of wetlands has already been destroyed or degraded by human activities in Southeast Asia,

while the scientific data is quite insufficient to understand wetland ecosystems and to conserve them.

We selected Matang mangrove forest for the study, where is the biggest mangrove forest in Peninsular Malaysia. The forest provides good habitat for wildlife and is also important for local fishery and forestry. We studied benthic animals and physicochemical factors in mangrove forest of Iriomote Island in Japan to compare with Matang mangrove.

2. Research Objectives

Research objectives of this study were to investigate the relations between wetland mangrove forest condition and human activities, and to describe general features of wildlife community and physicochemical factors in the wetland area. The final goal of this project was to develop a general scheme for wetland conservation, applicable to the other wetland areas.

3. Research Methods

(1) Mangrove animals

We conducted a study of wildlife (mammals, birds and fishes) occurring in and around Matang mangrove forest by direct observation, trapping and netting. Comparative study of benthic animals in the mangrove forests of Matang and Iriomote Island was carried out. Habitat utilization and feeding behavior of shorebirds were also studied in Matang.

(2) Geographical change of Matang area

Mangrove sediments were taken by drilling in the northern part of Matang mangrove area. We analysed environmental changes of the areas by lithofacies of sediments and diatom fossil assemblages which were extracted from the sediments. In addition to this study, we examine the distribution of living diatom to obtain some basic data for paleo-environment reconstruction.

(3) Physicochemical analysis

We collected mud and water samples for the analysis of physical environment of the area. We also studied ecological condition of the living organism and mud in the area from analyses of stable isotopes of carbon and nitrogen.

(4) Analysis of growth line of shells

Shells collected in Matang mangrove area were cut and examined the growth lines to monitor long-term environmental changes in the area.

(5) Development of wetland conservation plan

We proposed a conservation plan of Matang mangrove area with respect to mangrove forest management and biodiversity conservation.

4. Results and Discussion

(1) Mangrove animals

① Mammals: We observed 29 mammal species including 2 dolphine species in Matang mangrove area. Table 1 shows the relationship between observation sites of 12 medium size

mammals and habitat types of the study area. We observed many mammals on river bank and in dry forest. The plantain squirrel prefers to inhabit dry forest and the common palm civet prefers to use dry forest and oil palm plantation in contrast to the wild pig and the long-tailed macaque which used various type of habitat. We collected 13 bat species by mist nets and 2 rodent species by box traps.

Table 1. The occurence of large and medium-sized mammals in five vegetation types

| Species | Mangrove | | Dry forest | River Bank | Oil Palm Plantation |
|---|---|---|---|---|---|
| | Cut/Young forest | Mature forest | | | |
| Long-tailed Macaque | ○ | ◎ | ○ | ○ | |
| Silvered Leaf Monkey | | ○ | ○ | ○ | |
| Leopard Cat | ○ | ○ | | ○ | ○ |
| Palm Civet | | | ◎ | ○ | ◎ |
| Short-tailed Mongoose | | | ○ | ○ | |
| Wild Pig | ○ | ○ | ○ | ○ | |
| Plantain Squirrel | | ○ | ◎ | | |
| Malayan Pangolin | | | | | ○ |
| Smooth-coated Otter | | | ○ | ○ | |
| Small-clawed Otter | ○ | ○ | ○ | ○ | ○ |
| Bottle-nosed Dolphin | | | | △ | |
| Ridge-backed Dolphin | | | | △ | |
| Total | 4 | 6 | 7 | 8 + 2 | 5 |

◎ : High density, ○ : Observed (Used), △ : Observed in river

② Birds: We observed 161 species through the present study, while 158 species in total had been reported in the previous studies. A few species of large birds such as the lesser adjutant stork utilized cutover area of mangrove for feeding the large shell (*Anomura* spp.), however, number of bird species and density of birds in cutover area was less than that in mature forest. Owls utilized dry forest for sleeping site. Comparison study of bird communities between cutover area and the mature forest indicated that mangrove reforestation is important for recovery of species richness and density of birds.

Foraging behavior of shorebirds was different with benthos species. The lesser golden plover mainly fed on Polychaeta and Mytilidae. Mytilidae live in the shallower intertidal zone than Polychaeta which live in the deeper submerged at neap tide. The plovers changed feeding site from Polychaeta zone to Mytilidae zone with the lapse of days after neap tide. This observation suggested that temporal change of food availability is one of the important factors for food selection of shorebirds.

③ Fishes: The study on fish diversity was conducted in 24 study plots on and around Matang mangrove area. These plots were classified into four habitat types; (A) coastal zone, (B) rivers in mangrove forest, (C) plantation canals, and (D) rice field canals. Number of observed fish species in each habitat type (A-D) was 28, 40, 17, and 19 species respectively and a total of two classes, 12 orders, 39 families, 66 genus and 84 species were recorded in

the study. Eight species of the cyprinid fish were caught only in D type habitat (Table 2). In the rivers along mangrove area, we collected smaller number of species near cutover area than that around the mature forest.

Table 2 Number of fish species collected in four habitat types of Matang area

(%)

| Family | Coast | River | Plantation Canal | Rice field Canal |
|---|---|---|---|---|
| Engraulididae | 5 (18) | 2 ( 5) | 0 ( 0) | 0 ( 0) |
| Cyprinidae | 0 ( 0) | 0 ( 0) | 0 ( 0) | 8 (42) |
| Adrianichthyidae | 0 ( 0) | 2 ( 5) | 1 ( 6) | 0 ( 0) |
| Sciaenidae | 3 (11) | 1 ( 3) | 0 ( 0) | 0 ( 0) |
| Lutjanidae | 0 ( 0) | 2 ( 5) | 0 ( 0) | 0 ( 0) |
| Mugiidae | 1 ( 4) | 3 ( 8) | 3 (18) | 0 ( 0) |
| Gobiidae | 3 (11) | 12 (30) | 3 (18) | 1 ( 5) |
| Anabantidae | 0 ( 0) | 0 ( 0) | 4 (24) | 4 (21) |
| Cynoglossidae | 3 (11) | 0 ( 0) | 0 ( 0) | 0 ( 0) |
| Tetraodontidae | 2 ( 7) | 2 ( 5) | 0 ( 0) | 0 ( 0) |
| Other families | 11 (39) | 16 (40) | 6 (35) | 6 (32) |
| Total | 28(100) | 40 (100) | 17(100) | 19(100) |

④ Benthic animals: Crustacean species (e.g. *Thalassina anomula*, *Uca* spp.), mollusca (e.g. Pulmonata, *Terebralia palustris*) and polychaeta were found in Matang forest. Species richness and benthos density tended to decrease in cutover. Comparing Matang area and Iriomote Island, the number of species occurring were nearly the same but common species of the both areas were few, although area size and tree height of mangrove forest in Iriomote Island were lesser Matang area. In Iriomote Island the forest have never been cut, and the sandy layer may be able to sustain high organic density under aerobic environment. The study in each forest stage showed that occurrences of semi-land benthos, such as large mollusks and crustaceans, increase after cutting and reforestation. Twenty to thirty years after cutting, benthic animal community seems to reach a pre-cutting condition.

(2) Geographical change of Matang area

The distribution of living diatom showed a clear difference of diatom assembleges among habitat types. It was confirmed by sedimental study that average depth of mangrove sediments was 2.8 m in Matang area. According to a report of the Forest Department of Perak State, the mangrove area decreased about 0.5% during the last decade in Matang.

(3) Physicochemical analysis

$\delta^{13}C$ and $\delta^{15}N$ values formed 3 groups: mangrove ecosystem, marine ecosystem, and the intermediate situated along forest fringe and water routes (Fig. 1). The $\delta^{13}C$ and $\delta^{15}N$ values of living things collected in various habitats indicate a whether the species depend on terrestrial or aquatic ecosystems.

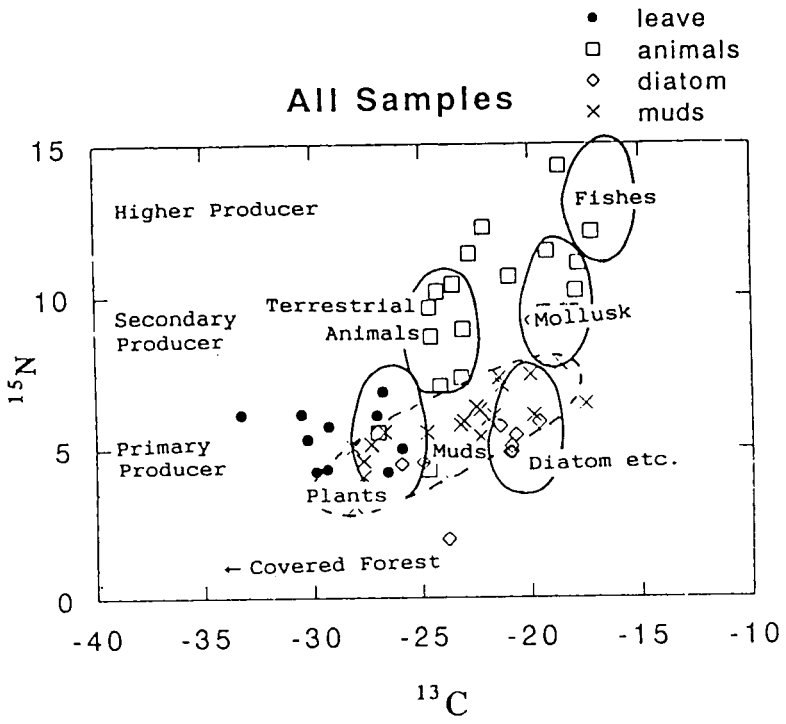


Fig. 1 Stable Isotope Analysis of $\delta^{13}C$ and $\delta^{15}N$

(4) Analysis of growth line of shells

Most of *Anadara granosa* from coastal mud flat were young and we could collect few big-sized shells, because of over-exploitation by local fishermen. The measurement of growth line of shells showed that about 50% of A. granosa caught in September were less than 1 year old. The rest were 1 year old, and those shells have the obstacle ring formed from January to March, which suggested the weather condition such as heavy rain in wet season affected growth of the shell.

(5) Development of wetland conservation plan

The density of large benthic animals and birds was low, and utilization of large mammals was less frequent in cutover of mangrove forests, though the lesser adjutant stork used cutover area for feeding of large-sized shell. The abundance of a kind of fish also decreased along the cutting forest area. Diversity and richness of wildlife species may recover by reforestation and the growth of trees. We preliminarily suggested some measures for the conservation of wetland; i.e. consideration of allocation size of harvested areas and designation of a conservation area, because the mangrove harvesting gives various effects on animals depending on wetland ecosystem.