Chapter 4

# CHANGES IN BIODIVERSITY AND ECOSYSTEM SERVICES

# Chapter 4　Introduction

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This chapter examines the changes in ecosystem services caused by changes in biodiversity. Ecosystem services were classified into three types—provisioning, regulating, and cultural—following the definitions of the Millennium Ecosystem Assessment. In particular, we focused here on ecosystem services that have close relationships with biodiversity.

Timber supply is one of the most important provisioning services of forest ecosystems, although the tree species available must change according to the change of forest structure caused by forest use system (Seino et al., in this Chapter). Woody material is also important as fuel. Coniferous trees are commercially more valuable in Japan, but broadleaf trees can have value as fuel for locals and for particular products (Oh). Recently, Non Timber Forest Products (NTFPs) have attracted more attention in the context of sustainable forest use (Naito, Kanazawa, in this Chapter). Mushroom and other organisms for livelihood are important NTFPs that depend on the forest type (Yamashita, Kato); thus, changes in the forest ecosystem have caused great changes in the patterns of forest utilization by local people.

We focused on the control of pest animals as a regulating service provided by the forest ecosystem. Some species of parasitoid wasps were found to be abundant in traditionally used landscapes (Maeto & Kitabatake). Agricultural damage cased by deer and monkeys in recent years may have a close relationship with past forest utilization. The rapid increase in young plantations caused an increase in the population of wild animals, which has led to serious damage to agricultural crops (Agetsuma). The negative services in systems with simplified biodiversity were affected by the local landscape (Morino & Koike).

The change in forest ecosystems and the intellectual and cultural changes of local people are an interactive process. An example of such interactions on Yaku Island was documented (Baba). The knowledge of plants and birds varies among local indigenous tribes, but it has changed in recent decades (Aihara & Momose). A diverse landscape is also important for local people, and in turn, it operates to maintain sustainable forest uses (Kaga & Momose).

We succeeded in elucidating some of the influences of the forest ecosystem and biodiversity on ecosystem services, but many remain unclear. The relationships between biodiversity and ecosystem services are not very tight and sometimes depend on local and regional conditions. More studies are required to clarify the relationship between biodiversity and ecosystem services.

# Tree Diversity and the Changes of Wood Utilization of Tropical Rain Forest in Borneo

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## Introduction

The lowland tropical rain forests of Borneo are characterized by high tree species diversity and the stratification of multiple foliage layers, which exceed 60 meter in height with emergent trees. Above-ground biomass is also high. The lowland forests of Borneo are characterized by many Dipterocarpaceae species and called a mixed dipterocarp forest. The diversity and stand structure of the dipterocarp forest relate with environmental conditions such as soil nutrient, topography and altitude.

Humans use forest products from tropical rain forest as wood in terms of biomass stock, and as tropical fruits and medicinal ingredients in terms of species diversity. With regard to wood utilization, the amount of harvests and the species that are harvested have changed with human activity. As a recent trend, deforested area is increasing and the depletion of the wood resource is expected to rise from increasing demand for resources. In the project "Sustainability and biodiversity assessment on forest-utilization options" by RIHN, we began our research in Deramakot Forest Reserve in Sabah, Malaysia, which introduced low impact selective-logging (Reduced Impact Logging, RIL) method. The policy and aim of forest management in Deramakot Forest Reserve are to establish the harmony between biodiversity maintenance and the sustainable utilization of forest products with the employment of an ecological approach. A strict forest management has been applied to Deramakot Forest Reserve (Lagan et al 2007). Thus, this site is a good model for the research project focused on the relationship between forest ecosystem and historical background of human forest utilization. Here, we report how harvested species changed with the introduction of heavy machinery and how the change was related with the density of wood in the lowland dipterocarp forest.

## Method

### *The study site*

The study site (5˚22'N, 117˚25' E, approximately 300 m asl) is located in a lowland forest of the Deramakot Forest Reserve (DFR) in Sabah, Malaysian Borneo. Forests in DFR had been selectively logged in the 1970s (Lagan et al. 2007). DFR was logged again with RIL from the 1990s in contrast with the surrounding areas which were harvested by a more destructive, conventional logging method. Thus, the forests in DFR can be divided into the following three types as the old-growth forests in DFR without any logging records after the 1970s logging, the forests logged with RIL after 1996 in addition to the conventional logging prior to 1996, and the forests continuously logged with the conventional method (Aiba et al. in Chapter 3).

***Diversity of wood density***

As for the dipterocarp trees, a commercial classification according to the specific gravity of wood is available based on vernacular names (Wood and Meijer 1964). In Sabah, dipterocarp trees were classified as Seraya (including genus *Shorea* and *Parashorea*, approx. 0.50 g $cm^{-3}$ in specific gravity), Selangan Batu (sect. *Shorea* and *Neohopea* of genus *Shorea*, approx. 0.80 g $cm^{-3}$ in specific gravity), Kapur (genus *Dryobalanops*, approx. 0.70 g $cm^{-3}$ in specific gravity), and Keruing (genus *Dipterocarp*, approx. 0.75 g $cm^{-3}$ in specific gravity). We followed the vernacular classification by Wood and Meijer (1964) in our analysis. For the analysis of wood utilisation, and the changes of the frequency distribution of wood density in relation to harvest intensity, data of specific gravity of wood were obtained from Wood and Meijer (1964), Burgess (1966) and Suzuki (1998) (including sapling data), and unpublished data by Seino. We applied those density data to the observed species in Deramakot Forest Reserve in the research plots described by Aiba et al. (in Chapter 3).

***Historical background of forestry in Sabah***

Historical background of forestry in Sabah was examined from literatures, official reports, and technical documents (Sabah Forestry Department .1989; 2003; Forest Research Institute Malaysia 2001).

## Results

***Historical background of timber production in Sabah***

The first commercial logging in Sabah was started in around 1895 by a UK enterprise, and the Forest Bureau in Sandakan was set up in 1915. Since then, the commercial harvest of forests in Sabah has been developed to a fuller scale. Main mode of the logging at the earliest time was axe cutting of trees and wood transportation was conducted by human power, horse, and rafting. As these methods depended on human power, those trees which were low in specific gravity of wood were preferentially logged due to the limitation of transportation technology and labour. Therefore, harvest was limited to the neighbouring districts of a town and riverside (Sabah Forestry Department 1989). There is a local terminology for this type of logging called “Memingel” in a traditional village in a river bank of Sabah. Memingel is a traditional wood transportation method – the logs cut by an axe on a small scale in upstream forests are naturally transported to the downstream village by floods during a wet season. Illegal encroachments using this method can also occur (Kitayama personal communication).

The amount of harvested wood in Sabah was increased by the major lumber companies especially after the World War II. After the introduction of tractor and mechanical equipments such as trucking, and the establishment of large-scale woodland path and logging road network, a large amount of logs was carried from the forests in central part of Sabah. This was accelerated especially after the

World War II. Moreover, it became comparatively easy to carry trees that were high in specific gravity of wood and a large amount of logs was harvested by improved techniques utilizing chainsaw and motor lorry. The harvest impact and deforestation pressure became higher by increased mechanization with heavier wood increasingly harvested (Sabah Forestry Department 1989; Forest Research Institute Malaysia 2001).

***Differences of specific gravity of wood***

Fig.1 shows the differences in the frequency distribution of stems for the specific gravity of wood among different logging impacts in Deramakot. The frequency distribution of the specific gravity of wood for the tree species in the natural lowland forest is shown by the normal distribution that has the average value of 0.57 g $cm^{-3}$ in agreement with Turner (2001). Mean specific gravity of individual stems was 0.67 g $cm^{-3}$ in old-growth forest, 0.62 g $cm^{-3}$ in forest harvested by RIL, and 0.49 g $cm^{-3}$ in forest harvested by conventional method, respectively.

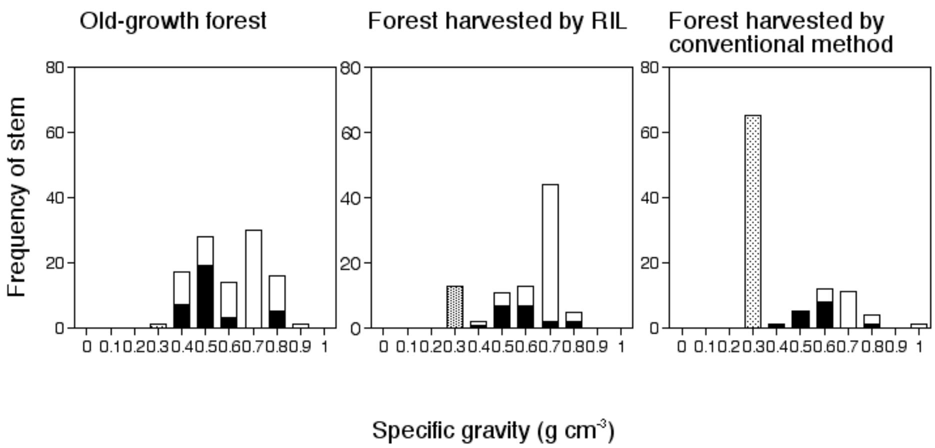


**Figure 1.** Comparison of the frequency of stems in the classes of the specific gravity of wood among different forest managements in Deramakot Forest Reserve. Closed, shaded, and open bar indicate specific gravity of Dipterocarpaceae, *Macaranga* of Euphorbiaceae, and the other tree species, respectively.

Fig.2 shows the differences of frequency distribution of species number for the specific gravity of wood among different logging impacts. Frequency distribution of the specific gravity of wood was not different among logging impacts (Kolmogorov-Smirnov test, $P > 0.05$). When specific gravity was weighted by species number, mean specific gravity was 0.64 g $cm^{-3}$ in old-growth forest, 0.64 g $cm^{-3}$ in the forest harvested by RIL, and 0.67 g $cm^{-3}$ in the forest harvested by conventional logging method.

Mean specific gravity of the major species of Dipterocarpaceae varies greatly; Seraya group, *Shorea domatiosa* (0.50), *S. macrophylla* (0.50), *S.gibbosa* (0.57), and *S. fallax* (0.56); Kapur, *Dryobalanops lanceolata* (0.69); and Keruing, *Dipterocarps kerri* (0.69 g $cm^{-3}$, specific gravity). On the other hand, average specific gravity of the pioneer species of genus *Macaranga* (Euphorbiaceae) was low; *Macaranga conifera* (0.40 g $cm^{-3}$, specific gravity), *M. hypolueca* (0.33), *M. gigantea* (0.36), and *M. pearsonii* (0.39). Logging impact resulted in the increase of the abundance of *Macaranga* trees that are characterized by light wood (approx 0.30 g $cm^{-3}$ in specific gravity) and associated fast growth with their preferential establishment on heavily disturbed area.

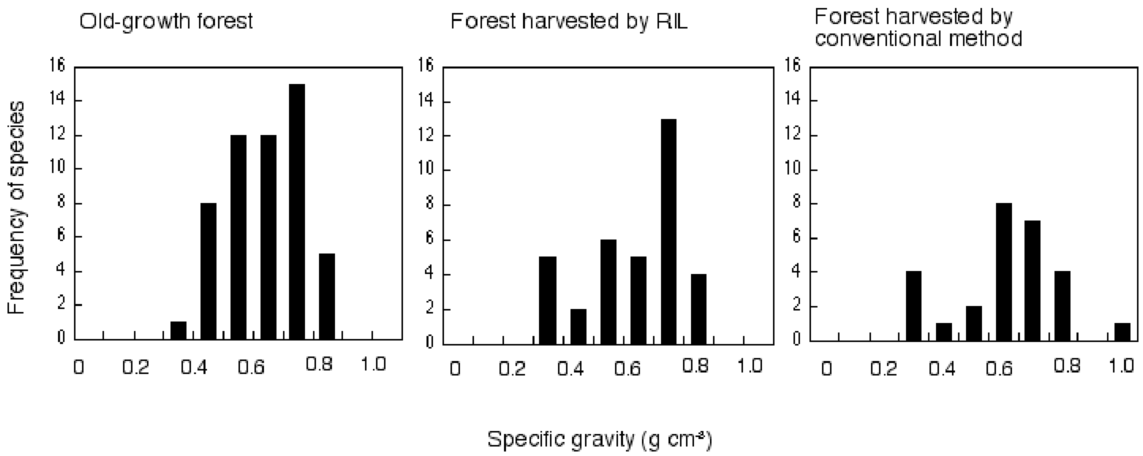


**Figure 2.** The comparison of the frequency of species in the classes of the specific gravity of wood among different forest managements in Deramakot Forest Reserve.

## Discussion

Results from the frequency of stems in the classes of the specific gravity of wood demonstrate the dominance of light wood in the conventionally logged forest primarily due to the dominance of *Macaranga* (Fig. 1). In the old-growth forest, dipterocarp trees of comparatively low specific gravity (light-wood, e.g., Seraya) accounted for roughly 30% of the total basal area, and those of high specific gravity (heavy-wood, e.g., Selangan Batu, Kapur and Keruing) accounted for roughly 10-20% of the total basal area in the Deramakot Forest Reserve. An appropriate logging plan is needed to control the resource depletion of such heavy-wood species. The heavy-wood trees were sparse in their population probably reflecting past harvest and the slow recovery due to the slow growth of heavy-wood species in the forest harvest by the conventional logging. Suzuki (1998) discussed relationship between specific gravity of wood and growth traits. Most of light-wood trees were characterized by fast growth, while heavy-wood trees were characterized by slow growth. Light-wood trees tend to bear a smaller number of vessels with large pore area and heavy-wood trees tend to bear a larger number of vessels with small pore area (Santiago et al. 2004). Santiago et al. (2004) conclude that fast-growing trees needed a large amount of water for photosynthesis and that they sacrificed wood density for hydraulic transportation of water.

Currently, the heavily logged forest outside Deramakot Forest Reserve has the species composition with the dominance of light-wood trees as a result of modern forest practice (Fig. 1). The advancement of the modern technology has lead to the simplification of ecological traits of species such as specific gravity of wood. The usage of Dipterocarpaceae timber is shown in Table 1. The usage is different depending on their wood specific gravity.

The timber with a much greater specific-gravity of wood (heavy wood) such as Borneo ironwood (*Eusideroxylon zwageri*) of Lauraceae is also available and it is used for different purposes such as pillar and roofing tile. On the other hand, the timber with much lighter gravities has not traditionally been used. For instance, the timber of *Macaranga* has no commercial importance. However, the light-wood species that have not been used commercially in the past are being utilized in recent years. The commercial utilization of a pioneer tree *Neolmarckia cadamba* of Rubiaceae is one of such examples (Sabah Forestry Department 2003). *Neolmarckia cadamba* has a light specific gravity and is used for packing materials/boxes. Human exploitation nearly depleted the timber resources of moderate and heavy wood and lead to a diversified use of light wood.

Table 1. Timber use of Dipterocarpaceae common in Sabah.

| Type of wood | Specific gravity ($g\ cm^{-3}$) | Purpose | Local classification based on wood |
|---|---|---|---|
| Heavy wood | 0.72 – over | Constructional timber<br>Wharf decking<br>Flooring interior<br>Etc. | Keruing<br>Kapur<br>Selangan Batu |
| Light wood | 0.48 – 0.72 | Flooring interior<br>Plywood<br>Interior fitting<br>Etc. | Seraya |

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# Broadleaf Tree Plantation by the Fishermen in Yakushima Island

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## Introduction: the tree planting movement by fishermen

In the 1990s, forest plantations by fishermen were often reported as topical incidents in Japan. Such an activity was also implemented in Yakushima Island. The festival for the plantation was held during 3 years from 1996 to 1998. Over ten thousands of young trees, several kinds of broadleaf trees, were planted covering 5.6 hectares of the national forest where the trees had once been logged. The site is called "the Forest of *Yaku-saba* (Spotted mackerel)". It was the obvious decrease of fishery resources that motivated Fishermen's union to the plantation in the island supposedly rich in "nature".

The Plantation by the oyster farmer at Karakuwa town of Miyagi prefecture was the critical momentum which propagated this movement throughout the nation. The Oyster farmer in the Moune Bay started planting the broadleaf tree, e.g. fagaceae (*Buna*), at the upstream of the Oo River from 1989. Before long, similar activities were taken place across the country, subsequently the integrated resource management has been discussed among the agriculture, forestry and fisheries industry at the regional scale (Tutatani, 1998).

Once in the postwar years of the recovery and following the period of high economic growth in the 1960s, the logging and the plantation of conifers from broadleaf trees were operated in the nationwide scale with the high demand for building materials. Meanwhile, the broadleaf tree became less valuable with the decreasing demand for fuel wood, as the energy revolution progressed. Today, fishermen re-appreciate the broadleaf tree because of its positive effect for fishery resources. These effects have long been known by the people. Such forests which attract fishes are called Uotsuki-rin (魚付き林) and have been existed from the Edo period and protected from cutting. Though further scientific research is required to explain the detail mechanism, functions of the forest, such as supplying nutritional substance into the sea or controlling the outflow of soil and rainwater were widely recognized.

On the other hand, from the stand point of the ecosystem conservation, the coordination among a sort of the cooperatives such as farmers, fishermen and forest owners are encouraged (Tutatani, 1998). Such a social linkage between forest resources and fishery resources which might affect each other are important but yet to be scrutinized.

Exceptionally, the study of Karakuwa town's case indicated the existence of the local background in such conservation activity. The critical factor is the project of the dam construction in progress at the upstream of the Oo River at that time. The fact that the infrastructure development possible to segmentalize the ecosystem urges people to such a conservation movement is significant.

Though it implies the significance to discuss sustainable use of natural resources from the aspect of social linkage, these earlier studies are not accumulated so many enough to develop a kind of theory for explaining the effect between two resources system. So in this study I clarified the context in which the fishermen go beyond their familiar territory of fishery resources to manage the resource system including the forest. For that, first I described the history of the regional fishing industry in Yakushima Island, focusing on the catch of mackerel. Second, I reviewed the cut of the broadleaf trees from the national forest in the past 50 years. Also I introduced some opinion of the local people about this planting. Then, I concluded that fisherman is the one of the actors who recognizes the value of the broadleaf tree. For the forest to remain valuable, fishery resources should be jointly managed in an integrated way in a specific circumstance. The management and the use of diverse fishery resources may be one approach to support the diversity of the forest.

## Brief summary of Yakushima Island

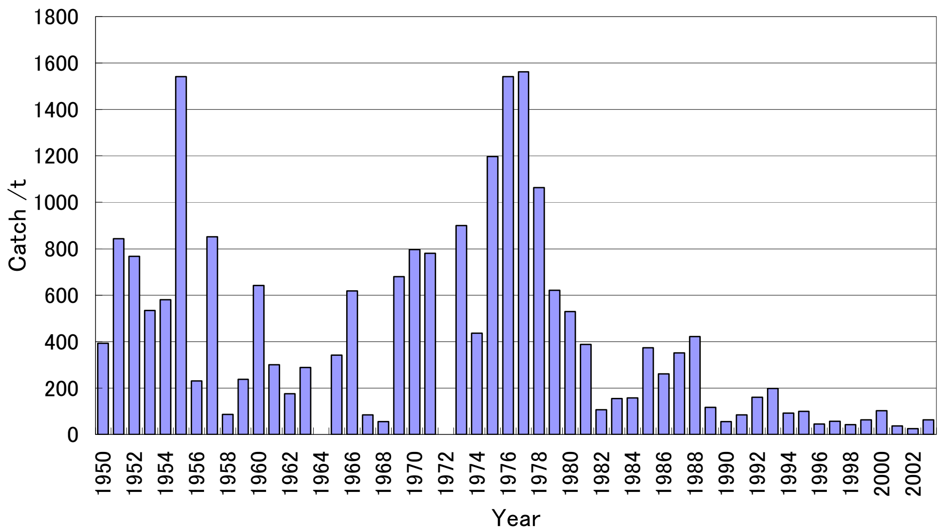
There exist two administrative districts in Yakushima Island, Yaku town and Kamiyaku town. The socioeconomic conditions are different in each district within the island. It partly comes from the difference of the natural conditions, e.g. the marine products. In Kamiyaku town located in the northern part of the island, people catch spotted mackerel in the fishing ground off the island. Isso, one of the villages in Kamiyaku town, had long been the main fishing port along the history of the island. On the other hand, in Yaku town located in the southern part, they catch flying fish in the Tane-Yaku canal. Because the plantation mentioned above was carried out by the Fishermen's union of Kamiyaku town, this study focused on this district.

## The decrease in the catch of Spotted Mackerel (*Gomasaba*)

Fig.1 shows the catch of mackerel from 1950 to 2003. Several characteristics can be mmediately pointed out. First, the catch is inconstant and seems to have several peaks. Second, the ecreasing trend in recent years is remarkable. After the catch marked the highest amount around 1977, it decreased sharply. In contrast, the total catch in Japan from the East China Sea has kept around 50,000 ton with yearly fluctuation. The catch fluctuation depends on two factors under the constant fishing effort, the population size, and the migration and the immigration of mackerel in the fishing ground. Even in consideration for the lowering of fishing effort as the result of aging of fishermen and depopulation, the decreasing fishery stock is serious problem to the fishing industry of Kamiyaku town. The plantation by the fishermen in Yakushima Island was carried out from 1996. In this term the catch kept decreasing without the tendency of recovery. Not only mackerel but other species living in the coastal zone are also decreasing. To realize the background of this drastic change in the catch, the local history was described in detail below.

The Fishing industry in Kamiyaku town has developed based mainly on fishing bonito, mackerel and flying fish. Until the middle of the Meiji period, bonito was the dominant target. The number of bonito fishing vessels had been about 50 in the beginning of Meiji period. Mackerel fishing became a substitute for bonito around 1900 because the fishing ground moved away off the island. The competition against the vessels from the main land also made it difficult to maintain. The fishing of mackerel had developed successfully with the motorization of vessels. The number of the power-driven vessels increased from 36 in 1926 to 80 in 1933 (Committee of Kamiyaku town history 1984). Around 1932, it was told that fishing ground shifted to near the island, and the catch of mackerel became active again. In this term, the amount of dried mackerel production was also increasing. There was the factory which produced about 4,500 ton in a year at this time. We can know that the annual fish catches were periodically changing since a hundred years ago.

Fig.1 The transition for mackerel catch in Kamiyaku Town




In the Post war period, the fishing industry recovered against the background of food scarcity. The total amount of the fish catch in Kamiyaku town marked its maximum (2402.5t) in 1955. Also the population and the number of vessels increased in this period. But soon after the middle of the 1950s, the catch dropped sharply. It is considered that many vessels from the mainland gathered around the fishing ground off the island and the fishery stock deteriorated. It is pointed that the difference of the fishing method is the factor. As compared with the pole-and-line fishing carried out by the islanders, the outsider operated by the seine fishing. The motorization of the vessel and the improvement of the equipment became the disadvantage for the islanders. The end of the regulation toward the fishing area in 1952 was one of the factors that made this area very competitive.

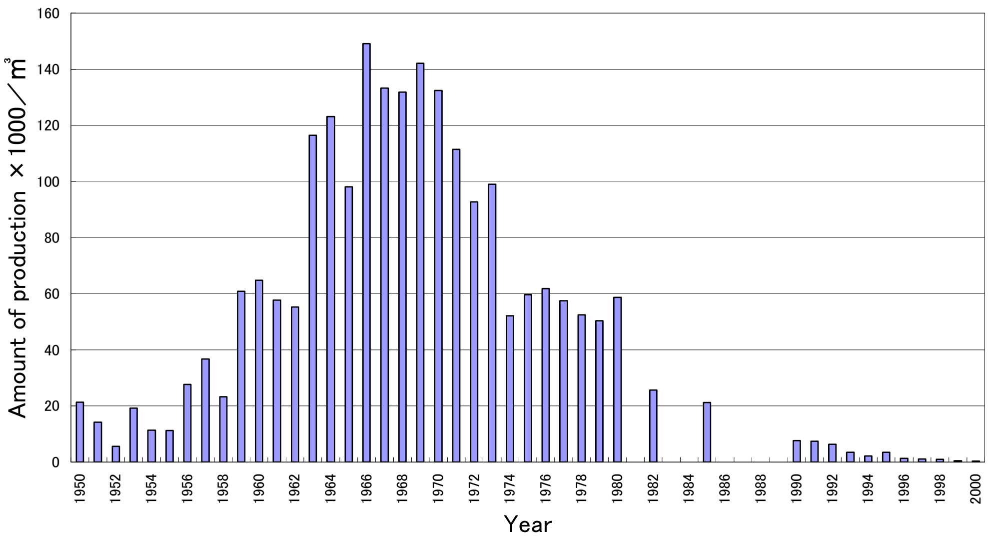
During the period of the economic growth, the catch level stayed unstable, together with the decrease of the labor. From around 1955, the number of the people working away from the island started increasing. The number of the fishermen which increased over 600 in 1955 decreased down to over a hundred until 1975. The fishery industry which was one of the important means to earn cash was noticeably in decay during the economic growth. Against the background of the decreasing population and catch, the modernization of the fishery was in progress. The size of the vessel was getting larger and the equipment improvement was pursuit to rationalize the management. Before that, mackerel fishing is limited with the vessel condition. The increase in the catch experienced from 1970 owed partly to the investment toward the machinery and equipment. At the same time, the oil shocks of the 1970s lead to the concentration of fishing effort in the coastal and offshore fishery. This trend was also backed up by the decay of the deep-sea fishery, following the setting of 200 nautical miles economic zone. These factors are considered to affect the resource stock.

## The transition of the Broadleaf Tree Logging in the National Forest

Figure 2 shows the amount of broadleaf tree yields from the national forest. Soon after the end of the war, the operation restarted from 1946, the government enacted the legislations and planed the program to meet the sudden expansion of the national needs for timbers. The yield started increasing especially after 1960s and marked its maximum during the late 1960s. This production increase was followed by the establishment of the public corporation to manage the conifer plantation, and the private company to product the raw material for pulp utilizing the broadleaf woods from the national forest.

In this term, the broadleaf tree was considered as “low quality” and put under the operation of full-scale logging. The effect of this operation can be known by the interview of the elder. When it rained, the muddy stream induced by the clear cutting had colored the mouth of the river in red. It is pointed out that the disappearance of “jiki-tobi”, the flying fish which periodically immigrate to the coast to spawn, is attributable to the deterioration of the forest environment.

Fig.2 The transition for broadleaf tree production from the national forest




Source: Forest management office data

## Forest and the Fisherman

Figure 1 and 2 indicate that the forest and fishery resources have experienced drastic disruption by the economic activity. But the mutual relation between mackerel catch and the amount of the broadleaf tree logging are not obvious. In fact, one interviewee recognized the positive effect of the broadleaf tree toward fishery, but he doubted its effect toward mackerel which is not inhabitant ashore.

Together with the natural fluctuation, current and water temperature variation, over fishing are supposed to be the critical factor to the decrease of the mackerel catch. The decrease of the man power is also one factor affecting the catch. Additionally, the import of the fish decreases the price of domestic fishes. Due to such circumstances, the fishermen directed their attention to the coastal fishery rather than the offshore fishery.

To keep the forest valuable, it is critical to retain the human resource supporting the ecological function. Fishermen are one of the stakeholders who regard the broadleaf tree valuable. The diversity of the stakeholders, especially those who live on the eco-system might keep the diversity of the forest. For that, fishery resource management is essential to forest resource management in Yakushima Island. As the local fishermen know the complicated factors existing in the background of the mackerel decrease, integrated resource management is suitable idea in such a circumstance.

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# The Significance of Ecosystem Services for the Livelihood of Local People in Sarawak

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## Introduction

Ecosystem services provide many benefits for human beings. In this paper, I focus on the provisioning services, and try to show how it is significant in local people's livelihood. Especially I focus on the food services and its utility for income.

Over the past half-century, the ethnic groups living in inland areas of Borneo, Malaysia, have experienced great environmental changes resulting from large-scale logging. These people, who had previously led a nomadic life in the forest, were forced to settle and turn to hill paddy cultivation (Rousseau 1990).

The common assumption for the displaced hunter-gatherers is that as hunting-gathering activities have declined, poverty has risen due to maladjustment to farming (Hong 1990). But in these previous studies, the significance of the forest resources such as wild plants and animals for their livelihood was not mentioned empirically. So, I try to make clear these points.

## Study site

The study area is the one of the former hunter-gatherer community, located in inland area in Sarawak. The village sea level is about 85m and surrounded by mountains. The forest around the village is dipterocarp forest.

They are originally nomads, dependent on the wild sago palm, they began to settle in villages and undertake hill paddy cultivation in the 1960s, acting on a government policy.

## Methods

This participant-observation study was conducted for about 11 months from January 2004 to May 2007 in the village. I investigated subsistence activity, mainly by recording activity times and identifying and measuring animals and plants they got. The dietary survey was conducted in one household and included a questionnaire and record of daily food consumption, number of meals, and meal contents. For cash income, I recorded the forest product for sale in the market, the number of sales, and their income from these sales.

## Subsistence activity

Their subsistence activities now, contain four kinds of activities, hunting of wild animals, fishing, gathering of wild plants and farming. The farming was introduced according to government projects, such as hill paddy cultivation project in 1960s or vegetable gardening project in 1990s.

Nowadays, they use guns mainly for hunting but the elder generation like to use blowpipe, hunting spear also, and younger generation like to use hunting trap. These are the common technique in other hunter-gatherers in Borneo (Puri 1997). They mainly use casting net or gill net for fishing, and sometimes use 2 types plated rattan fish traps or angling. However men did the hunting and fishing, gathering and farming were done by both of men and women. Gathering wild plants or fruits from the forest was also important for their subsistence. They cultivate not only hill paddy but also some vegetables, like maize, tapioca or long beans in the garden near the village.

Historically, various environmental changes have altered their subsistence methods. In the midst of such environmental change, they have learned to use devices such as catch nets, hunting guns and gill nets, as well as developing more varied hunting and gathering of forest resources.

To obtain food resources, they spent most of their time hunting and fishing, which were regarded as the most important for food. Compared to hunting and fishing, they speared little labor on cultivation. Hunting was more important than fishing, but if they did not get any animals, they often turned to fishing. The same relation held between fishing and gathering. If they did not catch enough fish, they gathered wild plants. Cultivated plants were used only when hunting, fishing, and gathering yielded no food. Thus, their food values place hunted prey at the top and cultivated plants at the bottom.

This can be expressed in other word. Food obtained from hunting and fishing is called *bao* or *lelu ayok* (“big side dish”), whereas food from gathering and cultivation is called *lelu* or *lelu ici* (“small side dish”), which demonstrates the importance attached to these food items.

## Significance of forest resources as foods

During June–August 2004, the villagers used 149 types of animals and plants as food. Wild plants comprised the largest percentage, with 67 species. Other foods included 28 fish, 17 mammals, 16 cultivated plants, 9 reptiles, 2 amphibians and 1 insect species (see table 1).

**Table1.** Food resources appeared in 139meals in 47 days in June to August 2004 at the A village

| Category | Times of Use |
|---|---|
| Wild plants | 67 |
| Fish | 28 |
| Mammals | 17 |
| Cultivated plants | 16 |
| Birds | 9 |
| Reptiles | 9 |
| Amphibians | 2 |
| Insect | 1 |
| Total | 149 |

I observed 139 meals, comprising 471 dishes, from June to August 2004. Rice totaled 60% of staple foods, whereas sago palm, the former staple, had a low 23% use rate (see Table 2).However, sago palm use was more varied, appearing in ten dishes, whereas rice was used in only three recipes. In particular, sago palm was preferred in a culturally important dish with wild boar meat. The self-support rate of sago palm was 40%, compared to 30% for rice.

For side dishes, the self-support rate was 100%. The use rates were wild plants, 37%; fishes, 34%; cultivated plants, 15%; and animals, 14% (see Table 3).

**Table 2.** Variety of staple food (In 139 meals consisting of 471 dishes)

| Category | Times of eat |
|---|---|
| Rice | 83 |
| Sago | 33 |
| Bananas | 13 |
| Cassava | 6 |
| Taro | 2 |
| Yam | 2 |
| Noodles | 2 |
| Total | 141 |

**Table 3.** Variety of non- staple food (In 139 meals consisting of 471 dishes)

| Category | Times of eat |
|---|---|
| Wild plants | 102 |
| Fishes | 95 |
| Cultivated plants | 41 |
| Animals | 38 |

Although few mammals were eaten, red meat was regarded as important. The use of animal and vegetable foods was almost equal. Wild plants exceeded cultivated plants, both in number and in kinds of use.

In the total diet, 63% of foods came from hunting-gathering, 21% from farming and 16% from purchases. The cash for purchasing food was earned from selling forest resources obtained by hunting-gathering. Thus, on the whole, nearly 80% of foods were supplied by hunting-gathering.

## Significance of forest resources as income

For them, fishing and gathering wild plants remain central for subsistence, food, and cash income. Then I'd like to try to make clear how these resources are important in relation with market economy. The nearest local market was located about 4 km from the village, or 1.5 hours on foot.

According to their income survey, they earned most of their income by selling forest products such as fishes or wild plants. They earned much of their cash income by fishes, wild plants, and baskets or mats made of rattan (see table 4).

Although they have been settled down and hill paddy farming for 40 years, they still rely on hunting and gathering of forest products provide most of their cash income.

## Conclusion

Among them, hunting-gathering is important both for food and cash income. Even after 40 years of farming experience, the main subsistence activities remain hunting and fishing. In all, 70% of their diet was supplied by hunting-gathering and 20% by farming. Wild plants were more widely used than cultivated plants, both in number and in kinds of use.

**Table4.** Sources of cash income (three months from June-August 2004)

| Category | Income (RM) |
|---|---|
| Fishes | 643 |
| Petai bean | 170 |
| Baskets or Mats of Rattans | 165 |
| Durians | 136 |
| Fishing trap of Bamboo | 90 |
| Flog | 32 |
| rattan shoots | 26 |
| Huts made of palm | 20 |
| Palm leaf | 16 |
| Total | 1298 |

* 1RM=33YEN

Although they have settled into village life and are influenced by the market economy, they have adapted their hunting-gathering activities to the market economy. By selling forest products, such as fishes or wild plants, they achieve a steady income. Thus, hunting-gathering has not declined but is, in fact, more focused. This differs from the usual hypothesis, that hunting-gathering by former nomads has declined in favor of farming.

They began the practice of shifting cultivation more than 40 years ago and also engage in periodic wage labor. However, the use of wild plants and fishes predominates over market-economy activities. Because of their proximity to a market, they earn most of their cash income by selling fishes and wild plants and fruits, which are also important to them as food. Thus, they continue hunting-gathering through their engagement with the market economy.

## Acknowledgements

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# Mushroom Utilization by the Iban in Eastern Sarawak, Malaysia

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## Introduction

Fruiting bodies of macrofungi (mushrooms, stinkhorns, bracket fungi etc) are used not only as food products but also for traditional uses (Spooner and Roberts 2005). It is well known that the dried tissue of one of the bracket fungi, *Fomes fomentarius*, is used as tinder in Europe. In northern parts of America and Europe, other traditional uses of fungi are also seen, such as dyeing, razor stops and perfume. Not only in boreal and temperate zones, but also in the tropics, local people eat wild mushrooms, as seen in reports from, for example, Guyana (Henkel et al. 2004), Mexico (Jarvis et al. 2004; Ruán-Soto et al. 2006), Venezuela (Zent et al. 2004), Cameroon (van Dijk et al. 2003), Ethiopia (Tuno 2001), Zaire (Courtecuisse 1993), Thailand (Desjardin et al. 2004) and Malaysia (Anderson et al. 2003), and also use them for other purposes, such as medicine (Zent et al. 2004).

The local peoples of Borneo have a tradition of utilizing forest products. Christensen (2002) reported that the Iban, the most populous ethnic group in Sarawak, use and give names to 17 species of fungi. Because more than 100 aphyllophoralian species (bracket and shelf fungi, not including agaric mushrooms) are found in our study area, Lambir, Sarawak (Yamashita unpublished data), the large part of fungal use by Iban people is still uncovered. In this study site, Iban villagers cut and burn secondary forests to establish rice fields, and leave the fields for fallow or plant para rubber seedlings on the fields after 1 or 2 years of rice cultivation (Ichikawa 2004). The fungal community structure differs according to type of land use (Yamashita et al. 2007), thus I expected that there would also be differences in the importance of a forest type from the view of fungal use. In this study, I aimed to reveal the recognition and utilization patterns for macrofungi by Iban people.

## Methods

From 27 December 2005 to 13 January 2006, I sought fruiting bodies of macrofungi in 29 forest stands within 30 km of Rumah Chabu, Lambir, Sarawak for about 3 hours daily, working with an informant. The informant was an Iban local villager, a man who was about 60-years old and lived in Rumah Chabu. Because he knew much about plants in this region, I expected that he would have substantial information about macrofungi. Study stands included fallows, an oil palm plantations, rubber plantations, isolated primary forest, and primary forest. In addition, we collected all the conspicuously large macrofungi at the roadside or rice field. When we collected each fruiting body, I asked him in Malayan to tell me the Iban name and how it was used. After that, I confirmed the spelling with four Iban villagers who understood English. The fruiting bodies collected were identified to determine the species and preserved as dried specimens.

## Results and Discussion

***Local knowledge and utilization***

A total of 171 fungal fruiting bodies of 49 Iban species were collected (Table 1). Twenty-five species are used as food. Kulat gelang (*Lentinus sajor-caju*) seems to be popular and Kulat sawit (*Volvariella* sp.) is sold in Miri city. Kulat kerang (*Schyzophyllum commune*), which forms rather tough fruiting body, is widely distributed around the world, and some other local ethnic groups, such as the Majangir in Ethiopia, also eat this fungi (Tuno 2001). Furthermore, 10 Iban species were used for purposes other than food. Seven Iban species of bracket fungi, e.g. Kulat batang, Kulat Rajang, Kulat kering and so on (*Earliella scabrosa*, *Ganoderma australe*, *Trametes elegans* and so on) were used as mosquito repellents by putting the fruiting bodies in flames and fumigating. A red-coloured shelf fungi named Kulat dunggul manuk (*Pycnoporus sanguineus*, *Stereum ostrea*), a stinkhorn named Kulat butuh apaisali (*Dictyophora* sp.), and Kulat tusu kamba (*Xylaria* sp.1) are used as medicine for sick fowl by soaking the fruiting bodies in water and letting the fowl drink the water. Some coral fungi, Kulat punas (not identified), are used as medicine to increase fertility by rubbing the fruiting bodies into the lower abdomen. However, nowadays Iban people in the study area normally use fungal fruiting bodies only as food.

***Latin names and Iban names***

Thirty-nine Latin species were recognized, although the informant named 49 Iban species. This does not mean that Iban people recognize fungal fruiting bodies in detail, because some Iban species obviously include many Latin species. For example, Kulat ipuh contains *Coprinus* sp., Boletaceae, and other agaric fungi. The informant gave the Iban name “Kulat ipuh” to mushrooms that he does not know or eat.

Among 18 Iban species that were observed more than 3 times, 6 Iban species corresponded to one Latin species and rest of them include a number of Latin species. In addition, one Latin species did not always correspond to a single Iban species. For example, Kulat batang includes 11 Latin species. One of these 11 Latin species, *Earliella scabrosa*, was named as Kulat batang, Kulat kering and Kulat rajang. It is not a surprise that Iban people lump many Latin species of bracket fungi into one Iban species, because microscopic traits are very important in order to identify most of the above-mentioned bracket fungi to the Latin species level. On the other hand, *Cookeina* spp. was always named as Kulat mangkok, *Xylaria* sp.2 as Kulat tusu babi, and *Lentinus sajor-caju* as Kulat gelang. The shapes of fruiting bodies of *Cookeina* spp. and *Xylaria* sp.2 were conspicuously different from other fungi. For example, *Cookeina* spp. is named as Kulat mangkok, which means cup-shaped mushroom. In addition, more than 40% of Iban names were based on traits and similes of morphological traits of fungal fruiting bodies. *Lentinus sajor-caju* seems to be one of the most popular fungal foods. These points suggest that recognition of fungal fruiting bodies by Iban people is based on morphological character, and that fungal fruiting bodies which are not important species are grouped into complexes such as Kulat ipuh, Kulat batang and so on.

***Effect of land use types on edible and other utilized fungi***

The average number of edible fungal species increased with decreasing human activities, although the number in oil palm plantations was higher than the number in isolated primary forest (Fig. 1). The number of Iban species of fruiting bodies with traditional uses was high in isolated primary forest and primary forest, which seemed to reflect the spatial distribution pattern of bracket fungi among forest types (Yamashita et al. 2007).

An oil palm plantation provided economically valuable fungi, Kulat sawit (*Volvariella* sp.). However, other forest types did not always provide economically valuable fungi. We did collect some edible and economically valuable fungi from many forest types, but without a regular pattern emerging. In addition, the informant said that the Iban do not go into forest only to get mushrooms because it is very difficult to know when and where they appear. This indicates that no specific forest type is particularly valuable from the perspective of production of fungal fruiting bodies.

***Further implications***

Compared to other tropical areas, the study area is characterized by the lack of a dry season. It is well known that the appearance of fungal fruiting bodies is stimulated by rainfall (Yamashita and Hijii 2004). Thus, the lack of a dry season makes it hard to predict when and where fungal fruiting bodies will appear. Tuno (2001) also pointed out the importance of predictability of fungal appearance by stating that the Majangir in Ethiopia also collect their favorite fruiting bodies when they come across them, because of absence of clear seasonality. It is possible that low predictability in the appearance of mushrooms affects the Iban culture of fungal utilization.

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**Table 1** List of collected mushrooms and other fungi

| Iban name | Frequency | Food | Use | Meaning of Iban name |
|---|---|---|---|---|
| Kulat ampuh bah | 7 | 7 | - | ampu(o)h, flood; bah, come on or |
| Kulat batang | 15 | - | 10 | a log |
| Kulat batang merah | 1 | - | 1 | batang, a log; merah, red |
| Kulat batang repuk | 1 | 1 | - | batang, a log; repuk, bad |
| Kulat bulu | 5 | 5 | - | hairy, feather |
| Kulat burak | 7 | 7 | - | white |
| Kulat butuh apaisali | 1 | - | 1 | butuh, penis; Apai Sali, Father of Stupidity |
| Kulat dunggul manuk | 3 | - | 2 | dunggul, a cock's comb; manu(o)k, chicken |
| Kulat gam | 3 | - | - | molar teeth |
| Kulat gelang | 3 | 3 | - | a large bracelet |
| Kulat gupung | 1 | - | - | gupu(o)ng, a bouquet, large bunch of fruit |
| Kulat ikan | 4 | 4 | - | ikan, fish |
| Kulat ipuh | 9 | - | - | ipuh, poison |
| Kulat ipuh belalang | 1 | - | - | ipuh, poison, belalang, cobra |
| Kulat jarum | 1 | - | - | jarum, needle |
| Kulat kasut | 1 | 1 | - | kasut, a shoe |
| Kulat kerang | 5 | 5 | - | of rattan or sugar-cane |
| Kulat kering | 6 | - | 5 | strong, tough, hard |
| Kulat kerup | 2 | 2 | - | the sound of biting into or chewing upon |
| Kulat labit manyi | 4 | 4 | - | labit, nest; manyi, bee |
| Kulat lapar | 1 | - | - | lapar, hungry |
| Kulat malam | 4 | - | - | night |
| Kulat mangkok | 7 | 6 | - | a cup or bowl |
| Kulat mangkok bulu | 2 | 1 | - | mangkok, a cup or bowl; bulu, feather, hairy |
| Kulat mata babi | 1 | 1 | - | mata, eye; babi, pig |
| Kulat mayau | 1 | - | - | cat |
| Kulat merah | 2 | - | 2 | red |
| Kulat minyak | 7 | 7 | - | oil |
| Kulat panyun | 11 | 11 | - | a large plant |

**Table 1** List of collected mushrooms and other fungi (*Continued*)

| Iban name | Frequency | Food | Use | Meaning of Iban name |
|---|---|---|---|---|
| Kulat pending chit | 2 | 2 | - | pending, ear; chit, rodent or mouse or rat |
| Kulat pending mayau | 3 | 3 | - | pending, ear; mayau, cat |
| Kulat peril udok | 1 | - | - | peril, scrotum; udok, dog |
| Kulat pik | 3 | 3 | - | no meaning |
| Kulat pinang | 1 | - | - | pinang, the areca palm |
| Kulat punas | 3 | - | 3 | childress |
| Kulat rajang | 7 | - | 5 | epiphytic fern |
| Kulat rambut | 1 | - | - | hair |
| Kulat repuk | 5 | 5 | - | repu(o)k, brittle, rotten |
| Kulat resak | 1 | 1 | - | resak, name of tree (tree species) |
| Kulat rian | 4 | 4 | - | durian |
| Kulat risik | 4 | 4 | - | no meaning |
| Kulat sawit | 1 | 1 | - | oil palm |
| Kulat suntung | 2 | - | - | cuttlefish |
| Kulat tapak lelabi | 2 | 2 | - | tapak, paddle; lelabi, a freshwater turtle |
| Kulat telinga gajah | 1 | - | - | telinga, ear(M); gajah, an elephant |
| Kulat tukul | 4 | - | 1 | tukul, a hammer |
| Kulat tusu babi | 3 | 2 | - | tusu, breast; babi, pig |
| Kulat tusu kamba | 1 | - | 1 | tusu, breast; kamba cf. bunsu kamba, the little |

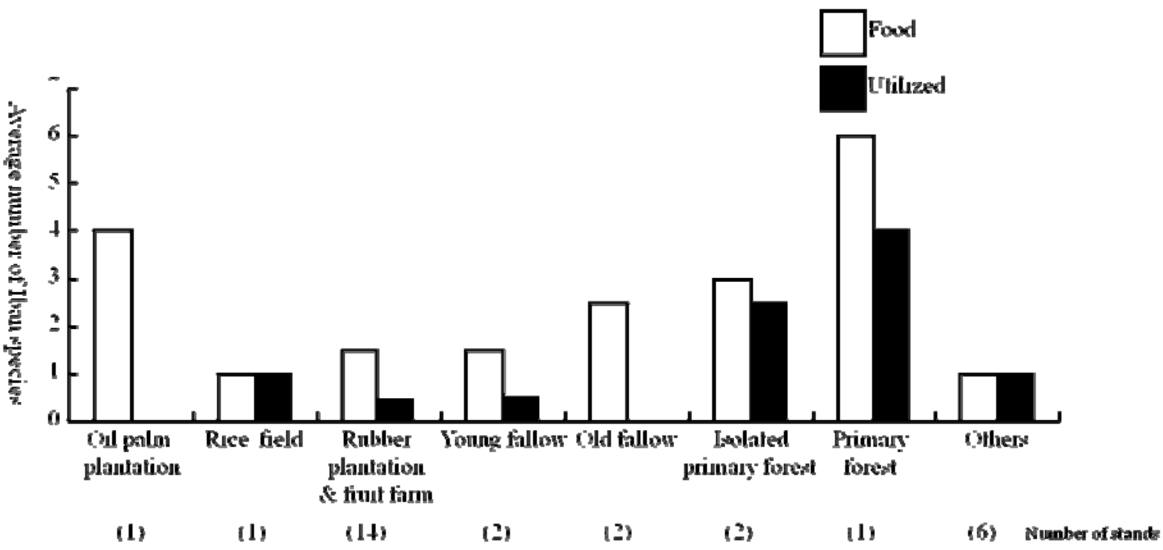


Fig. 1 Number of edible and utilized fungal species in each forest type

# Change of Orang Sungai's Subsistence Activities in the Kinabatangan River Basin in Sabah, Malaysia

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## Introduction

Sabah was once the central area for export of tropical timber. Timber logging, increased from the late 1950s, and timber became the largest exporting good to countries such as Japan. Excess logging led to the decrease of forest. Sabah has recently adopted a significant change in its Forest Policy to implement an export regulation on raw timber and decrease timber exports. Palm oil and crude oil are the current main export goods, but forest products such as plywood and sawn timber still play an important role. The Sabah Forestry Department has worked towards sustainable forest management for the remaining forest and has adopted several forest policies such as the implementation of the Forest Certification Scheme from the late 1990s. The Kinabatangan River is the longest river in Sabah, and its basin was once the central area for timber logging.

In the basin of the Kinabatangan River, the indigenous people of Orang Sungai (River People) have long lived by forest product gathering, hunting, shifting cultivation and fishing. The population of Orang Sungai is approximately 40,000, and they are one of the many indigenous groups that live in Sabah. They have received the greatest impact from commercial logging around the Kinabatangan River as they live in wide areas of the river basin.

There have been many studies on forestry or forest policies in Sabah, the forest policy during the colonial period, the royalty system (Tachibana 2000), and socio-economical studies of the logging system and the timber industry. However, there has been no study to show how involvement in the booms and busts of the timber industry has affected the indigenous people, illustrating the topic from the perspective of these people.

The research area is Village W in the basin of Kinabatangan River, Sabah. Research was done through living in the village and interviewing the indigenous people who had been engaged in timber logging and hearing about their life stories and their involvement in the logging industry.

## Overview of the Research Area

### *1. Location of the Village and the Environmental Background*

Sabah is 73,000 km$^2$ by area, which is 22.3% of the total area of Malaysia. The population is approximately 2.6 million (Department of Statistics, Sabah 2000). The Kinabatangan River which runs through the northeastern part of Sabah State is the longest river in the state at 560 km by length and 16,800 km$^2$ by size of the basin area. The upstream area of the river basin is mainly highlands and mountains covered with forest, and the downstream area is flood plain covered with mixed dipterocarp trees. Many wild mammals and birds can be seen in this area, including orangutans, Asian elephants, and proboscis monkeys (Reza Azmi 1996). However, the environment has changed dramatically due to the recent forestry and oil plantation expansions.

The research area of Village W is located in the midstream of the Kinabatangan River. It is located at the south of Bukit Garam, where the district office of Kinabatangan is located. From Bukit Garam, it is a 30 minutes car drive towards Tawau, turning west into the farm road in the oil palm plantation and driving 60km further. It is now possible to drive directly into the village as the oil palm plantation has been expanded to just south of the village in 2004. The only transportation upstream is by boat, and Village K can be reached by 2 hours by a 30 hp boat.

Village W is located in the downstream section of the Kinabatangan River, so floods are not rare. According to the data from the Forest Department, the annual precipitation of this area is the highest in Sabah at 3,000 to 3,500 mm. The average temperature is 27 degrees Celsius, lowest at 23 and highest at 31. Height above sea level is approximately 200 m. The village is located in the lowlands along the river. As for vegetation, *Shorea leptoclados, Dryobalanops lanceolata, and Dipterocarpus caudiferus* are the dominant species. This area is rich in biodiversity. Endangered species living in this area are Asia Elephants (*Elephas maximus*) and Tembadau (*Bos javanicus*). Orangutan (*Pongo pygmaeus*) also live in this area, and deer, pigtail monkeys, and hornbills are several more examples of the animals that can be observed (Sabah Forestry Department 2005).

***2. The Households of Village W***

The people of Village W are Orang Sungai, and many of these villagers are Muslims. There is praying in mosques on Fridays, and the Islamic religion has a great impact on the customs of the village. Houses are built along the river and have raised floors for protection against the frequent floods.

The current activities are timber logging, forest product gathering of sawn timber and rattan, hill rice or vegetable cultivation by shifting cultivation, and fishing. In the village are an elementary school, mosque, and an assembly hall.

There are currently 40 households and approximately 250 people in Village W. Each household owns an individual house. Until Second World War, people used to create simple houses and move for shifting cultivation. In this paper, a household is defined as a group of people who live in one house. There is usually one nuclear family per household, but there are cases where a family lives together with a newly married couple or other close relatives. People began to settle down in the current location from the 1940s, and the construction of the elementary school in 1963 accelerated this trend. The number of households reached a peak as timber logging became more popular, and it has been decreasing since. Since 1999, 13 households have moved out of Village W.

Below is the analysis of data gained from 17 households in Village W. The members of Village W are the heads of households, their spouses, and their children. There are only 4 men whose hometowns are not Village W: Mr. H, age 74, from Paitan, Mr. J and Mr. JM, age 68 and 64, originally from Lemag (current Bukit Garam), and Mr. K, age 24, from Bukit Garam. The oldest 3 came to the village for timber logging and married the women from the village. Mr. K, age 24, is still single and came to the village after his sister married a man from Village W. He has a job in Village W.

The women whose hometown are not Village W moved to the village through a marriage with a man from the village: Ms. A, age 41, from Village A, Ms. B, age 3, from Tawau, Ms. C, age 30, from Bukit Garam, and Ms. D, age 26. More women than men have moved to Village W. Although there are some who are new to the village, the majority of the villagers are originally from the village.

### *3. The Subsistence Activities of the Villagers and their Working Status*

Table 1 shows the working status of the villagers. Villagers are involved in various activities such as shifting cultivation, vegetable cultivation, fishing, and forest product collection. Therefore, these activities have been listed as Kerja Kampung (Work in village). The only public facility in Village W is the elementary school. The only activities which receive a Kerja Tamat (fixed income) are teachers at the elementary school, security guards at the elementary school, and village leaders such as Ketua Kampung and JKKK.

Information about Kerja Kampung was collected from observations and interviews in the village. For agriculture, hill rice cultivation is the main activity, but in 2006, only 2 households planted in that year. Some of the reasons mentioned by the villagers were the flood which occurred earlier that year after 6 years of no flood, the unsettled weather, or the sickness of a family member. On the other hand, many households planted their seeds in 2007. They originally planted 3 times a year, in March, July, and October. It changed to twice a year, in March and July. It has recently become only once a year in July and harvest in October. The crops are sweet rice, non-glutinous rice, red-kerneled rice, and black-kerneled rice. Over 5 types of rice were mentioned in the interviews.

Other households purchase rice from stores. It can be purchased at general stores in the village, but most households purchase at stores in Bukit Garam or Sandakan for more reasonable prices.

Vegetables and root vegetables are usually grown in small private farms around each house. They usually cultivate for 1 to 2 years, and when the soil is no longer fertile, they find a different place, log, burn, and plant again. Some vegetables that can be harvested throughout the year are cassavas, Sayur Manis, eggplants, pumpkins, and sweet potatoes. Some vegetables that are planted twice a year are Sawi, corn, okra, and Kacang Panjang. They feed their families and sell the rest. They sell in the village, or sometimes go to the estate or to Bukit Garam.

In Village W, plantation of rattan and fast growing species are popular. They are currently waiting for the next opportunity to harvest.

Fishing is done within the territory of the village for feeding families and selling. There are various methods, such as using fishing nets and fishing poles, but chemical poisoning and the use of electricity are prohibited. Prices of fish are strictly regulated by the village. The distance to the town is the issue for selling outside the village.

### *4. Education*

Table 2 shows the current status of schooling children and educational background of graduates in the village. A kindergarten is run by an NGO based in Sabah that supports voluntary social development of the local people. It is each parent’s decision to send a child to kindergarten for it is not compulsory education. Before the establishment of the elementary school in 1963, villagers went to the downstream village of Pintasan or Lemag (current Bukit Garam, the center of the district) for education, and many villagers did not have this chance. The elementary school was constructed as a result of the demand from the villagers. Junior high school is only available in Bukit Garam, which is 1.5 hours downstream from the village. One has to stay in a dormitory or a relative's house to attend the junior high school. As shown in the figure, many of the graduates are only elementary school graduates, unable to attend junior high school.

Until the 1980s, villagers had to go to Sandakan for high school, but now it is available in Bukit Garam. Even after graduating from high school, many people stay in the village. Connections are said to be more important than educational background in finding a job in the village. Because of financial reasons, only a few have the chance to go to university. It is becoming more difficult to find a job in the village, and at the same time, jobs in town require a certain degree of educational background.

## Indigenous People in Forest Use and Commercial Logging

The people of Orang Sungai who live along the Kinabatangan River have experienced the booms and busts of large-scaled commercial logging since the 1950s. In order to illustrate the involvement of the people in Village W in forest use, interviews were carried out to research past subsistence activities and the life stories.

### *1. Subsistence Activities before Commercial Logging*

The basin of the Kinabatangan River was famous during the Sulu Period for non-forest products such as aloewood, ivory, hornbill beaks, and bird nests. Until the 1940s, the people were involved in forest product gathering, especially damar (resin) and rattan gathering, shifting cultivation, and fishing.

Before being involved in commercial logging, many villagers were involved in forest product gathering. They had collected damar regularly from trees in the forest such as Kapur (Dryobalanops spp.). Damar was sold to stores of Chinese brokers in Sandakan. As for rattan, there were several types, an example of which was Rotan sega (Calamus caesius).

In shifting cultivation, hill rice was harvested about 2 to 3 times a year. When there was a shortage of rice harvest, the village moved to other land for shifting cultivation. People cultivated sweet potatoes and cassavas around their houses. Houses were built with bamboo and palms, and were easy to build again.

### *2. Subsistence Activities during Commercial Logging Period*

Until the early 1960s, timber logging was done around Sandakan, but in the late 1960s, it expanded to the downstream of the Kinabatangan River as well as to Lahat Datu (Tachibana 2000). The reasons were that land along the Kinabatangan River was relatively flat, and that rivers were used to carry timber. In the 1970s, the area also expanded into the inland, and in the 1980s, the center of timber logging shifted to the upstream of the Kinabatangan River, which was the area with the richest resources. Logging of secondary forest also began, which was mainly in the coastal areas.

It was after the Second World War when large-scaled timber logging began in the basin of the Kinabatangan River. It was in the downstream area of the river where logging first took place.

In the early 1950s, the British Borneo Timber Company acquired the logging concession in the downstream area of Seguliud-Lokan and began to operate. Logging had long been a monopoly of this company, ever since the colonial period. Saws and axes were used for logging, and timber was carried by Kuda Kuda (a large sleigh for carrying logs), and by railways and tramways.

The news of the beginning of the logging in Seguliud-Lokan soon spread to Village W, and many single men from Village W went out of the village to seek job opportunities. The people traveled down the river in a small rowing boat. The jobs given to the villagers were very simple, such as transporting logs, peeling tree bark, or tying up the logs.

According to Mr. U, age 74, who used to be a Kuda Kuda puller, one Kuda was pulled by a group of 8 men. He pulled from 3 to 5 logs in a day. Pay was in accordance with the pulled distance, and this pay was split amongst the members of the group. The more they pulled, the more pay they received.

Long term logging concessions were only allowed to a few companies, but in the 1960s, they were also given to timber companies run by overseas Chinese owners. A company run by an overseas Chinese owner, gained the long term logging concession in the Forest Reserve nearby Village W, and large scale logging was operated from 1956 to 1977.

As new logging camps opened very close to the village, many villagers became engaged in logging, and this gave a tremendous impact on the subsistence activities in the village. The people who had been working in downstream areas also came back to the village to work in the newly opened logging camp.

Kuda Kuda, railways and tramways were used when logging camps first opened, but the work of logging eventually became automated. In mid 1970's, logging companies began using chain saws and tractors for logging, and soon the villagers became involved in such machinery work.

There were also many villagers involved in transporting timber from logging camps to log ponds in Sandakan, being hired by the timber companies. They worked as a captain or as crew of the timber transporting ships. Depending on the water level, one round trip took about 1 to 2 weeks, and depending on the amount of the timber, they took about 1 to 3 trips per month. One boat had a captain, an engineer, and a sailor.

Timber logging decreased in the 1980s as the number of trees decreased. After the 1980s, timber companies operated relatively small scale timber logging.

In the 1990s, the scarcity of resources and the prohibition of log exports by the government led to the closure of many logging camps around the village. As a result, many people moved or began working at the Forestry industry as logging camps moved to the upstream of the Kinabatangan River.

### *3. Current Subsistence Activities*

The exit of the logging companies from Village W had a substantial impact on the subsistence activities of the indigenous people. They can no longer sell fish or vegetables to the logging camps. The opening of the oil palm plantations also had a substantial impact. The oil palm plantations expanded at the south of the village. Some villagers opened small oil plantations, and some villagers are working at oil plantations. The work is relatively tough for the amount of pay, and many have quit.

Other sources of income are scrap metal and rattan collection, fishing, shifting cultivation, but there is a limit to the number of activities. Metal scrap gathering involves searching for and digging up the scrap parts of abandoned tractors from the old logging camps. Scrap was sold to a tauke, and more people began to be involved in this activity from 2004 onwards. The tauke then transported the scrap to Sandakan and sold it to metal factories.

The decrease of wage labor in logging industry led to a significant decrease in the job opportunities in the village. More and more households have moved to the downstream of the Kinabatangan River such as Bukit Garam or Sandakan, where county public offices are located.

## Conclusion

Orang Sungai people had long been involved in shifting cultivation, fishing, and forest product gathering in the basin of the Kinabatangan River in Sabah. When commercial logging began and many logging camps were opened around the village, many villagers became involved directly as logging workers. Villagers also received indirect financial benefits such as by selling vegetables or fish to these logging camps.

The booms and the busts of commercial logging had a significant impact on the subsistence activities of the villagers. The current subsistence activities of the villagers are shifting cultivation or fishing as before, logging of timber from trees that are currently scarce, plantation of rubber trees or oil palms, or seeking new job opportunities in the cities. They are still searching for new subsistence activities in place of timber logging.

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**Table 1**: The Subsistence Activities of Villagers and Working Status

| Job Type | W village F | W village M | Outside F | Outside M | Total |
|---|---|---|---|---|---|
| Kerja Kampung | 22 | 29 | | | 51 |
| House work | | | 5 | | 5 |
| Oilpalm farming | | | 3 | 1 | 4 |
| Imam | | 2 | | | 2 |
| School Safeguard | | 2 | | 1 | 3 |
| Kindergarten Teacher | 2 | | | | 2 |
| Village Leader | | 1 | | | 1 |
| JKKK | | 1 | | | 1 |
| Police Officer | | | 1 | | 1 |
| Elementary School Teacher | | | | 1 | 1 |
| Secretary for Political | | | | 1 | 1 |
| Nurse | | | 1 | | 1 |
| Tourist Guide | | | | 1 | 1 |
| Hotel Cook | | | | 1 | 1 |
| Furniture Sales | | | | 2 | 2 |
| Cars Sales | | | 1 | | 1 |
| Selling Staff at Retail | | | | 1 | 1 |
| Oil Palm Plantation | | | | 3 | 3 |
| OfficeWorker | | | 1 | | 1 |
| Weed Cutting | | | | 1 | 1 |
| Others | 1 | 1 | | | 2 |
| Unknown | | | | 1 | 1 |
| Total | 25 | 36 | 12 | 14 | 87 |

Source: Household Survey by the Author

**Table 2**: Current Status of Schooling Children and Educational Background of Graduates in the Village

| Current Students | Female | Male | Total | Graduates | Female | Male | Total |
|---|---|---|---|---|---|---|---|
| Tadika | 3 | 2 | 5 | No | 12 | 5 | 17 |
| SR1 | 2 | 2 | 4 | SR1 | 0 | 0 | 0 |
| SR2 | 2 | 0 | 2 | SR2 | 0 | 0 | 0 |
| SR3 | 2 | 1 | 3 | SR3 | 0 | 0 | 0 |
| SR4 | 1 | 2 | 3 | SR4 | 0 | 0 | 0 |
| SR5 | 2 | 1 | 3 | SR5 | 0 | 1 | 1 |
| SR6 | 0 | 0 | 0 | SR6 | 11 | 12 | 23 |
| SM1 | 1 | 0 | 1 | SM1 | 2 | 4 | 6 |
| SM2 | 1 | 1 | 2 | SM2 | 0 | 2 | 2 |
| SM3 | 1 | 1 | 2 | SM3 | 3 | 13 | 16 |
| SM4 | 1 | 1 | 2 | SM4 | 0 | 0 | 0 |
| SM5 | 1 | 1 | 2 | SM5 | 10 | 12 | 22 |
| SM6B | 0 | 0 | 0 | SM6B | 0 | 0 | 0 |
| SM6A | 1 | 0 | 1 | SM6A | 0 | 0 | 0 |
| U | 0 | 0 | 0 | U | 0 | 0 | 0 |
| Total | 18 | 12 | 30 | Total | 38 | 49 | 87 |

No: No Schooling, SR: Elementary School, SM: Junior High and High School, U: University. Source: Household Survey by the Author

# Distribution and Collection of the Non-timber Forest Product, Gaharu, along the Upper Streams of the Baram River in Sarawak

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## Introduction

Gaharu is a forest product from rainforests in India and eastwards throughout Southeast Asia. Some species of trees in the genus *Aquilaria* which belong to the Thymelaeaceae family accumulate resin in parts of their trunks. The resin forms aromatic nodules called gaharu.

Gaharu has a long history as a traded good (Dunn, 1975, Lim and Parid, 2001). A Chinese document from the third century already recorded that gaharu was imported from Southeast Asia. Hong Kong, as its Chinese characters demonstrate, flourished as an entrepot port to deal with aromatic woods.

Gaharu needs to be burned or heated for the fragrance to be released. The fragrance of gaharu can be quite faint and subtle, but profound. In Islam and Buddhism, gaharu in the form of wood chips or incense is necessary for religious acts in order to purify the space. Gaharu is also used as Chinese herbal medicine for asthma and gastrointestinal fragility, because of its calming effect. In Japan, the art of incense ceremony using gaharu became established as Koh-doh in the Muromachi era (1336-1573), and is still performed by enthusiasts today (Morita, 1992).

Gaharu is one of the most expensive forest products in the world. The price of gaharu sold as wood pieces or small chips varies with quality (grade). Long established retail shops in Japan are selling the best gaharu for 10,000 yen (US$ 90) per gram, making it much more expensive than pure gold or platinum. In 2004, all species of *Aquilaria* were subject to trade controls under CITES appendix II. However, because it is relatively easy to carry, a large volume of gaharu is allegedly traded illegally (Soehartono and Newton, 2001: 37).

This paper has four purposes. First, it aims to examine the distribution characteristics of gaharu trees in a community with primary forest. Second, the paper makes a comparison with the distribution characteristics under other land use patterns. Third, the paper shows the methods by which local gatherers extract gaharu. Fourth, it is shown how much the sale of gaharu contributes to the local economy.

## Location for Research

The location for this research is Village L, a Penan village in the upper reaches of the Baram River in Sarawak, Malaysia. The Penan is a hunter-gatherer of the Borneo rainforest. Among 6,000 Penan people living along the Baram River, around 300 are nomadic, and the others lead settled or half-settled lives.

In order to reach village L, one must drive along the logging road from Miri, a coastal city, for 10 hours and then walk for two more hours (See Figure 1). Primary forest without any commercial logging is still continuous around the village. The village comprises 28 households and 118 people, with a make-up shown in Figure 2.

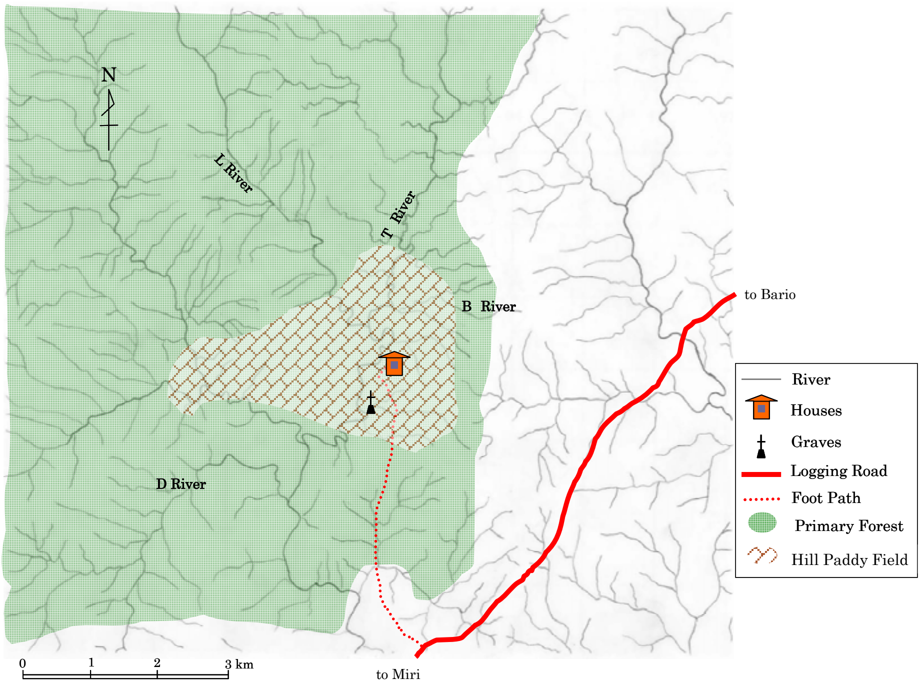


Fig. 1. Map of Village L

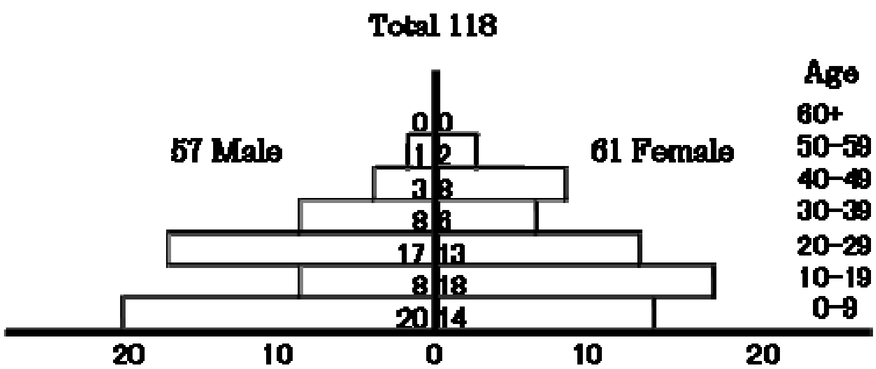


**Fig. 2. Population composition of L Village**

People in village L live by hunting with blowpipes and gathering, and also by shifting cultivation. The average area for shifting cultivation per household is 2.33 acres. Their relatives living nearby taught agriculture to them, but the relatives themselves had learned agriculture from farming peoples such as the Kelabit and the Saban.

## Research Method

The field survey was conducted in August 2004. L Villagers went along and cooperated in the field survey. First, we walked around a total of 90 ha along the B River, D River, T River, and L River in primary forest areas. We used GPS (MAP60-CS-AP) made by Garmin for estimating the geographical position and also PC software (Trip and Waypoint Manager) in order to estimate the size of the area. The reception of GPS signals that we attempted near the trees was about 60%. We took photos and kept records of all individual gaharu trees. We used Vertex III made by Haglof in order to estimate the height of the trees. We used a tape

measure to measure the diameter. As for the degree of decay of felled trees, we used the following four degrees estimated visually:
Degree 1: Immediately after felling, with green leaves
Degree 2: Sapwood is decayed
Degree 3: Heartwood is decayed, sapwood is missing
Degree 4: Most decomposed

In order to make a comparison, we carried out same research in 50 ha of secondary forests eight years after commercial logging and 40ha of secondary forests three- to ten-years after shifting cultivation, and in 10 ha of secondary forests 15 years after shifting cultivation.

I interviewed the villagers as for the amount and quality of extracted gaharu over a month, and was shown actual samples.

## Result

### Species of Gaharu

Gaharu taken in Village L are of two species: *Aquilaria microcarpa* and *Aquilaria beccariana*, both belong to the Thymelaeaceae family. *A. microcarpa* is called Gaharu Tokong, which means mountain Gaharu in Penan language, and *A. beccariana* is called Gaharu Ba, which means river Gaharu in Penan. *A.* malaccensis can be also seen in other areas in Sarawak, but it does not grow here.

## Extraction Method

When Penan look for a gaharu tree in the forest, they pay attention to fallen leaves and tree bark. As soon as they find a fallen leaf, they can immediately find the tree nearby. It is reported that in Indonesia, when one finds a gaharu tree, one cuts down the tree whether it contains resin or not (Soehartono and Newton, 2001). However, Penan in village L make a little cut on the tree bark and if they find that there is a little resin, they use an ax or a knife to cut out only the part where resin has accumulated. If a gaharu tree is not cut down, the tree may accumulate resin again. It takes several months or several years to accumulate resin.

## Gaharu Trees Distribution

We recorded 73 gaharu trees in the total of 90 ha primary forest around the village (Table 1). They were all *A. beccariana*. Table 2 shows data for tree heights and diameters. The felled trees are also contained in the number. The average tree height was 9.1m and the average diameter was 11.4 cm. Of these trees, 11 that were believed to contain a relatively large amount of resin were cut down by villagers. It turned out that not all gaharu trees generated resin, but only relatively mature trees generated it. All four trees whose height was over 18 m and whose diameter was over 28 cm were cut down. As for the degree of decay, two trees were in Degree1, two in Degree 2, five in Degree 3, and two in Degree 4. If we exclude two felled trees that were decayed so much and did not retain their original forms, the average tree height of the felled trees was 15.5 m and the average diameter was 19.9 cm.

In contrast, as Table 3 shows, in about 50 ha of eight-year commercial logged forest, there were only two gaharu trees. In about 40 ha of secondary forests for three to ten years after shifting cultivation, there was no gaharu tree. In about 10 ha of secondary forests for fifteen years after shifting cultivation, there was only one gaharu tree.

Table 1. Gaharu trees distribution in primary forest

| Location | Area (ha) | No. of gaharu trees | Distribution density | No. of felled trees |
|---|---|---|---|---|
| Around B river | 12 | 17 | 1.41 | 6 |
| Around D river | 32 | 14 | 0.43 | 2 |
| Around T river | 30 | 20 | 0.67 | 2 |
| Around L river | 16 | 22 | 1.38 | 1 |
| Total | 90 | 73 | 0.81 | 11 |

Table 2. Size of the gaharu trees in primary forest

| Height | Diameter at breast height | | | | | |
|---|---|---|---|---|---|---|
| | >28cm | 27.9-20cm | 19.9-10cm | 9.9-6cm | <5.9cm | Tatal |
| >18m | 4(4) | 3(1) | 2(1) | 0 | 0 | 9(6) |
| 17.9-10m | 1 | 5 | 6 | 6(1) | 0 | 18(1) |
| 9.9-5m | 0 | 2 | 2 | 12(1) | 8 | 24(1) |
| 4.9-2m | 0 | 0 | 0 | 1(1) | 14 | 15(1) |
| <1.9m | 0 | 1(1) | 0 | 1(1) | 5 | 7(2) |
| Total | 5(4) | 11(2) | 10(1) | 20(4) | 27 | 73(11) |

( ) number of felled trees

Table 3. Gaharu trees distribution in secondary forests

| Land use | Area(ha) | No. of gaharu trees | Distribution density |
|---|---|---|---|
| 8 years after commercial logging | 50 | 2 | 0.04 |
| 3-10 years after shifting cultivation | 40 | 0 | 0.00 |
| 15 years after shifting cultivation | 10 | 1 | 0.10 |

Table 4. Villagers' one-month income from gaharu (August, 2004)

| Name | Days | Area(ha)* | Quantity(kg) | Quality | Price (RM) |
|---|---|---|---|---|---|
| Mr. G | 5 | 150 | 0.15 | Grade3 | 90 |
| Mr. K | 20 | 600 | 1.6 | Grade3 | 1,040 |
| Mr. S | 20 | 600 | 0.1 | Grade1 | 200 |
| | | | 3 | Grade4 | 15 |
| Total | 45 | 1,350 | 4.85 | | 1,345 |

* The extraction area per day is presumed to be 30ha.

## Income for Villagers

During the month of August 2004, three villagers collected 4.35 kg of gaharu from an estimated 1,350 ha of forest. In reference to the prices that Kayan brokers use (first grade: RM2,000 per kg; second grade: RM1,500 per kg; third grade: RM650 per kg; fourth grade: RM50 per kg; and fifth grade: RM3 per kg), this amount would be equal to RM1,345 (US$366) (See Table 4). For L villagers, Gaharu is the biggest source of income and their rattan handicrafts are second.

## Conclusions

73 gaharu trees were distributed in about 90 of ha primary forest around the Village L. Habitat density is lower than one per ha. It turned out that not all gaharu trees generated resin, but only relatively mature trees generated it. When land use such as commercial logging or shifting cultivation is introduced, the habitat of the gaharu trees is subjected to destructive damage. The Penan in village L do not cut down all gaharu trees, but cut out only parts where resin has accumulated with an ax or a knife and let the tree survive. Gaharu is the biggest source of income for the L villagers.

## The present situation of the gaharu wood habitat

Today, in Sarawak, except for National Parks and Wildlife Sanctuaries, very few areas of substantial-sized primary forest remain; however, in the upper reaches of the Baram River, a sizable forest without any logging operation still remains. Today, approximately 18,000 ha of primary forest exists within the boundaries of the village that people in Village L recognize. When we apply the distribution density that we have acquired to the 18,000 ha, it is estimated that there should be about 15,000 gaharu trees within the village boundaries.

In October 2004, the Malaysian Timber Certification Council (MTCC) granted a certificate to a private logging company to “manage” the remaining 55,000 ha of primary forest that neighbors Village L. The Penan people living inside are making protests regarding this certified logging because the MTCC certificate does not recognize their native customary rights.

In the forest industry, timber has been recognized as the major forestry product and others as minor. However, it was only a few decades ago that people started focusing on timber in the rainforest. The export of non-timber products, as trading goods, surpassed that of timber until half a century ago. In extracting non-timber products including gaharu, it is possible to ensure certain productivity without necessarily felling the trees. In comparison with timber, these products were traded for much more appropriate prices. As a result, profits have been returned to local gatherers. In order to conserve the rainforest, the lives and cultures using it, it is necessary to review forest values other than timber and to devise policy options to secure sustainable use of forest products.

## Acknowledgements

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# Underuse of Coppice Woodlands Decreases the Abundance of Parasitoid Wasps, Potential Natural Enemies of Agricultural and Forest Insects, in Central Japan

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## Introduction

Coppice woodlands, which have been rotationally harvested for the production of wood, charcoal, fertilizer, and mushrooms, are a typical vegetation cover in satoyama landscapes in Japan (e.g., Takeuchi et al. 2003). Satoyama landscapes include not only woodlands, but also farmlands (rice paddies, orchards, vegetable fields, and other agricultural areas), settlements, and water reservoirs. These landscape elements are mutually connected in terms of ecological processes. Rural woodlands and other semi-natural ecosystems neighboring agricultural fields can be used as temporal habitats of natural enemies that invade croplands and control insect pests (e.g., Altieri and Nicholls 2004; Hajek 2004). Biological control is one of the most sought-after services of insect biodiversity (Samways 2005).

However, the area of regeneration cutting for rotational harvesting has gradually decreased over the last several decades, mainly from considerable changes in energy consumption and fertilizer use in Japan (Takeuchi et al. 2003). This may decrease the abundance and function of indigenous natural enemies in rural agricultural and forest landscapes. Such rural landscape changes and underuse of coppice woodlands have affected a variety of arthropods, including endangered or rare species (Maeto and Makihara 1999; Takeuchi et al. 2003; Inoue 2003; Makino et al. 2006; Maleque et al. 2006), but little is known about changes in the assemblages of parasitoid wasps, which are among the major groups of natural enemies of pest and non-pest insects (e.g., Gauld and Bolton 1988; Hajek 2004). The decline in understory vegetation, which is often observed in old coppice woodlands, may reduce the abundance and diversity of parasitoids, although no evidence is currently available to support this prediction.

The aim of this study was to clarify the effects of underuse, i.e., aging of deciduous coppice woodlands, on the abundance of parasitoid wasps in the understory layers. We focused on the family Braconidae (Hymenoptera), the second largest group of parasitoid wasps. Members of this group have highly diversified host ranges and are very important in bio-control programs of pest insects (Gauld and Bolton 1988; Hanson and Gauld 1995).

## Materials & Methods

### *Study area*

This study was conducted in an area of coppice woodlands in Ogawa (580-800m a.s.l.), located at the southern edge of the Abukuma Mountains in Kitaibaraki, Ibaraki Prefecture, central Japan (Makino et al. 2007). In this area, woodlands have been subjected to human activities such as burning, cattle grazing and clear-cutting for fuel wood (Suzuki 2002), and small scale clear-cutting of broad-leaved stands has been ongoing through the present. We selected nine plots in deciduous broad-leaved stands, dominated by

*Quercus serrata*, *Q. mongolica*, and *Fagus crenata*, representing a chronosequence from 4 to > 100 years after clear-cutting (Table 1).

**Table 1** Study plots and collection summary of braconid parasitoids in Ogawa in 2002

| Plot code | Age (years) | Area (ha) | Number of braconid subfamilies | Number of braconid individuals |
|---|---|---|---|---|
| O4 | 4 | 5 | 15 | 1110 |
| O12 | 12 | 4 | 13 | 670 |
| O24 | 24 | 24 | 15 | 797 |
| O51 | 51 | 10 | 14 | 405 |
| O54 | 54 | 14 | 15 | 311 |
| O71 | 71 | 19 | 15 | 408 |
| O128 | 128 | 98 | 13 | 343 |
| O174 | 174 | 11 | 15 | 340 |
| O178 | 178 | 10 | 13 | 368 |

***Sample collection***

Parasitoid wasps were collected with Townes-style Malaise traps (Golden Owl Publishers; 180 cm long, 120 cm wide, 200cm high; coarse mesh) in 2002. The traps were placed in study stand to avoid edge effects. Trapped insects were collected every 2 weeks from late April to early November. A mixture of ethanol and propylene glycol was used as preservative in the insect containers of the traps.

***Parasitoid wasps***

Braconid wasps (Hymenoptera, Braconidae) collected in two traps, 10 m distant from each other, were used for each plot in the following analyses. All specimens were dried, mounted, and identified to subfamily or tribe, and all voucher specimens were deposited at Kobe University (Graduate School of Agricultural Sciences), the Museum of Nature and Human Activities, Hyogo, and the Forestry and Forest Products Research Institute (FFPRI).

***Analyses***

Data on braconid wasps were pooled for each plot through the seasons. Principal component analysis (PCA) was performed on the abundance of subfamilies (tribes) in each plot to make an ordination of plots and braconid subfamilies. Simple regression of the abundance of parasitoids was analyzed in relation to stand age after clear-cutting. For these analyses, the number of individuals per trap was log-transformed as $\log_{10}(X + 0.5)$. Statistical analyses were carried out with SPSS for Windows, ver. 11.5.1 J (SPSS Inc.).

## Results

In total, we collected 4,752 individuals of braconid parasitoids (Table 2). The number of captures increased abruptly in May, remained high during summer, and dropped from mid-August to September (Fig. 1). The specimens belonged to 17 subfamilies, and the major guilds of their host insects are summarized in Table 2. Fourteen subfamilies (including the tribe Dacnusini of the Alysiinae) were presumed to be parasitoids of plant feeders (herbivores), and four subfamilies (including the tribe Alysiini of the Alysiinae) were presumed to be parasitoids of detritus feeders (including wood borers and mushroom feeders). The former group accounted for 74.7 % and the latter for 25.3 % of total captures.

**Table 2** Subfamilies of braconid parasitoids collected, and presumed feeding guilds of their host insects

| Subfamily (tribe) | Major feeding guild of hosts<br>P – plant feeders<br>D – detritus feeders | Recorded range of host insects*<br>C – Coleoptera, L – Lepidoptera, D – Diptera<br>He – Hemiptera, Hy – Hymenoptera | Number of individuals |
|---|---|---|---|
| Agathidinae | P | Plant-feeding larvae of L | 54 |
| Alysiinae (Alysiini) | D (P) | Detritus-, mushroom-, or rarely plant-feeding larvae of D | 509 |
| Alysiinae (Dacnusini) | P | Plant-feeding larvae of D | 229 |
| Aphidiinae | P | Plant feeders of aphids | 8 |
| Braconinae | P (D) | Plant-feeding or occasionally wood-boring larvae of C, L and D | 257 |
| Cheloninae | P | Plant-feeding larvae of L | 692 |
| Doryctinae | D (P) | Wood-boring larvae of C, or rarely plant-boring larvae of L | 326 |
| Euphorinae | P (D) | Plant feeders or rarely detritus feeders of C, He, etc. | 50 |
| Helconinae | D (P) | Wood-boring, mushroom-feeding, or seed-boring larvae of C | 249 |
| Homolobinae | P | Plant-feeding larvae of L | 24 |
| Ichneutinae | P | Plant-feeding larvae of L and Hy | 42 |
| Macrocentrinae | P | Plant-feeding larvae of L | 72 |
| Meteorinae | D (P) | Wood-boring or mushroom-feeding larvae of C larvae, or plant-feeding larva | 118 |
| Microgastrinae | P | Plant-feeding larvae of L | 1,392 |
| Miracinae | P | Plant-feeding larvae of L | 13 |
| Opiinae | P | Plant-feeding larvae of D | 305 |
| Orgilinae | P | Plant-feeding larvae of L | 2 |
| Rogadinae | P | Plant-feeding larvae of L | 410 |
| Total | | | 4,752 |

*According to Shaw and Huddleston (1991), Wharton et al. (1997), and literature cited by them

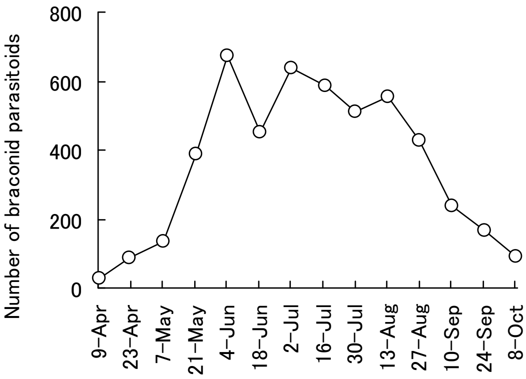


**Fig. 1** Seasonal prevalence of braconid parasitoids collected by Malaise traps in Ogawa in 2002

Figure 2 shows the PCA ordination of plots and subfamilies (tribes) with more than 20 individuals. Along the first axis (proportion of variance = 0.462), nine plots were arranged by the age of stands (Fig. 2a; $\tau = -0.889$, $P < 0.001$, between the first axis score and stand age), and the parasitoids of plant feeders were mostly clustered among younger plots (Fig. 2b). In contrast, the parasitoids of detritus feeders were near the origin of the first PCA axis, indicating no obvious relation to stand age.

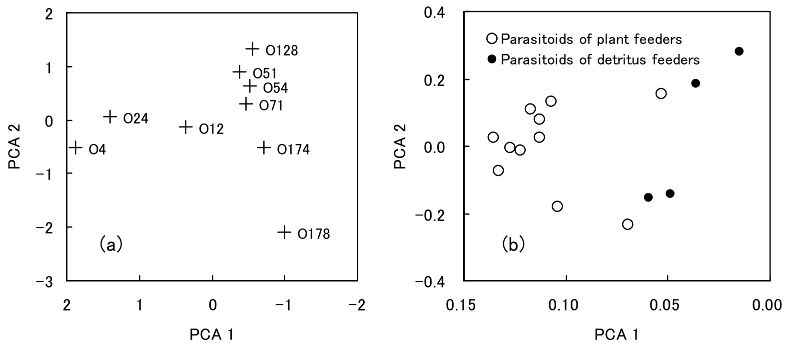


**Fig. 2** Ordination of plots (a) and braconid subfamilies (b) by principal component analysis (PCA)

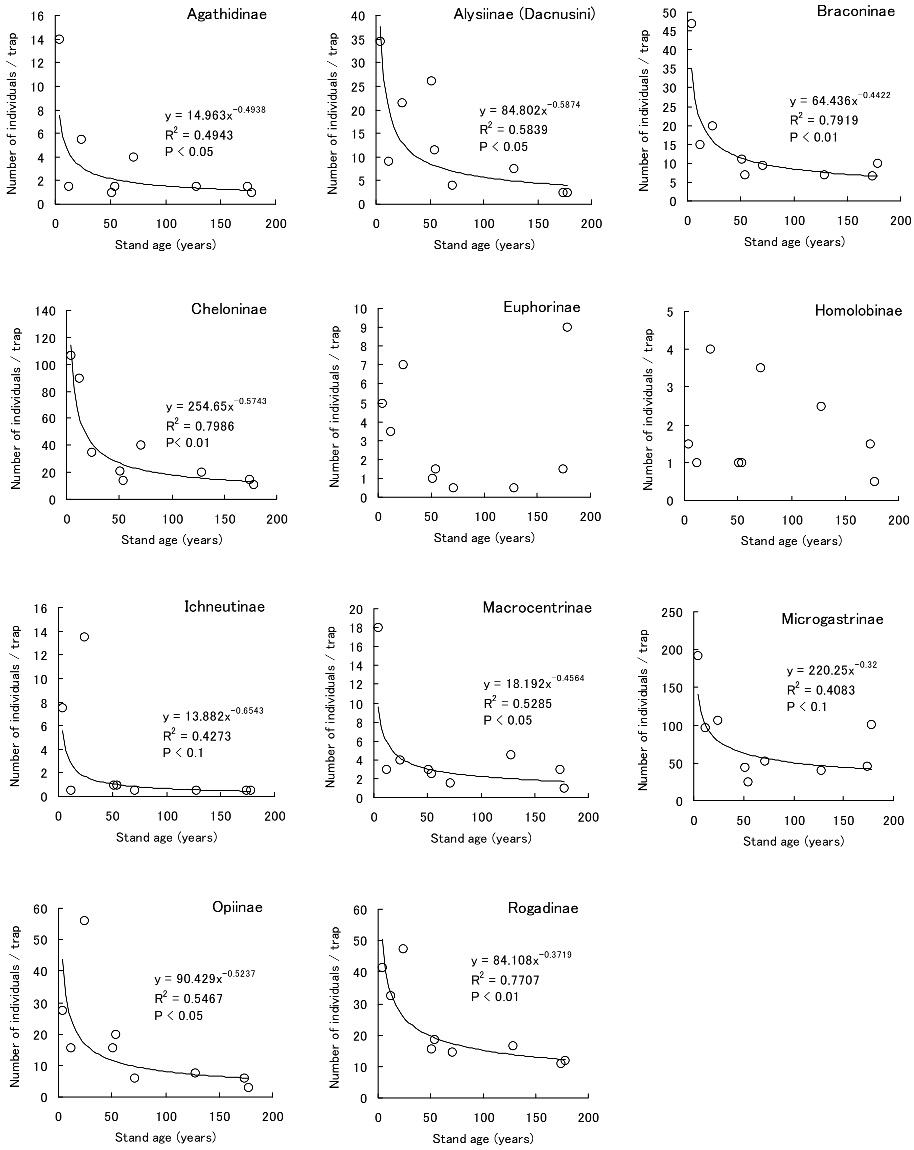


**Fig. 3** Relationship between stand age after clear-cutting and the abundance of braconid parasitoids of plant feeders for each subfamily

Figure 3 shows the abundance of the parasitoids of plant feeders in relation to stand age after clear-cutting. The number of captures per trap in most groups except for two small subfamilies, the Euphorinae and Homolobinae, declined markedly with the increase in stand age. In the parasitoids of detritus feeders, however, changes in abundance along with stand age were not consistent (Fig. 4), whereas a temporal increase and decrease in the middle-aged stands were evident for the Alysiinae (Alysiini) and the Doryctinae, respectively.

Data of the parasitoids of plant feeders were pooled. Their collective abundance along with stand age is shown in Fig. 5. Overall abundance of the parasitoids of plant feeders declined steeply for about 50 years after clear-cutting, indicating a power function of stand age.

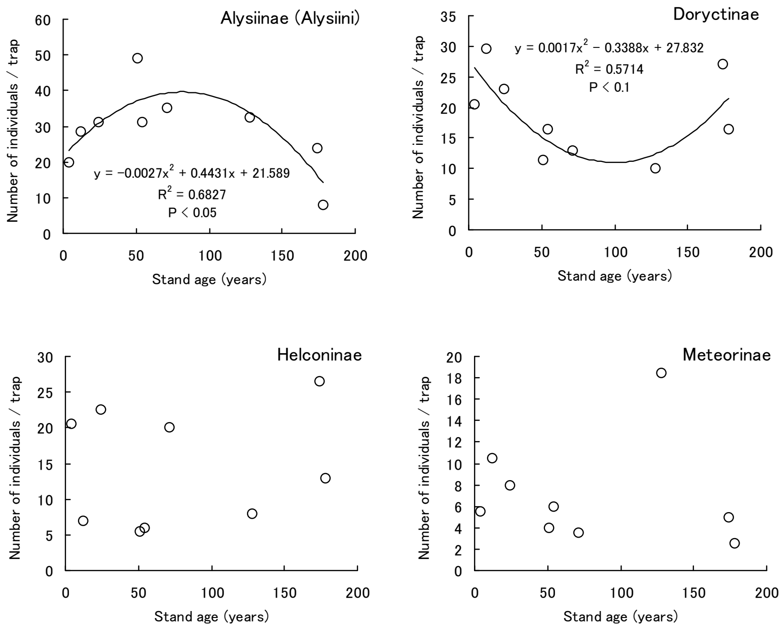


**Fig. 4** Relationship between stand age after clear-cutting and the abundance of braconid parasitoids of detritus feeders for each subfamily

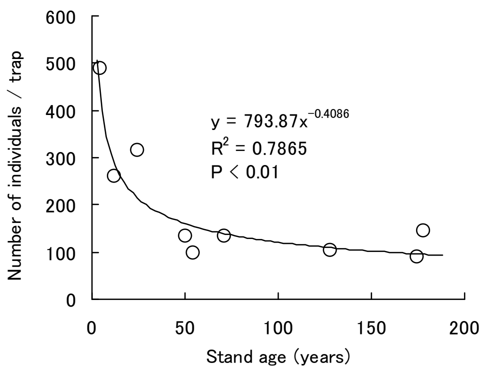


**Fig. 5** Relationship between stand age after clear-cutting and the overall abundance of braconid parasitoids of plant feeders

## Discussion

In rural landscapes of Japan, old-growth secondary forests provide invaluable habitats for saproxylic insects, such as stag beetles or *Pidonia* longicorn beetles, as well as for some herbivores feeding on flowers and seeds in the canopy (Maeto and Makihara 1999; Maeto et al. 2002; Inoue 2003). Thus, old woodlands free from agricultural or forestry use should be preserved when possible for the conservation of regional biodiversity.

On the other hand, large elements of biodiversity in satoyama landscapes have deteriorated with the abandonment of conventional land use in temperate Japan (Takeuchi et al. 2003; Inoue 2003, 2007; Sueyoshi et al. 2003; Ishii and The Nature Conservation Society of Japan 2005; Makino et al. 2006, 2007). Besides aquatic plants and animals, herbs, grasses, shrubs and herbivorous insects feeding on them are declining in semi-natural grasslands and in the understory layers of coppice woodlands. This not only leads to the extinction of endangered insect species (butterflies), but also weakens ecological functions of rural landscape elements.

In traditional rural ecosystems, semi-natural elements, such as meadows and coppice woodlands, are potential sources of natural enemies for neighboring paddy fields, orchards, vegetable fields, and tree plantations. In the conservation of biological control agents (e.g., Altieri and Nicholls 2004), we expect indigenous natural enemies in semi-natural vegetation to regulate agricultural and forest insect pests. However, our study shows that abandonment or underuse of young coppice woodlands impoverishes the assemblages of indigenous parasitoids of plant-feeding insects and depletes their populations. At least some of them must be potential natural enemies of insect pests in agricultural and forestry fields.

The geographical transition in the abundance of braconid parasitoids of plant feeders in Ogawa and its neighboring area was reconstructed from our data shown in Fig. 5 on a regional forest GIS developed by the FFPRI (courtesy of Dr. A. Miyamoto). It shows that the high-density habitats of parasitoids (over ca. 250 individuals per trap) have been reduced in the last few decades (Fig. 6).

Well-preserved assemblages of indigenous natural enemies in semi-natural elements within rural landscapes make up the base of Integrated Pest Management (IPM), which has been proposed in order to reduce the use of chemical pesticides in pest management (e.g., Pedigo 2002). Modest conventional use of woodlands should be more encouraged in satoyama landscapes for the purpose of environment-oriented agriculture and forestry.

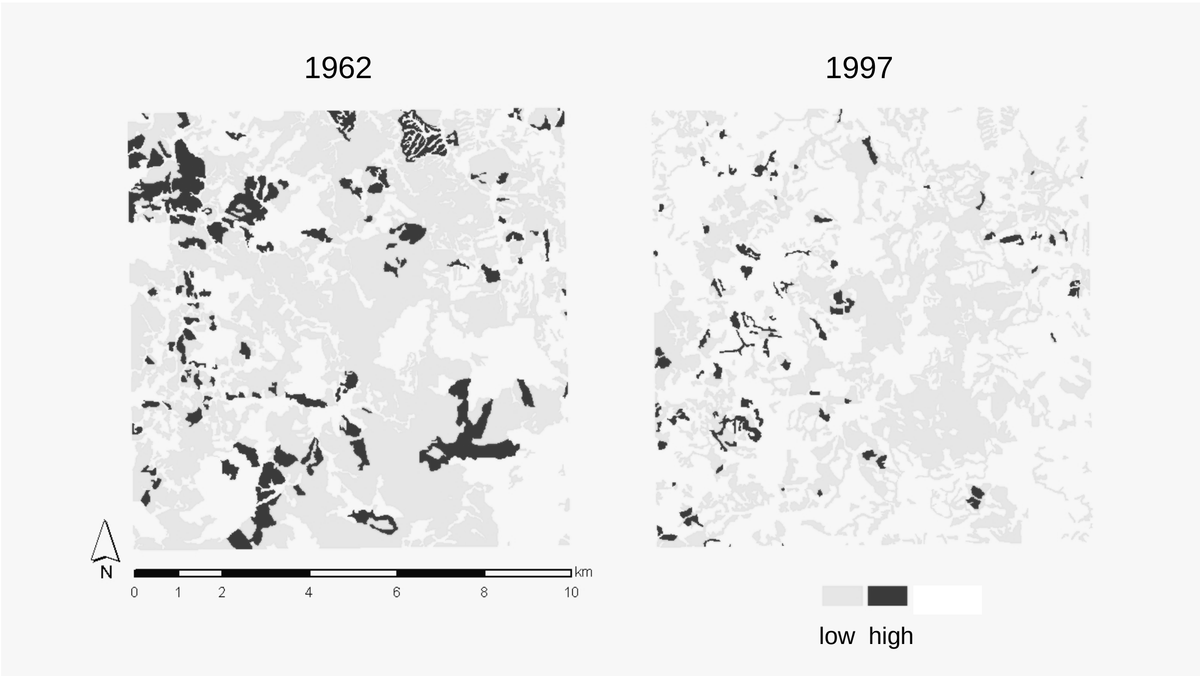


**Fig. 6** Reconstructed map of the transition in the abundance of braconid parasitoids of plant feeders in Ogawa and its neighboring area from 1962 to 1997 on a regional forest GIS developed by the FFPRI (courtesy of Dr. A. Miyamoto). Dark and light areas indicate coppice woodlands with more and less than ca. 250 parasitoid individuals per trap, respectively

## Acknowledgments

We thank Dr. S. Makino and Mr. H. Goto for field collection of parasitoid wasps with Malaise traps and valuable information about the study area and plots. We are grateful to Dr. A. Miyamoto for reconstruction of the distribution of parasitoids in Ogawa and its neighboring area using GIS.

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# Land Use and Crop Damage by Japanese Macaque on Yakushima Island, Japan

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## Introduction

In Japan after WW II, natural broad-leaved forest was extensively converted to artificial coniferous forest (including *Cryptomeria japonica*) for timber production. The Japanese government promoted extensive afforestation throughout the archipelago from the mid-1950s to the mid-1980s. The expansion of farmlands has also altered forests. In particular, some types of fruit have high economic value, and orchards have expanded onto sunny slopes following the clearing of forests. Hence, Japanese forests have changed extensively within a short period.

The ecological aspects of forests have also changed extensively, which should alter the forest ecosystem services available for humans. Wild animals have caused severe crop damage recently, which may be a result of changes in the forest ecosystem. Crop damage is a long-standing source of conflict between humans and wild animals in Japan. However, damage caused by monkeys, deer, wild boars, and other animals has increased extensively since the 1970s. On Yakushima Island, we investigated the spatial elements of land use (including forest use) by humans, which are related to the occurrence of crop damage by monkeys (hereafter monkey damage).

## Materials and Methods

We studied two areas on Yakushima Island, i.e., Nagata and Koshima, where there are many orchards, primarily citrus (Fig. 1). Extensive afforestation ensued on the island in the 1960s and 1970s. In 1960, farmlands occupied approximately 40% of the total area. Now, the land is used for forests, farmland, and housing. Orchards expanded from 1960 to 2000 (Fig. 2). In 1980, orchards appeared in the northeastern area where forests had expanded in 1960. Citrus orchards, which have high economic value on the island, have also expanded markedly in other areas since the 1970s.

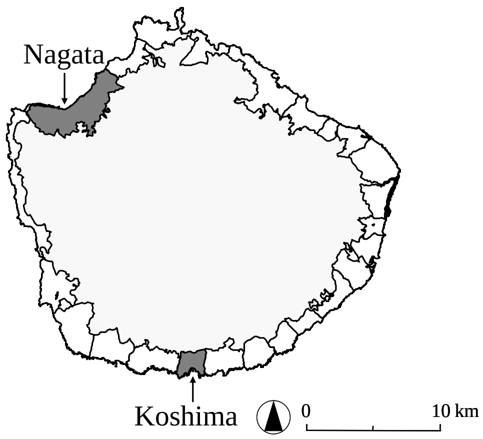


**Fig. 1** Location of the study areas on Yakushima Island.

Monkey damage on the island has been severe since the 1980s in the Nagata area, and since the 1990s in the Koshima area. Previous studies investigated the distance between farmlands and forests (Hill 1997; 2000; Naughton-Treves 1998; Saj et al. 2001) and the areas adjacent to farmland (Hill 2000); such spatial elements may affect the occurrence of monkey damage. To elucidate the relationship between land use by humans and the occurrence of monkey damage, however, the spatial elements of land use should be investigated. We performed a questionnaire survey of 11 farmers in the Nagata area and 15 farmers in the Koshima area to determine the extent of monkey damage to orchards in the two areas. The term of the survey was from 1 to 19 September 2003. We selected 12 parameters (Table 1) and used logistic regression to examine the relation between each parameter and the occurrence of monkey damage. In addition, we constructed a risk map of the probability of the occurrence of monkey damage in each area by combining the results of the model and using a geographic information system (GIS).

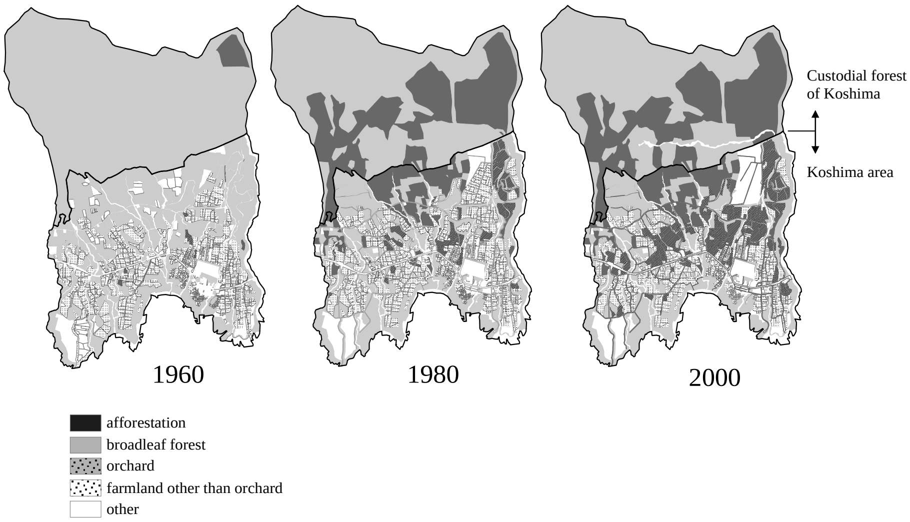


**Fig. 2** Land use changes in Koshima.

**Table 1** List of parameters considered.

| | Name of parameter |
|---|---|
| dependent parameter | |
| economic damage to crops caused by Macaque | *Damage* (damage=1, no damage=0) |
| independent parameter | |
| distance between forest and orchard (*m*) | *Forest* |
| distance between housing and orchard (*m*) | *Housing* |
| distance between road (wide) and orchard (*m*) | *Road* 1 |
| distance between road (middle-wide) and orchard (*m*) | *Road* 2 |
| distance between road (narrow) and orchard (*m*) | *Road* 3 |
| distance between river (wide) and orchard (*m*) | *River* 1 |
| distance between river (middle-wide) and orchard (*m*) | *River* 2 |
| distance between river (narrow) and orchard (*m*) | *River* 3 |
| speceis of fruit tree planted in orchard | *Fspecies* (TANKAN; *Citrus tankan* , HAYATA=1, PONNKAN; *Citrus reticulata* , Blanco=2, TANKAN and PONNKAN=3) |
| age of fruit tree planted in orchard | *Fage* |
| whether there is electric fence or not arround orchard | *Fence* (fence=1, no fence=0) |
| type of forest nearest orchard | *ForestType* (broadleaved forest=1, Japanese cedar forest=2) |

## Results

The multivariate logistic regression analysis produced probabilities for the occurrence of monkey damage, which are the dependent parameters included in the model. The model was:

$$log\{p(x)/(1 - p(x)) = -1.172 - 0.034Forest + 0.004Road1 + B \quad (1)$$

Nagata: $B = 2.507$

Koshima: $B = 0$

where the primary factors selected were *Forest*, *Road*1, and *B*. The parameter *B* indicates differences in monkey damage between the areas and was significant (p = 0.000); the perceived monkey damage was greater in the Nagata area. Parameters regarding the quality of the orchard showed no significant differences.

We calculated the probability function of monkey damage as $p(x)$. We then constructed two risk maps of monkey damage using the function and GIS (Fig. 3). More than 90% of orchards in the Nagata area and approximately 30% of orchards in the Koshima area might suffer monkey damage, with a risk > 50%.

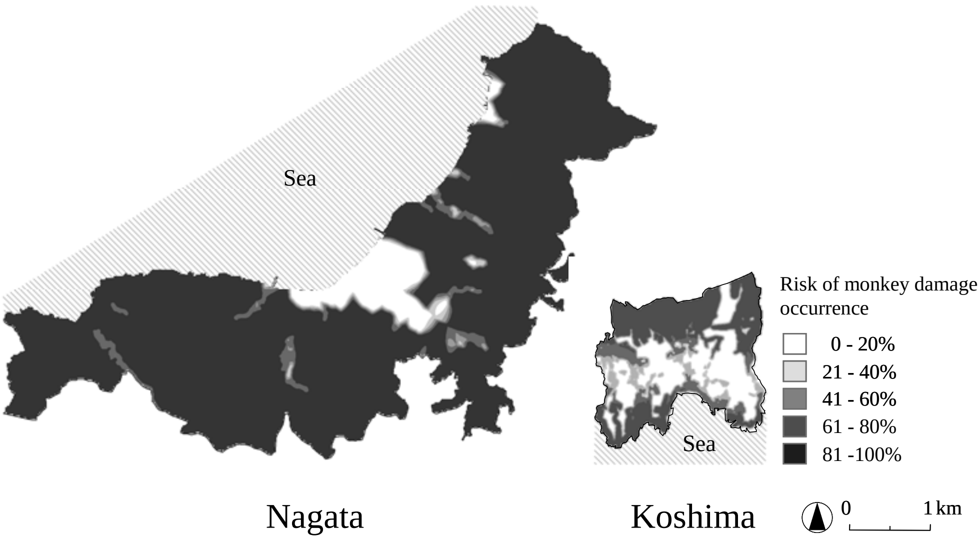


**Fig. 3** Maps indicating the risk of crop damage caused by Japanese macaque.

## Discussion

The model indicated that the distance between forests and farmlands (i.e., the parameter *Forest*) was negatively correlated with the occurrence of monkey damage. This result supports those of previous studies that suggest similar patterns of occurrence for monkey damage on Yakushima Island (Hill 1997; 2000; Naughton-Treves 1998; Saj et al. 2001). Monkeys are arboreal animals and forest is a space of safety for them. Therefore, when the distance between forests and farmlands is greater, the risk of raiding farmlands might be higher for monkeys. The model also indicated that the distance between roads and farmlands (i.e., the parameter *Road*1) was positively correlated with the occurrence of monkey damage. This road parameter accounts for wide roads, which are prefectural main roads with much traffic. Therefore, monkeys might avoid these roads. These spatial elements of land use, rather than variables related to orchard characteristics, are important in predicting the occurrence of monkey damage on the island.

The distance between forests and farmlands could change with the alteration of forests and large-scale timber extraction. At the study sites, the extent of changes in land use was small, although the forest physiognomy has changed extensively in the last 40 years. Orchards have expanded since the 1970s by the clearing of forest areas. Newer orchards are more likely to be closer to forests and thus are more likely to suffer from monkey damage. We used only the current spatial elements in these analyses. Therefore, it is not possible to predict how previous changes in forest use affected the occurrence of monkey damage. We can only suggest that new farmlands located on newly cleared land would be more likely to suffer damage from monkeys.

Compared to the Koshima area, monkey damage was high in the Nagata area, where the population density of Japanese macaque was higher and the damage began earlier in the season. In other words, farmlands more likely suffer monkey damage in the Nagata area than in the Koshima area, even when the parameters *Forest* and *Road*1 are the same. The parameter *B* may imply variation in the density of monkeys, their habituation to humans, and their habitats. The forest ecosystem would affect the parameter *B* and cause differences in the extent of monkey damage.

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# Crop Raiding by Wildlife due to Landscape Modifications: Ecological Function Losses Caused by Forest Development on the Island of Yakushima, southern Japan

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## Monotonous forest and deterioration of ecological functions

In primary industries, mass production requires intensive and monotonous land use, especially large-scale logging and commercial planting, such as seen in monocultures of coffee, palm, gum, and sugarcane, which are cultivated widely throughout tropical and subtropical regions (e.g., Nagata et al. 1994; Hartemink 2005). However, such monotonous land use has damaged the ecological functions and services that result from forest ecosystems (e.g., McNeely et al. 1990; Lugo 1997).

In Yakushima, located off the south coast of Japan, monotonous land use has developed mainly as large-scale logging of natural forests and replacement with coniferous trees, in accordance with policies of the Forest Agency that were formulated in 1958 and aimed at increasing wood production. However, forest development has disturbed animal and plant communities (e.g., Aiba unpub. data; Yumoto unpub. data) as well as ecological functions (e.g., Japan Institute of Land and Environmental Studies 1981). On the island of Yakushima, endemic subspecies of Japanese deer (*Cervus nippon yakushimae*) and monkeys (*Macaca fuscata yakui*) have experienced major habitat disturbance. In general, the food supply of herbivores fluctuate widely after logging and planting for about 20 years in Japan (e.g., Koizumi 1988; Sone et al. 1999; Hanya et al. 2005). Logging initially destroys plant production, but it quickly recovers with improved exposure to sunlight. However, it subsequently decreases rapidly to minimum levels, concomitant with growth of trees (Fig. 1). On Yakushima, the extensive forest transformations of the 1960s and 1970s have preceded intensive crop damage by these species in the 1980s and 1990s. Thus, crop raiding by mammals occur after major fluctuations in their habitat caused by monotonous plantations. This paper reviews the processes and factors of agricultural crop raiding by these mammals in relation to forest development on Yakushima, with reference to cases from other locations in Japan.

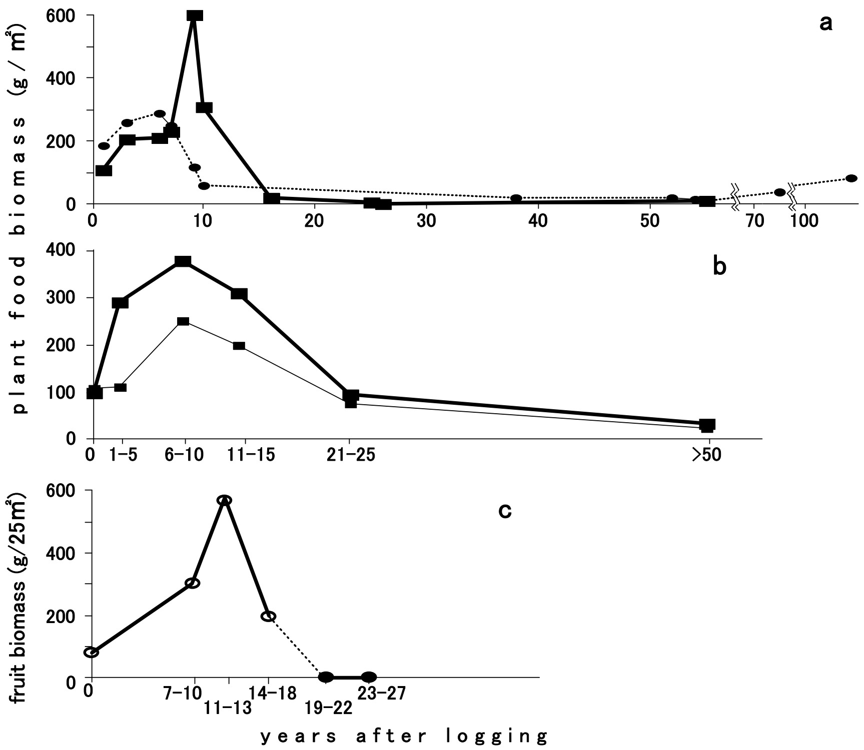


**Fig. 1**. Food plant biomass (g dry weight/$m^2$) after clear-cut logging of broad-leaved forests. (a) Food plant biomass for Japanese sika deer under cedar plantations (solid line) and secondary broad-leaved forests (broken line) (modified from Takatsuki 1992). (b) Food plant biomass (g dry weight/$m^2$) for Japanese serow under conifer plantations in November (solid line) and August (thin line) (drawn from Sone et al. 1999). (c) Fruit biomass (g/25 $m^2$), as food for Japanese monkey, in primary and secondary broad-leaved forests (solid circles) and cedar plantations (open circles) (modified from Hanya et al. 2005).

## Forest development

Yakushima is a circular, mountainous island (ca. 500 $km^2$) located in southern Japan (30°N, 130°E). Approximately 14,000 inhabitants live in about 20 villages located less than 100 m above sea level (a.s.l.); most other areas are afforested with about 80% being National Forest property. Natural forests, consisting mainly of evergreen broad-leaved trees, occur from 0 to 800 m a.s.l.; between 800 and 1800 m, the forests consist of both broad-leaved and coniferous trees. In addition, many natural Japanese cedars occur, especially over 1200 m a.s.l. (Tagawa 1994). Annual precipitation at lower altitudes is 2500–5000 mm; at higher altitudes, rainfall reaches 7000 mm, and occasionally 10000 mm (Kagoshima Prefecture 1992). At the coast, the annual mean temperature is about 20℃ (Tagawa 1994); above 1000 m a.s.l., the climate is much cooler, with snow cover in winter.

On Yakushima, intensive logging began in the upland regions for cedar. Logging of conifers increased in the 1950s but decreased in the 1960s owing to tree depletion (Fig. 2). However, with increased demand for wood and pulp products, the logging area shifted to broad-leaved forests at intermediate altitudes. Logging volumes of broad-leaved trees increased significantly from 1963, but decreased after 1973 (Fig. 2) with the reduction in the market price of wood (Japan Federation of Bar Associations 1991) combined with increased awareness of nature conservation (Kamiyaku Town 1984). After the logging of broad-leaved trees, Japanese cedar was widely planted in areas that were not the natural habitat of this species (Fig. 2).

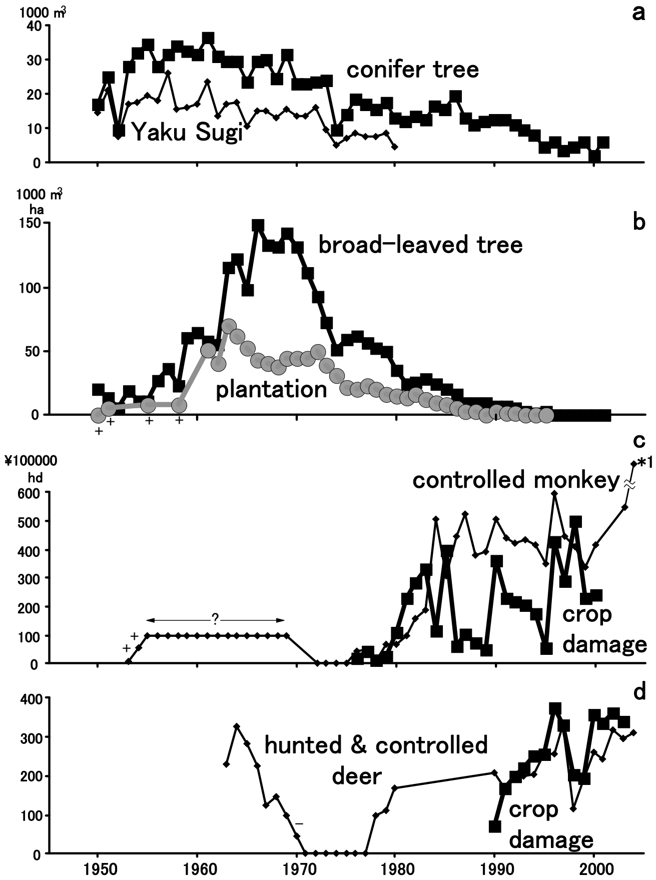


**Fig. 2.** Annual logging volumes, conifer planting areas, agricultural crop damage by wildlife, and number of hunted animals. Possible underestimated values (+), possible overestimated values (–), and approximate values (?). (a) Logging volume of conifer trees (solid line) (Suwa pers. commun.) and cedar (thin line) (Fujimura 1971; Miura 1984). (b) Logging volume of broad-leaved trees (solid line) (Suwa pers. commun.) and conifer plantation area (gray line) (Kagoshima Prefecture 1992; data of Forest Agency). (c) Amount of crop damage (×\100000, ca. $800) by monkeys (solid line) and number of monkeys culled (thin line) (Azuma 1984; Hirose 1984; Kagoshima Prefecture 1992; Agetsuma 1998). Values of *1 are 833 individuals. Monkeys were captured for experimental use in the 1950s and 1960s. After 1972, all captures were conducted as pest control measures. (d) Amount of crop damage by deer (solid line) and the number of hunted and culled deer (thin line) (Kagoshimaken Shizen Aigo Kyokai 1981; Kagoshima Prefecture 1992; Sueyoshi 1992). Deer hunting was prohibited during 1971–1977. From 1999, deer control has focused in the vicinity of farms.

## Land-use changes in lower areas

Below 300 m a.s.l., the inhabitants of Yakushima had deforested the land and cultivated it intensively for traditional practices, such as swidden cultivation, fuelwood, and charcoal (Sprague unpub. data). As a result, the area of "rough land," that is, treeless land, spread extensively in the 1920s (Sprague unpub. data). On Yakushima, monkeys (Agetsuma 1995) and deer (Agetsuma and Agetsuma-Yanagihara 2006) in a natural forest are mainly dependent on the tall trees for their foods; therefore, a “treeless land” may be of little use to them, although deer could utilize herbaceous plants (Takatsuki 1990) and monkeys could feed on the fruit of some shrubs (Hanya 2004). In addition, increased human activity in farming areas would discourage the use of such places by these animals. However, fuel and fertilizer revolution occurred. In addition, because of the shift in the industrial structure of the island, the area of farmed land and number of farmers decreased significantly between 1950 and 1975 (Fig. 3). Then, some areas of treeless land and farmed areas were converted to orange groves in the 1970s through the promotional efforts of local governments (Agetsuma 1998). Although, most treeless lands were abandoned and subsequently reverted to broad-leaved forests after 1970s (Sprague unpub. data), thereby providing renewed resources for wildlife. Consequently, in lower areas, an overall decrease occurred in treeless lands with a simultaneously increase in broad-leaved forests and orange groves. Production of oranges has increased greatly since 1980 (Fig. 3).

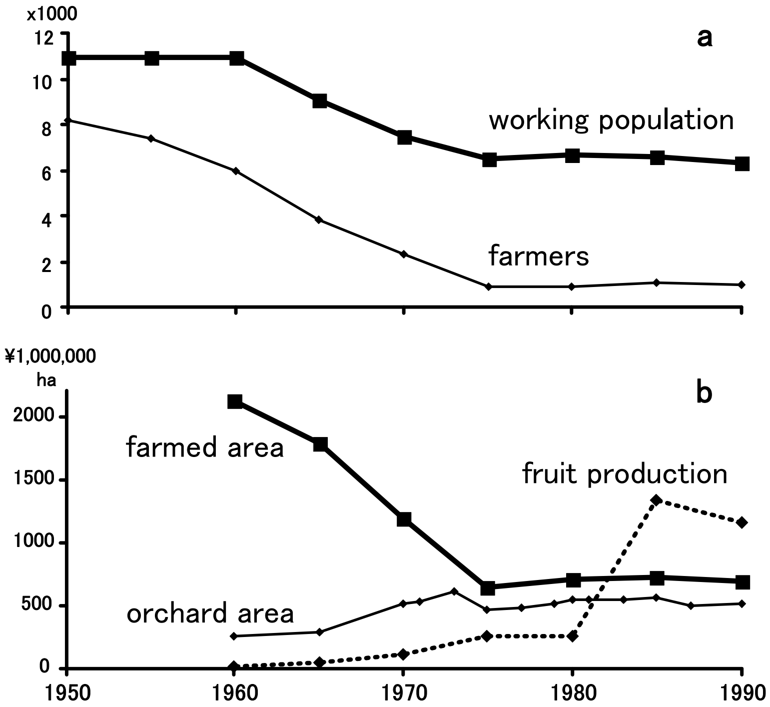


**Fig. 3**. Working population, farmland area, and fruit production (×\1000000, ca. $8000) in Yakushima. (a) Total working population (solid line) and numbers engaged in agriculture (thin line) (Kagoshima Prefecture 1992). (b) Farmed areas of the five main crop items (solid line), orchards (thin line), and fruit production (broken line) (Kagoshima Prefecture 1992; Agetsuma 1998).

## Outbreaks of crop raiding and pest control

Monkeys damage oranges, other fruits, and sweet potatoes (data of Kamiyaku Town). On the island of Yakushima, crop raiding by monkeys was reported before 1950 (Itani 1994), but the amount of damage increased greatly after 1980 (Fig. 2). After 1978, in response to crop raiding, local governments implemented pest control on monkeys. However, between 1978 and 1983, even though the number of controlled monkeys increased, crop damage still increased (Fig. 2) and the high level of damage is continuing, even though 300–600 monkeys have been culled every year since 1984. In spite the fact, many assume that increases in the monkey population have been averted by culling. However, the numbers have not been determined scientifically but have been influenced mainly by voluntary efforts of local hunters and the availability of bounties from local governments. Therefore, it would be purely coincidental if the number of monkeys culled equalled the number required to halt population growth. It is more likely that the population has increased to match the number culled, thereby maintaining a constant population size.

On Yakushima, severe raiding of agricultural crops by deer has been recorded from the 18th century (Kamiyaku Town 1984). However, over the last 60 years, crop raiding by deer greatly increased in the 1990s (Fig. 2). Crops damaged were mainly orange trees by bark stripping (data of Kagoshima Prefecture), sweet potatoes, and rice (Sueyoshi 1992). Deer hunting has been conducted traditionally in Yakushima, and during the 1950s, more than 1000 deer were killed annually (Kamiyaku Town 1984). The number of hunted deer, however, rapidly decreased between 1964 and 1970 (Fig. 2), and ultimately, deer hunting was banned in 1971. It was reintroduced in 1978 as a pest control measure, but damage to crops and forestry seemed not to be widespread during this period (Tagawa 1987). Deer control was implemented over the whole island, and thus deer with no association to crop damage were also controlled. However, from 1999, deer control was limited to around farmland in an effort to target actual raiding deer. After 1980, the number of culled deer remained at 200–300 (Fig. 2). Thus, raiding deer were controlled more intensively than pre-1999, but no reduction in crop damage occurred.

From the empirical data, two common trends in crop raiding by both mammals are recognizable. One is the timing of the rapid increase in crop raiding, which occurred after a delay of approximately 20 years from the logging peak of broad-leaved forests (Fig. 2). The other is the ineffectiveness of pest control in reducing crop damage.

## Impact of forest development on mammal ecology

The impact of transforming natural forests to monotonous conifer plantations on the ecology of wildlife includes alteration in diet, habitat use, and other behaviors (Gill et al. 1996). To evaluate the impact, population density is used as an easily measurable index. On Yakushima, the density of monkey groups has tended to decrease with the spread of plantations (Hill et al. 1994) and correspond closely to the food production of forests (Hanya et al. 2004, 2005). Ohsawa et al. (1995) and Agetsuma et al. (2003, unpub. data) surveyed deer density in forests at different degrees of planting. These studies showed that deer densities in heavily planted sites were much lower than those of relative undisturbed sites (Fig. 4). The impact cannot be minimized, even several decades after planting. Deer hunting and cull statistics suggest that the deer population declined soon after intensive logging. Numbers of hunted deer decreased greatly in the 1960s (Fig. 2), which may indicate a population decline. Similar decreases in population densities caused by food depletion due to the establishment of conifer plantations have also been reported in roe deer (*Capreolus capreolus*) (Gill et al. 1996) and Japanese serow (*Capricornis crispus*) (Sone et al. 1999). It is probable that the monkey and deer populations decreased owing to lowered productivity through logging and planting. Subsequently, they gradually recovered, in tandem with renewed production, mainly in naturally regenerating forest stands.

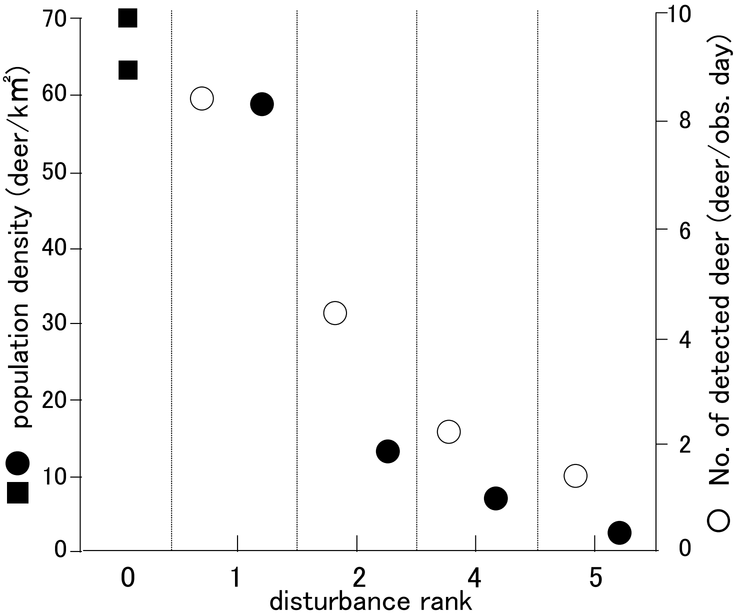


**Fig. 4**. Relative deer population density at six sites in Yakushima. Solid squares indicate estimated population densities in two lowland natural forests (50–200 m a.s.l.) almost without plantations in 2001 (Agetsuma et al. 2003). Solid circles indicate the estimated densities in 2004 (Agetsuma et al. unpub. data) and open circles denote the number of detected deer per observation day in 1994 (Ohsawa et al. 1995) at four sites, including plantations at intermediate altitudes (300–700 m a.s.l.). Sites with higher disturbance ranks have more areas of younger plantation. Disturbance rankings 1–5 are from Hill et al. (1994).

## Relationship between crop raiding and habitat transformation

In Hyogo Prefecture, a positive relationship was found between the occupancy of conifer plantations and crop damage by deer (Sakata et al. 2001). In addition, crop damage by monkeys was greater in regions with 40–50% areal coverage by conifer plantations (Japan Society for Preservation of Birds 1988). These statistics imply some negative influences of plantations regarding the prevalence of crop raiding. On Yakushima, crop raiding increased rapidly with fluctuations in food resources after logging and conifer planting. However, the populations might have been lower than the pre-intensive logging period, which means that a population eruption cannot explain the onset of intensive crop raiding. Crop raiding is possibly influenced by specific ecological and behavioral changes; otherwise, more incidences of raiding would have been previously recorded (i.e., in the1950s) when the animal population was higher and the area of farmland greater than in the 1980s (Fig. 3). Ambiguous or inverse relationships between herbivore densities and damage to crops, forestry, or natural vegetation have been reported (e.g., Oi and Suzuki 2001; Sakata et al. 2001). Ochiai (1996) suggested that damage to plantation trees by serow commenced before the increase in population density. These data suggest that functional responses, such as a shift in ecological strategies, play an important role in crop raiding, rather than simply wildlife density.

The reasons why animals change ecological strategies might be explained as adaptations to fluctuations in habitat. Different ecological strategies has been understood as adaptations to habitat stability and unpredictability (e.g., Begon et al. 1986). Such adaptations would explain interspecific differences of ecology. Similarly, the same species and even individuals within their respective ranges of capability must change their ecology in relation to habitat stability. To confirm the shift in ecological strategies of mammals due to habitat disturbance, it is necessary to further analyze the history of habitat disturbances in relation to crop raiding.

Changes in landscape structure would facilitate crop raiding. At the intermediate altitudes on Yakushima island, forests have been transformed into low-productivity conifer plantations. In contrast, at lower altitudes, low-productivity treeless terrain has reverted to broad-leaved forest (Sprague unpub data). The natural resources for wildlife have changed inversely from "middle to low altitude" to "low to middle altitude". This shift in landscape structure encourages raiding and makes it difficult to defend crops. The problem is a result of ecological function loss due to landscape modification. Therefore, appropriate landscape management strategies are required to resolve the issue of crop raiding by wildlife.

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# Factors Affecting Wild Resource Use: Actual Use of Wild Resources by the Penan Benalui of East Kalimantan

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## Introduction

Many studies have shown that local people know numerous useful wild species (e.g., Boom 1987; Milliken et al 1992; Balée 1994; Christensen 2002). Long inventories of useful wild species are usually considered to express the importance of biodiversity to local people. Some (or even many) species on such a list, however, are hardly used (e.g., Dwyer 1990, 122; Koizumi & Momose 2007). Actual use of species is determined by availability, preference, need, and other factors.

This paper examines use of wild species by the Penan Benalui, a former hunter-gatherer group of East Kalimantan, Indonesia. Among 713 species of wild plants examined in a previous study (Koizumi & Momose 2007), 540 species are reported useful by the Penan Benalui. According to them, however, only 212 species are of good quality, often used, or important for a certain purpose(s) (ibid.). I describe two examples of wild resource use here. One is wild species used for food during a three-month survey. In this example, several species were intensively used. The other is rattan species used for basketry. Changes in the use from 2002 to 2007 are described. I then summarize factors affecting actual use of species and discuss the advantage of knowing currently less or rarely used but potentially useful species.

## Penan Benalui

The Western Penan is a Bornean hunter-gatherer group, and the Penan Benalui is a subgroup of the Western Penan (Needham 1972; Hildebrand 1982; Brosius 1992, 52–55, 60–68; Puri 2005, 2–6). About 2900 Western Penan, not including the Penan Benalui, live in Sarawak, Malaysia (Brosius 1999), and about 450 Penan Benalui live in East Kalimantan, Indonesia. Traditionally the Western Penan were essentially self-sufficient in obtaining food, eating forest products such as sago palms, fruits, bearded pigs, leaf monkeys, and palm shoots, though they also interacted with farmers for trade and protection from raids (Brosius 1991; 1992, 111–96).

According to the Penan Benalui, farmers encouraged the Penan Benalui to live in their villages and to learn how to farm. Behind this encouragement was pressure from Indonesian bureaucrats and pastors on the farmers to persuade the Penan Benalui to settle and farm (Puri 1997, 78; 2005, 56). The Penan Benalui gradually adapted to sedentary life from the mid-1950s (Puri 1997, 77–78; 2005, 55–56). The present Penan Benalui are practicing a mixed subsistence economy. They, however, largely depend on forest products for cash income as well as for food and material culture.

## Methods

Fieldwork was conducted in the village of Long Belaka (2°41´ N, 115°43´E), a Penan Benalui community, in East Kalimantan, Indonesia from 2002 to 2007. The residential site of the village is located about 300 m above sea level and surrounded by mountains. The forest around the village is mainly lowland dipterocarp forest.

Plants were collected with informants in mature and secondary forests and along riversides around the village at about 300–600 m above sea level (Koizumi & Momose 2007). During these collections, informants were interviewed about ethnobotanical information including plant names and uses. The informants were ten men and two women between the ages of about 30 and 60 who were relatively knowledgeable about plants. I made a list of plants for each use mentioned in the field. For each use category, one or two (or three) villagers were asked to name plants associated with that use. I also asked which plants were often used, were of good quality, or were considered important for each use category.

The food survey was conducted from September to November 2004 for a total of 20 days (Dounias et al 2007). At each house of the study village, I conducted interviews about foods the inhabitants had eaten. I asked the names of dishes, ingredients of the dishes, and asked who hunted, collected, or harvested the ingredients. There were 20 houses in the village at the time of the survey. Data was collected for 346 day-houses. I could not interview at some houses on some days because the people were staying at a downriver village or swidden field. I analyzed the times of use of each kind of ingredient. If an ingredient was used at a house for a dish at a meal, it was counted as "1 time."

Voucher specimens were identified by me and other botanists. Voucher specimens are mainly deposited in Herbarium Bogoriense (Indonesia) and the Kyoto University Museum (Japan).

## Results

### *(1) Wild plants and animals appeared in the food survey*

Only 16 or 17 species of wild plants appeared in the food survey (Table 1), though the Penan Benalui know at least 193 edible species (Koizumi & Momose 2007). One of the reasons for this is that forest fruits were not available during the survey period. Some food resources, especially fruits and fungi, are not available throughout the year.

Although the Penan Benalui knew about 10 edible ferns, *Diplazium esculentum* (Retz.) Sw. was almost exclusively used. The species was abundant in open places around the village, especially on moist soil along rivers. The fern was thus easy to collect and considered a delicious fern by the villagers. The fern, however, was a far less favored food than meat, especially when oil was not available and the leaves were just boiled. Nevertheless, the species was often collected when meat was not available.

Sago starch was processed only from *Arenga undulatifolia* Becc., though the Penan Benalui know eight kinds of wild sago palms. Distribution, abundance, and taste of the palms account for the use of the species. Four palms are not found near the study village. Two palms grow near the village, but they are not very abundant. Two species, *A. undulatifolia* and *Eugeissona utilis* Becc., are abundant around the village. According to the villagers, the starch of *A. undulatifolia* is sweet, while that of *E. utilis* is bitter unless it is cooked with fat. The processing of sago starch requires much effort, and the villagers processed the starch only when they did not have rice. Furthermore, many villagers preferred to earn money to buy rice rather than to process the starch.

The shoots of *A. undulatifolia* and *E. utilis* were similarly often used. They were abundant, as explained above, and have large shoots. The shoots of the two species have different tastes, but the villagers liked both of them. According to a villager, eating the shoots of *Oncosperma horridum* Scheft. is a good remedy for headache. Although it was not asked in the survey, the shoots were collected and eaten not only for its good taste but also for the medicinal property.

Leaves of *Albertisia* sp. were pounded and cooked with other ingredients like monosodium glutamate. The plant was not abundant but not rare in the forest around the village. Although monosodium glutamate was usually used, villagers said that palm shoots tasted better when they were cooked with the leaves.

Table 2 shows wild animals appeared in the food survey. (The villagers used wild meat bought in a downriver village at two times, but they are excluded from Table 2.) The bearded pig (*Sus barbatus*) was used far more often than any other animals. It was the most favored food for most villagers. When adult bearded pigs were hunted, the meat was distributed to all families of the village. The sambar deer (*Cervus unicolor*) is also a large animal, but the villagers did not value the meat so much as that of the bearded pig. The sambar deer is one of the pest animals, and they were usually hunted around swidden field. In general, when men went hunting with a spear and dogs or with a shotgun, they and other villagers hoped that they would get the bearded pig. Some men sometimes went hunting with a blowpipe to hunt the gray leaf monkey (*Presbytis hosei*) when the bearded pigs were scarce. The people may also hunt other animals that they happen to encounter (Puri 1997, 2005).

### *(2) Depletion of a rattan species and change in rattan use*

During the study period, a change in use of rattans was observed. *Calamus caesius* Blume is the most valued rattan species for fine basketry in the study area. The villagers of Long Belaka were frequently producing **bukui**, a kind of rattan basket, made from *C. caesius*. In 2003 and 2004, they had bad rice harvests and worked hard to collect and process forest products to earn money to buy rice. Rattan baskets were among the most common forest products they sold. Some women even newly learned how to weave **bukui**. In 2005 or 2006, however, some families stopped producing rattan baskets made from *C. caesius*. According to an elder, his family stopped producing the baskets because the rattan was depleted. (Conversely, another man about 40-year old said that rattan was still abundant. Being asked further, he answered that the rattan was depleted around the village, but was still available at places which could be reached by 3–4-hour walk from the village.) The villagers started to produce **kavung**, a different model of rattan basket, for sale in 2006. They learned the model from the Kayan, swidden agriculturalists. The baskets can be made from *Calamus javensis* Blume and *Korthalsia* cf. *hispida* Becc., both of which are most common species around the village.

## Discussion

### *(1) Factors affecting actual use*

In the above examples, availability of resources in time and space affected actual use (Fig. 1). Availability in time or seasonality controls the possibility of use. It is impossible, for example, to collect the fruit of a certain species when it is not fruiting time. Seasonal resources, however, contribute to people’s livelihoods when available. Availability in space, in terms of distribution, habitat, and abundance, is closely related to searching costs. Searching costs can be reduced if two or more resources are collected at the same time.

There are also collecting and processing costs, which are related to morphological, chemical, behavioral, or other characters of resources. The costs can be reduced or increased by collecting and processing techniques. The possibility to use a resource may even depend on whether a community or an individual has a proper technique or not.

The decision to use a resource depends on the balance of perceived costs and benefits. The perceived costs partly depend on the perception of effort by individuals. The same work, for example, can be a relatively easy task for young men and a hard task for elders. The benefits that can be gained from a resource are related to quality and amount of the resource. At the same time, however, it is not determined by the resource itself. People judge the benefits according to their perception of the quality, preference, and need. The need for a resource changes according to the situation of each individual, household, community, and of the outside world (e.g., the market).

***(2) Advantage of knowing potentially useful species***

People usually know several or many species for a certain purpose. In general, different species have different availability and quality. This will result in people's perception of different costs and benefits of using these species. (As I have explained, the costs and benefits here are determined not only by objective factors but also by subjective factors.) The species of a better cost-benefit balance will more likely to be used. As far as there is a highly available or highly valued species, the species is intensively used and others are less or not used. It is not surprising that people know seasonally available resources and resources used for special occasions (such as eating a certain food, etc. when someone is sick, when someone becomes tired), though they may not be used at all during a short period. Rare resources may not be searched for specially, but they will be collected or hunted when people happen to encounter them. What, however, is the advantage of knowing species of perceived inferior quality?

The situation can change. Availability of a good quality resource may be depleted by overuse, as in the rattan case in this paper. An alternative resource then exhibits a better cost-benefit balance than the depleted one. An inferior resource can even become a best resource if a new way of use or new technique is introduced, or if the people's preference changes. The informants often introduced a plant by saying, "This is used for ——— (a certain purpose) if there is no ——— (a plant name)." People are prepared, to some extent, for changing situations. Knowledge of alternative species or resources will help people to quickly adapt to a new situation.

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**Table 1**
Wild plants appearing in meals of 346 day-houses in September to November 2004 at Long Belaka

| Category | Species | Habitat | Times of Use |
|---|---|---|---|
| Green leaves (ferns) | *Diplazium esculentum* (Retz.) Sw. | Open place | 69 |
| | *Pteris tripartita* Sw. | Open place | 1 |
| Green leaves (seed plant) | *Piper* sp. | Forest | 2 |
| Starch (sago palm) | *Arenga undulatifolia* Becc. | Forest | 40 |
| Starch (tuber) | Sp. 1 | Village site | 1 |
| White shoots (palms) | *Arenga undulatifolia* Becc. | Forest | 13 |
| | *Eugeissona utilis* Becc. | Forest | 13 |
| | *Oncosperma horridum* Scheft. | Forest | 3 |
| | *Daemonorops fissa* Blume | Forest | 1 |
| | *Licuala* sp. | Forest | 1 |
| | Not asked | | 1 |
| White shoots (ginger) | *Etlingera foetens* (Blume) R.M. Sm. | Forest | 1 |
| White shoots (bamboo) | Sp. 2 | Open place? | 1 |
| Condiment | *Albertisia* sp. | Forest | 12 |
| Ginger flowers | *Etlingera. elatior* (Jack) R.M. Sm. and/or *E. pyramidosphaera* (K. Schum.) R.M. Sm. | Forest | 2 |
| Fungi | Sp. 3 | Forest | 1 |
| | Sp. 4 | Open place | 1 |
| Fruit | *Passiflora foetida* L. | Village site | 1 |
| | Total | | 164 |

**Table 2**
Wild animals appeared in meals of 346 day-houses in September to November 2004 at Long Belaka

| Animals | Times of Use |
|---|---|
| Bearded pig (*Sus barbatus*) | 316 |
| Sambar deer (*Cervus unicolor*) | 25 |
| Barking deer (*Muntiacus muntjac* and/or *M. atherodes*) | 9 |
| Mouse-deer (*Tragulus javanicus* and/or *T. napu*.) | 9 |
| Malayan softshell turtle (*Dogania subplana*) | 3 |
| Bushy-crested hornbill (*Anorrhinus galeritus*) | 2 |
| Common porcupine (*Hystrix brachyura*) | 2 |
| Gray leaf monkey (*Presbytis hosei*) | 1 |
| Pig-tailed macaque (*Macaca nemestrina*) | 1 |
| Asian leaf turtle (*Cyclemys dentata*) | 1 |
| Rough-necked monitor (*Varanus rudicollis*) | 1 |
| Palm weevil (species not studied) | 1 |
| River shrimp (species not studied) | 1 |
| Fishes (species not distinguished) | 165 |
| Total | 537 |

| | Necessary conditions | Costs: Searching | Costs: Collecting / Hunting | Costs: Processing | Benefits: Use (domestic use or sale) |
|---|---|---|---|---|---|
| Biological factors | · Phenology (Availability in time) | · Distribution<br>· Habitat<br>· Abundance<br>(Availability in space) | · Morphology<br>· Behavior | · Physical character<br>· Chemical character | · Quality and amount |
| Human factors | · Technique<br>· Physical ability | · Technique (knowledge, experience)<br>· Physical ability<br>· Perception of effort | | | · Perception and evaluation of the quality<br>· Preference<br>· Need (domestic, market) |

**Fig. 1** Example of factors affecting wild resource use

# Importance of a Mosaic of Vegetations to the Iban of Sarawak, Malaysia

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## Introduction

Human disturbance has been creating habitat mosaics (Smith and Wishnie 2000), and swidden agriculture is one kind of human disturbance. In swidden agriculture, a piece of forest is cut and burned, and the land is used for farming for one year or for a few years (or more), then left fallow until forest grows again (e.g., Conklin 1957; Chin 1985). A mosaic of farming land, young to old fallows, and primary forest are usually found around swidden farmers' settlements (e.g., Colfer 1997; Wadley, Colfer, and Hood 1997). The land can regain nutrients during the fallow period (Szott, Palm, and Buresh 1999), and weed seed banks are reduced (De Rouw 1995). Furthermore, fallows are actually abundant in useful plants for local people and are actively used by them (Balée 1994, Colfer 1997; Chazdon and Coe 1999; see also Voeks 2004). In addition, early successional species are adopted to open environments created by disturbance (Bazzaz and Pickett 1980). This implies that they are less likely to become extinct by use pressure. Overexploitation of primary forest may be avoided by effective use of secondary vegetation (see also Momose 2005). The traditional swidden agriculture is not a destructive practice, nor are swidden fallows themselves a threat to biodiversity.

This study examines use and classification of plants in primary and secondary environments by the Iban living near the Lambir Hills National Park in Sarawak, Malaysia. The Iban is the largest indigenous group of swidden farmers in Sarawak (Ichikawa 2004). Around an Iban village, a mosaic of swidden fields, young to old fallows, rubber and pepper gardens, orchards, and fragmented primary forests is found (Ichikawa 2004). According to ecological studies conducted in Lambir Hills National Park and the area surrounding it, primary forest has higher diversity of plant species than secondary forest (Momose et al. in this report). Primary forest, however, is decreasing, and secondary forest after logging and farming as well as oil-palm plantations are increasing around Lambir Hills National Park and in Sarawak (Ichikawa 2007). We have to understand the importance of primary and secondary forests for local people as well as their biodiversity to consider the consequence of the land use change. By examining the use and recognition of plants and forests by the Iban, we will show differences in importance of primary and secondary vegetation to the local people who are creating and using the mosaic environment.

## Methods

Fieldwork was conducted in the territory of an Iban village Rumah Chabu (4°10′ N, 114°01′E) near Lambir

Hills National Park, Sarawak, Malaysia in 2003. A vegetation survey in 0.1 ha (10 × 100 m) plots in various environments was conducted as part of a larger ecological project. For our purpose, the vegetation of trees and vegetation on the forest floor was investigated. The vegetation of trees was surveyed in 11 plots: three in fragmented primary forests, two in old fallows (more than 20 years after abandonment), three in young fallows (5 years after abandonment), and three in rubber gardens. All trees ≥ 10 cm dbh (diameter at breast height) were tagged, mapped, measured, and identified. Vernacular names were identified by two Iban informants, who were men about 60 years old.

The vegetation of the forest floor was surveyed in 16 plots: three in fragmented primary forests, five in young fallows, four in new fallows (1 year after abandonment), and four in rubber gardens. Within each plot, small woody and herbaceous plants on the forest floor were identified in forty 1 × 1 m subplots. Vernacular names were identified by the Iban informants.

For an ethnobotanical survey, we collected specimens with the Iban informants and asked them about vernacular names, uses, and places to collect the plants during the vegetation survey and other occasions. We also asked about classification of vegetation types and about traditional belief and stories about forests and plants. Voucher specimens collected in the vegetation and ethnobotanical survey were stored in the Herbarium of the Forest Research Center, Sarawak.

To evaluate the abundance of useful trees ≥ 10 cm dbh, basal area ($m^2$/ha) and density of individual trees (number of individuals/0.1 ha) of all useful species for each use category (Fig. 1) in each vegetation type were calculated. Species that were used for two (or more) categories were included for both of the categories.

For plants of the forest floor, the number of subplots ($n_i$) where a useful species i for a certain use category (Fig. 2) appeared was counted. The sum total of $n_i$ (N) for all useful species for each use category in each vegetation type was then calculated. The density of useful plants was expressed as N per 40 subplots. One plot was counted twice (or more times) for a certain use category when the plot had two (or more) useful species for the category. Species that were used for two (or more) categories were also included in both of the categories.

For analysis of vernacular names (Iban names), primary and secondary names were distinguished. A primary name is a single expression to indicate a taxon, and a secondary name is formed from a primary name by adding a modifier (Martin 1995, 210). Three name types were distinguished (Fig. 3), and the number of species and percentage of individual trees (as found in the vegetation survey of tree ≥ 10 cm dbh) having each name type in each vegetation type were calculated.

## Results

***(1) Useful trees ≥ 10 cm dbh***

Figure 1 shows basal area and density of useful trees ≥ 10 cm dbh. The fragmented primary forests showed much higher basal area of timber species than plots of other vegetation types (Fig. 1A). More timber species were found in the fragmented primary forests (25 species in three plots) than in the old fallows (10 species in two plots), the young fallows (6 species in three plots), and the rubber gardens (4 species in three plots). The Dipterocarpaceae (13 species) contributed 82.7% of basal area of timber species in the fragmented primary forests.

The old fallows showed the second highest basal area and density of food species, while the rubber gardens showed the highest values (Fig. 1). In the rubber gardens, however, rubber trees (*Hevea brasiliensis* Müll Arg.), whose seeds and leaves can be (but were only occasionally) eaten as vegetables, comprised 75.5% of basal area or 77% of individuals of food species. If this species is excluded, food plants were most abundant in the old fallows. There were nine species of food plants found in the old fallows, and five of them were *Artocarpus* spp. These *Artocarpus* spp. produce edible fruits and accounted for 72.3% of basal area or 55% of individuals of food species in the old fallows. *Artocarpus* spp. were also abundant in the rubber gardens and the young fallows. In the old fallows, *Shorea amplexicaulis* Ashton, from whose seeds cooking oil is processed, was also commonly found (13.8% of basal area or 20% of individuals of food species in old fallows).

One of the most common *Artocarpus* spp. in the old and new fallows and the rubber gardens was *A. elasticus* Reinw. The species contributed the most to basal area and density of species used for crafts in these vegetation types. Strong fiber can be obtained from the inner bark of the species and is used for rope. The latex was also often used for birdlime.

The people most often used *Vitex pinnata* L. for firewood. The plant was a dominant species in the new fallows and also abundant in the old fallows and the rubber gardens.

Larger basal area of plants for religious and magic purposes in fragmented primary forests and old fallows than other vegetations were mainly due to *Xylopia* spp. and *Euodia malayana* Ridl., respectively. Branches of *Xylopia* spp. may be burned with *Goniothalamus* spp. (see the fifth subsection of the results) to keep the fire burning longer. *Dillenia suffruticosa* (Griff.) Mart. was also found in old fallows. Branches of *D. suffruticosa* were cut and stuck in rice fields to drive rats and mice away.

***(2) Plants of the forest floor***

The vegetation survey of the forest floor included ferns, herbaceous seed plants, rattans, and shrubs as well as saplings of many tree species. Many more species were recorded than in the survey of trees $\geq$ 10 cm dbh. Many of the species, however, were not used by the Iban. The density of the useless species was excluded from Figure 2.

Vegetable species were most abundant in the young fallows (Fig. 2). Most commonly found vegetable species in the young fallows were *Nephrolepis biserrata* (Sw.) Scott, a fern species especially favored after giving birth, and *Stenochlaena palustris* (Burm.) Bedd., the most favored fern species in the study village. *Gnetum gnemon* L. (leaves as well as fruit and seeds were eaten) and rattans (shoots were eaten) were also common. In the new fallows, *N. biserrata* was similarly abundant, but rattans were rare and *G. gnemon* was not recorded. Vegetable species found in the rubber gardens were similar to those of the young fallows, but their density was lower. *N. biserrata* and *S. palustris* were not recorded in fragmented primary forests, though rattans were common and *Gnetum* spp. were not rare.

The density of medicinal species[1] was similar among the plot types (Fig. 2), but species composition was different. *Lygodium* spp., for example, were very common in the young fallows and also found in the new fallows and the rubber gardens, but not in the fragmented primary forests. The plant was believed to cure a headache in the morning by tying the stem around the head. *Merremia* spp.[1] were abundant in the new fallows, but not recorded in other vegetation types. The plant was used to cure sexually transmitted disease by shamans. *Spatholobus* spp. were found in all vegetation types, but the density was relatively high in the fragmented primary forests and the rubber gardens and rare in the new fallows. When people get injured, they may cut the stem and drink the sap so that the bleeding would stop (but larger stems were used).

In the use category of crafts (Fig. 2), *Dicranopteris linearis* Und., *Melastoma malabathricum* L., rattans, and some other plants were included. *D. linearis*, a fern species, has fiber used for crafts. The species was most common in the rubber gardens and not recorded in the new fallows. *M. malabathricum*, a weedy shrub species, was abundant in the new fallows, but not found in the fragmented primary forests. The fruit was used as a black dye. Rattans were commonly found except in the new fallows. *Archidendron clypearia* (Jack) I. C. Nielsen, whose leaves were used as a blue dye, was commonly found in the rubber gardens (but the leaves were usually collected from lager trees).

The higher density of species of the religious & magic category in the young and new fallows than in the other vegetation types (Fig. 2) was due to high density of *Dillenia suffruticosa* and *Merremia* spp.[1], respectively.

Saplings of timber species showed high density in the new fallows and the fragmented primary forests (Fig. 2). Species composition, however, was different. In the new fallows two pioneer species *Alphitonia excelsa* (Fenzl) Reiss. and *Macaranga gigantea* Müll Arg. contributed 85% of the density value, while five species of the Dipterocarpaceae contributed 51% of the value in the fragmented primary forest.

### *(3) Classification of plants*

Three types of names can be distinguished among Iban names of plants. They are defined as follows: (1) a primary name including one scientific species (type 1 name; e.g., **tekalong** for *Artocarpus elasticus*, **selangking** for *A. nitidus* Trécul), (2) a secondary name including one (or rarely two) scientific species (type 2 name; e.g., **resak kerubong** for *Dipterocarpus geniculatus* Vesque, **resak ensulai** for *D. palembanicus* Slooten), and (3) a primary name including two or more species, but with no secondary name to distinguish them (type 3 name; e.g., **seladah** for *Dacryodes rostrata* (Blume) H. J. Lam, *Santiria laevigata* Blume, and *Scutinanthe brunnea* Thwaites).

The number of species appearing in the survey of trees ≥ 10 cm dbh greatly varied according to plot type, but the number of species which were labeled by type 1 names was almost the same (Fig. 3A). These species accounted for many of individuals in the young fallows (79%) and the rubber gardens (88%) (Fig. 3B).

Type 1 and 2 names distinguish plants to the scientific species level. Most individuals in the young fallows (92%) and the rubber gardens (91%) had type 1 or 2 names (Fig. 3B). This means that most individuals in these vegetation types were linguistically recognized with the same distinctions as scientific species. (We have to add, however, that *Vitex pinnata* and *Hevea brasiliensis*, both of which had a type 1 name, accounted for 42% of individuals in the young fallows and 58% in the rubber gardens, respectively.) In the fragmented primary forests and the old fallows, the percentage of individuals having type 1 or 2 names were only 49% and 53%, respectively.

***(4) Management and use of the vegetations***

Fragmented primary forests were called **pulau,** and were secured to conserve timber for house construction or to protect graves by the study people (timber reserves and cemetery forests are given different names by the Iban of other areas [e.g., Wadley, Pierce, and Hood 1997]). Timber may be logged from cemetery forest when needed. The people did not go to **pulau;** probably because the places were somewhat far from the longhouse. Although not included in the vegetation survey, the people called large primary forest outside their living area (in Lambir Hills National Park) **kampong**. They rarely entered **kampong** because they believed there were lots of spirits, though shamans sometimes went to **kampong** to obtain magical power. An exception was made in the fruit seasons, when other people also went (but not often) to **kampong** to collect fruits and hunt bearded pigs.

The people did not consciously manage fallow vegetations, but usually went to fallows for collecting vegetables, firewood, materials for crafts, and offerings for annual events as well as for hunting. They called fallows one to three years after abandonment **jérami'**, about five years after abandonment **temuda'**, and after many years and with large trees **pangérang**. To collect vegetables, **temuda'** near the longhouse were most often used.

Rubber has not been tapped in the last 20 or 30 years because of low selling price of the latex. When the rubber was tapped, the undergrowth was cut to make the tapping work easier for the villagers, but today there are lots of small trees and grasses covering the rubber gardens. Some fruit trees were planted at edges of rubber gardens.

***(5) Beliefs and stories about forest and plants***

Although not appearing in the vegetation survey, **Ara** (large strangling *Ficus* trees, such as *F. kerkhovenii* Koord. & Valeton) was believed to host spirits and was feared by the people. Some men, however, were said to communicate with spirits on **Ara** to get strong magical power that can absorb other people's vitality and provide an ability like that of **Ara** strangling other trees. The plant was found in (fragmented) primary forest. An Iban story about **Ara** goes like this: A man lost his way in forest. Someone called him, and he followed the voice and found a longhouse. He entered and stayed at the longhouse. In the morning, he found himself on **Ara** and could not get down.

The people used **Selokai** (*Goniothalamus* spp.) for protection from spirits in the forest and the longhouse. The plants were abundant on the forest floor of primary forest (in Lambir Hills National Park). The people believed that lots of evils would come if it rains while the sun is shining. They would put leaves on their ears or burn leaves and branches so that spirits could not see them. They also burned the bark in the longhouse to protect pregnant women and babies from evils. There was a story about **Selokai**: A man went out to hunt bearded pigs. He met a man carrying a bearded pig. They made a fire to bake the pig to eat together, but the man who had been carrying it suffered from the smoke and ran away. The pig turned into a man. There was **Selokai** in the firewood. The man was a spirit and had tried to have the first man eat a human. For another example of a talisman, the people planted **Kemali** (*Leea indica* Merr.) at the border of a cemetery forest after they buried a dead person there so that the ghost of the person would not come out of the forest.

There was a story about **Kuang-Kapong** (Indian Cuckoo, *Cuculus micropterus*; Aihara 2007) and **Kemunting** (*Melastoma malabathricum*). **Kuang-Kapong** made trees fruit in the past. One day, however, **Kemunting** said, “I am the king from today. Plants other than me should not fruit very often.” Plants in forest thus do not fruit very often. On the other hand, **Kemunting** likes rice, so rice fruits well.

## Discussion and conclusion

Fragmented primary forests were conserved by the study people, and the people were getting timber for house construction from there. Actually, the vegetation type had a large basal area of timber species, and they were regenerating well. At the same time, (fragmented) primary forests were not safe places for the Iban because there were lots of spirits. Some plants were used to control or drive away spirits.

In contrast, secondary vegetations were used in everyday life. The young fallows, where the people usually collected vegetables, had rich vegetable flora both in terms of the number of species and their density. A good firewood species was also abundant in the young fallows. There were more fruit trees in the old fallows and the rubber gardens. Plants producing materials for crafts were also abundant in secondary vegetations. For the study people, secondary vegetations were places for humans and their livelihood. **Kemunting** was one of the symbolic plants of the human area, and it helps rice to crop.

The abundance of useful plants in secondary vegetations is probably the result of both natural and cultural factors. The vegetations compared here had different species composition, and thus it is natural that they had different importance to the people. Different cultures, however, may recognize different useful plants in the same vegetation (Voeks 2007). In general, there were more useful plants used in everyday life by the study people in secondary vegetations than in primary forest. This implies that the people have developed more knowledge about plant use of secondary vegetations than of primary forest. By using plants near their settlement, people can save effort to collect plants. The knowledge or use pattern may also be ecologically reasonable. For example, collection of vegetables and firewood from early successional, fast growing species would not seriously threaten the species.

Land use is changing around the study village, and primary forest is decreasing. If primary forest disappears, it will become difficult for people to find large timber for construction. The disappearance of primary forest also means, to the Iban, the disappearance of the place of spirits. Conversely, the secondary forests are now increasing. But if they disappear because of plantation development, people will become unable to find necessities that were once abundant around the village and will have to buy them. As long as the people depend on natural products they collect by themselves, they will conserve primary and secondary forests to the extent that fulfill their needs.

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## Endnote

1. The distinction between medicinal plants and religious and magic plants was not always clear, but the study people distinguished between plants used to cure disease and plants used in religious or magic ceremonies. The former plants were included in the use category of medicine. *Merremia* spp., however, was used to cure disease only by shamans and was included both in the medicinal category and the religious and magic category.

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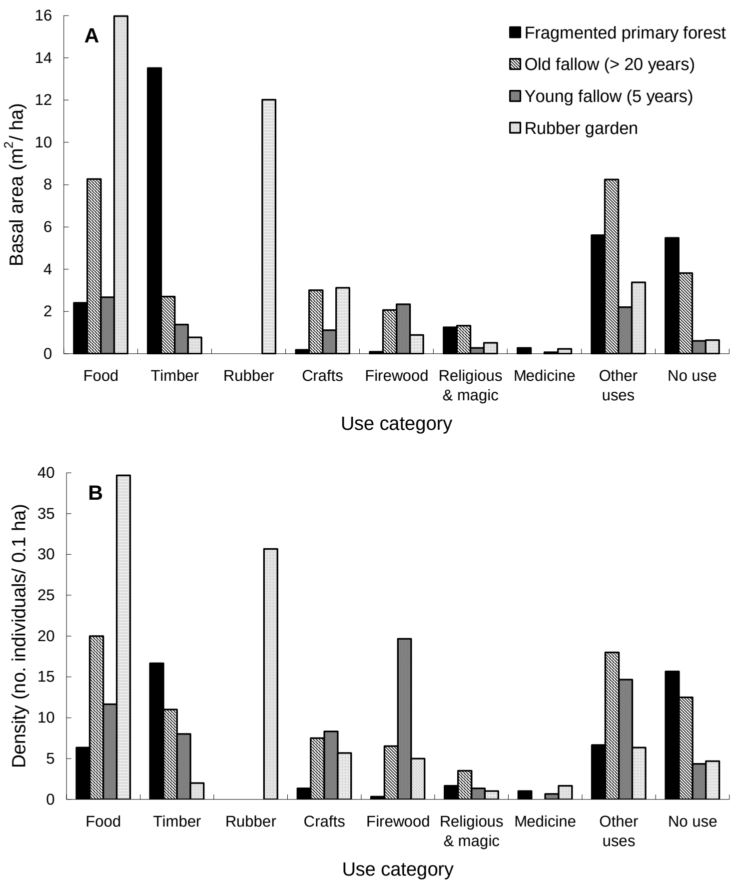


**Fig. 1** (A) basal area ($m^2$/ha) and (B) density (number of individuals/0.1 ha) of useful and useless trees ≥ 10 cm dbh in four types of vegetations.

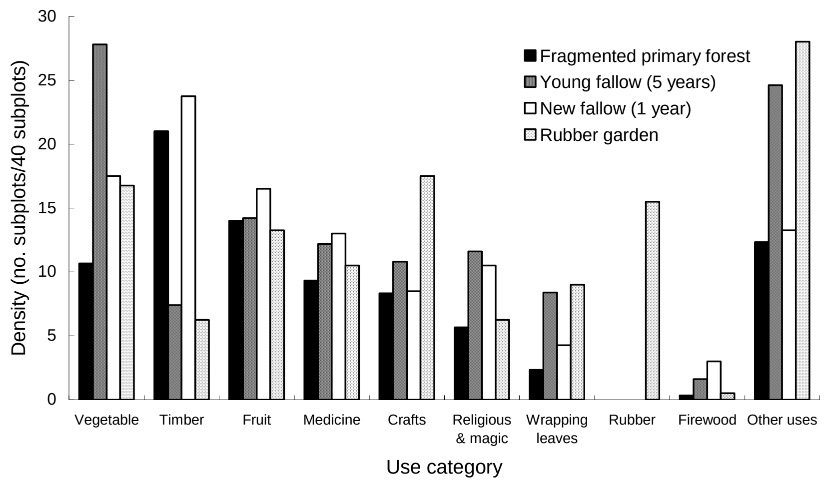


**Fig. 2** Density (number of subplots/40 subplots) of useful plants on the forest floor in four types of vegetations.

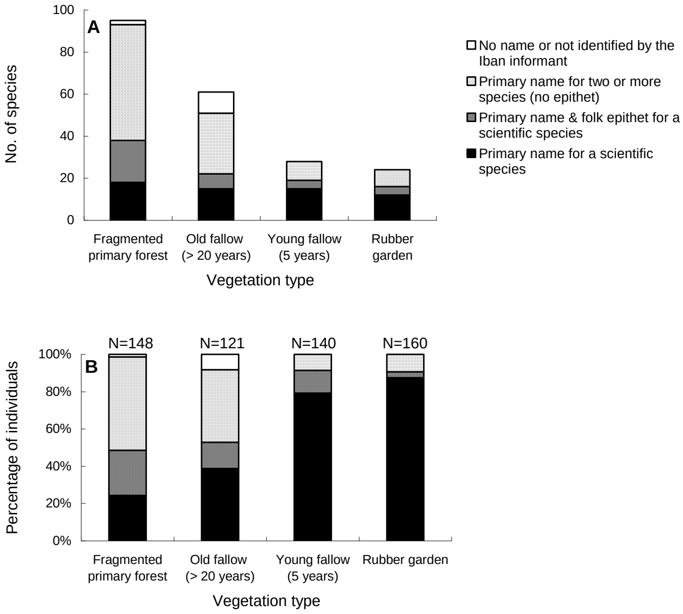


**Fig. 3** (A) Number of species and (B) percentage of individuals (appeared in the survey of trees ≥ 10 cm dbh) having different types of names in the four vegetation types. Data from three 0.1-ha plots are compiled for each of fragmented primary forests, young fallows, and rubber gardens. Data from two 0.1-ha plots are compiled for old fallows.

# Iban Knowledge of Wild Birds in a Habitat Mosaic

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## Introduction

Birds play important roles in people's culture. Birds often have symbolic meanings and are related to traditional culture and belief systems (e.g., Feld 1988; Hagiwara 1996). In Borneo, people practice bird augury, and it affects people's activities (e.g., Hose and McDougall 1901; Richards 1971; Jensen 1974; Sather 1984). Birds also economically contribute to people's life. Bird's nests and hornbill's casques, for example, have been traded by local people of Borneo to Chinese traders (Freeman 1999).

Birds contribute to people's culture and economy and at the same time use habitats created by human activities. Traditional coffee agroforests have proved to create a complex habitat and support a rich avifauna. (Moguel and Toledo 1999). Different human management of lands results in different compositions of birds even under the same area (Kataoka, Iwata, and Prawiradilaga 2006).

This paper reports on the importance of birds to the Iban living near Lambir Hills National Park, Sarawak, Malaysia. Primary and secondary environments in the area are analyzed for the number of bird species and individuals having cultural importance to the Iban. The objective of the study is to show how the Iban recognize the importance of birds in a habitat mosaic created by their subsistence and economic activities.

## Methods

Fieldwork was conducted in Lambir Hills National Park, Sarawak, Malaysia (4°12´ N, 114°02´E at the headquarters) and Rumah Chabu, an Iban village (4°10´ N, 114°01´E at the longhouse), from April to July and from September to October 2005 and from September to October 2006. The main vegetation type of Lambir Hills National Park is lowland mixed dipterocarp forest (Yumoto and Nakashizuka 2005). Rumah Chabu is situated 4 km from an edge of the national park and has a population of about 400. Around the village, swidden fields, swidden fallows, wet rice fields, rubber gardens, orchards, fragmented primary forests, and some other environments were found.

The plot census method (Yui 1997) was used to estimate composition of wild bird species in different habitats. Thirty-two 10 × 100 m plots in seven vegetation types were used. In primary forest of Lambir Hills National Park, five plots were located on the forest floor and two plots were located along a walkway at a height of 20 m. In and around Rumah Chabu, nine plots were in fragmented primary forests, five plots were in rubber gardens, five plots were in old fallows (more than 20 years after abandonment), three plots were in middle-aged fallows (about 7 years), two plots were in young fallows (about 3 years), and one plot was in a village open space. The fragmented primary forests were protected by the villagers as timber reserves and spiritual places. The rubber gardens were not used for tapping rubber during the study period, and fruit trees and herbs were also abundant. In the old fallows, small and large trees were found. In the middle-aged fallows, there were small trees, but herbaceous plants were still abundant. The young fallows were covered by herbaceous plants and shrubs. The village open space was almost bare, but some herbaceous plants were found. Each plot was surveyed three (or two) times between 0700 and 1200 hours, and birds seen or heard were counted. (Detailed information concerning these vegetation types is reported by Momose et al. and Kaga et al., and detailed ecological results of this census are included in Itioka et al. in this report.)

To collect ethnoornithological information, birds were observed in various habitats in and around the Lambir Hills National Park and Rumah Chabu with an Iban informant (key informant), who was a man about 60 years old. For observed wild birds, the informant was asked for Iban names, uses, and other information. Additional information was collected from five informants (the key informant and four other men above 50 years old) by showing pictures in a field guide to birds of Borneo (Francis 1984) They were selected as informants because of several dozens of villagers interviewed, they were the only people who were knowledgeable about birds. Uses of birds were also observed in the study village.

For analysis of cultural importance of birds to the Iban, importance categories shown in Tables 1 and 2 and Fig. 1 were distinguished. They include not only practical importance but also spiritual importance. Furthermore, pests were considered to be culturally "important" in the sense that they had negative roles in people's lives.

For analysis of names, primary and secondary names were distinguished. A primary name is a single expression, even if composed of more than one constituent (e.g., **Tandok-ulat** [lit. 'antenna of caterpillar'] for Common Iora, *Aegithina tiphia*), and a secondary name is a name formed from a primary name by adding a modifier (Martin 1995, 210). In terminal rank, some species were labeled by primary names and others by secondary names. Primary and secondary names in terminal rank are called terminal names in this paper. The number of species that were labeled by a terminal name was also analyzed. The number was judged from the present study, and thus the number of species that were distinguished to the species level by Iban names can be an overestimate.

## Results

***(1) Cultural importance of birds to the Iban***

A total of 150 species were observed during the study. Among them, 126 species appeared in the plot census, but 24 species were observed only in other occasions. According to the ethnoornithological information, 85 species (57%) were culturally important to the Iban, and 65 species (43%) were not (Table 1). Three species had two kinds of importance to the Iban, while the rest of the culturally important species had one.

Thirty-nine species were related to the Iban belief system and stories. According to informants, for example, if people hear the song of **Bubut** (Greater Coucal, *Centropus sinensis*), someone would die at their longhouse. **Jerruit** (tailorbirds, *Orthotomus* spp.) is **udok antu** (spirit dog) of **Antu Gerasi** (giant spirit that hunts humans), and people would not be able to return home and would die if they followed the song of **Jerruit** in forest. If people hear the song of **Beragai** (Scarlet-rumped Trogon, *Harpactes duvaucelii*) when they are in forest for hunting, they hunt bearded pigs. At **Gawai** (Iban ceremony or festival), two men sang about **Lang sengalang** or **Lang laut** (Brahminy Kite, *Haliastur indus*), a spirit of a war chief, and other six bird species, which were said to be sons-in-law of **Lang sengalang** (a lot of literature [e.g., Jensen 1974] has reported seven sons-in-law of **Lang sengalang**, but we recorded only the six). These birds were **Ketupung**

(Rufous Piculet, *Sasia abnormis*), **Beragai** (Scarlet-rumped Trogon), **Papau** (Diard's Trogon, *Harpactes diardii*), **Nandak** (White-rumped Shama, *Copsychus malabaricus*), **Panguas** (a woodpecker species), and **Bejampong** (Crested Jay, *Platylophus galericulatus*). In a ceremony of constructing a new house in September 2006, eight packages of rice in leaves were prepared for the seven birds and **Antu Petara** (favorable spirit). Ten sticks of trees called **Paung burong** were also buried at the base of pillars after blood of a chicken and a pig was poured to the ground. To prepare **Paung burong**, the key informant went to forest before dawn on the ceremony day and waited until **Nandak** started to sing at dawn. He then pulled out saplings about 30 cm in height by his right hand on hearing the song (any species of tree can be used). According to the key informant, **Paung burong** is used to avoid **Antu Gerasi** coming to the house, avoid bad dreams, cure disease, get a lot of money, and so on.

According to informants, all but the seven species related to the ceremonies above may be eaten, but **Empulu** (bulbuls, *Pycnonotus* spp.) and **Puna** (Pigeons, *Treron* spp.) are usually eaten. We included 34 species, the reported species and some others that were observed to be eaten during the study, in the category of food. Birds were caught by birdlime, net, and gun. Birdlime was most often used to hunt smaller birds during agricultural activities. Birdlime was made from the latex of *Artocarpus elasticus* Blume and attached to the top of a wooden stick about 30 cm long. The stick would be put near a small stream or pool in the forest to hunt birds coming for bathing. The technique was said to be effective when it had not rained for three or more days. Birds were usually baked and eaten in the field. **Engkeruak** (White-breasted Waterhen, *Amaurornis phoenicurus*) was often found at ridges between wet rice fields. According to informants, villagers mimic the call of the bird to attract them and then hunt. The birds are usually eaten by whoever hunted them, but can be sold at a market near the village at a price of 10 Malaysian Ringgit (RM).

Two species were used for decoration. A hat decorated with plume of **Ruai** (Great Argus, *Argusianus argus*) was observed on the last day of **Gawai** held in July 2005. In the night after dinner, one villager wearing the hat danced around a pillar decorated with banana leaves and fruits and sweets and finally cut off one of the fruits or sweets. He handed the hat to another man, and then the same performance was repeated again and again. Great Argus is a protected species (Appendix II of CITES), but the longhouse was keeping the plume so that it could be used in the future. The hat was stored as soon as the ceremony was finished. For another example, villagers put plumes of **Bruie** (Black Hornbill, *Anthracoceros malayanus*) in frames and vases.

**Entalik** (Blue-crowned Hanging Parrot, *Loriculus galgulus*) and **Bayan** (Long-tailed Parakeet, *Psittacula longicauda*) can be sold. These species are favored as pets because they have beautiful colors and an interesting habit of hanging upside down from a twig. The villagers have not been catching them in recent years, but they used to be caught in September and sold at the price of 20 RM and 10 RM, respectively.

Eleven species were recognized as pests by villagers. Flocks of **Pipit** (munias, *Lonchura* spp.) were observed at rice fields, though the damage was not serious. When a flock of **Tiong batu** (Hill Myna, *Gracula religiosa*) was eating the fruit of **Kemayau** (*Canarium* sp.), villagers made fire to drive them away by the smoke. **Manaul** (hawks) eat chickens that villagers keep, and villagers sometimes shoot **Manual** so that they would not come. As far as the key informant knew, villagers shoot about 10 individuals a year. **Banggau** (egrets of white colors, two species of *Egretta*) can be both pests and beneficial birds. They eat fish in ponds.

Villagers threw rocks when they saw the birds in ponds. They, however, also eat pest insects in swidden and wet rice fields. The key informant said that he was waiting for **Banggau** to come. The birds usually come to the study area in September. Although **Achang** (Domestic Pigeon, *Columba livia*) was not included in the study, villagers did not like the birds because they lived in the longhouse and soiled it.

***(2) Iban names of birds (classification of birds)***

Among 150 species studied, 139 species (93%) had Iban names and 11 species (7%) did not (Table 1). Informants said that they did not know the 11 bird species without an Iban name. The 139 species were labeled by 94 different names in terminal rank (65 primary names in initial rank). We distinguish four types of Iban names of birds by the number of species included in a terminal name (one or more species) and the structure of the name (primary or secondary name) (Table 1). First, some species were distinguished to species by a primary name (e.g., **Bubut** for Greater Coucal, *Centropus sinensis*; **Entekop** for Lesser Coucal, *C. bengalensis*). Percentages of bird species labeled in this way were 35% for culturally important species (for detailed categories, 44% for species related to Iban belief system and stories, 21% for food species, etc.) and only 12% for culturally unimportant species.

Second, some species were distinguished to species by a secondary name (e.g., **Puna bedidi** for Large Green Pigeon, *Treron capelli*; **Puna bagau** for Thick-billed Pigeon, *T. curvirostra*; **Engkechong lilin** for Chestnut-winged Babbler, *Stachyris erythroptera*; **Engkechong kubok** for Black-throated Babbler, *S. nigricollis*). Among the birds studied, 55% of culturally important species were distinguished to species either by primary or secondary names, while 31% of culturally unimportant species were distinguished to species.

Third, some species were labeled only by primary names and not distinguished to species (e.g., **Banggau** for Chinese Egret, *Egretta eulophotes* and Little Egret, *E. garzetta*). Names that were included in this name type usually included two or three species. Exceptions were **Engkechong**, which included 12 species of babblers (culturally unimportant species; but some abundant babblers were distinguished by secondary names, and their names were included in the second type), **Tagerih**, which included 5 species of woodpeckers (culturally unimportant species), and **Kangan**, which included 4 species of flycatchers (food species). Twenty-six species or 40% of culturally unimportant birds had this type of name.

Lastly, some species were labeled by secondary names, but not distinguished to species (e.g., **Puna mayang** for Little Green Pigeon, *Treron olax* and Pink-necked Pigeon, *T. vernans*; **Empulu betul** for Olive-winged Bulbul, *Pycnonotus plumosus*, Red-eyed Bulbul, *P. brunneus*, and Cream-vented Bulbul, *P. simplex*).

***(3) Habitat types and cultural importance of birds to the Iban***

The birds were not evenly observed among different habitats. In the village open space and the young fallows, fewer species were observed than in forested habitats (Table 2). The number of individuals, however, generally declined as the succession progressed (Fig. 1A). In the rubber garden, both the number of species and the number of individuals were high.

In the rubber gardens, culturally important birds were also rich in the number of species and number of individuals (Table 2, Fig. 1A). The number of culturally important birds was largest in the village open space and second largest in the young fallows (Fig. 1A), though they include a limited number of species (Table 2). This is because some culturally important species were abundant in these habitats. The smallest number of individuals of culturally important birds was observed in the primary forest (Fig. 1A). In the primary forest, five species that appeared in the plot census did not have an Iban name (Table 3). A total of 11 species observed during the whole study period did not have an Iban name, and seven of them were found only in primary forest of Lambir Hills National Park. The rubber gardens were richest in the number of species, but all the species had Iban names (Table 3).

The number of species related to the Iban belief system and stories was largest in the rubber gardens (Table 2). Among forested habitats, the number was smallest in the primary forest. The primary forest also had the smallest number of individuals in this category (Fig. 1B). The number of individuals was largest in the village open place. The most often observed species of the category in the village open place was Chinese Egret (*Egretta eulophotes*; 3.64 individuals/0.1 ha, 5 h).

Regarding birds for food, the number of species was similar among forested habitats, though the number was somewhat smaller in the middle-aged fallows (Table 2). The number of individuals of food species was more abundant in the young fallows and the rubber gardens than in other habitats (Fig. 1B). Villagers often hunted birds in orchards and rubber gardens during the study period.

Rhinoceros Hornbill (*Buceros rhinoceros*) has an important symbolic meaning in the Iban culture and is used for decoration (Hose and McDougall 1901; Freeman 1999), but the species was not observed during the study. According to the key informant, recently the species is rarely seen, even in Lambir Hills National Park. He said this was because trees of their favorite fruits were disappearing. Plumes of other hornbills are also used for decoration by the Iban (Freeman 1999), but only Black Hornbill was observed in the study. The birds came out from primary forest in the morning and used various habitats during daytime. Great Argus, another species for decoration, was observed in various forested habitats.

Among the two species for pets, a small flock of Blue-crowned Hanging Parrot was observed only once in the canopy of primary forest (but not in the plot census). The people used to catch the birds in fragmented primary forests, but they ceased to catch and sell them because the species were rare and small and thus difficult to catch. Flocks of the other species, Long-tailed Parakeet, were often observed in rubber gardens.

More pest species were found in the rubber gardens than other habitats (Table 2). The number of individuals of pest species was largest in the village open space, followed by the young fallows and the rubber gardens (Fig. 1B). The most common pest species in the village open space and the young fallows were Philippine Glossy Starling (*Aplonis panayensis*; 10.8 individuals/0.1 ha, 5 h) and Dusky Munia (*Lonchura fuscans*; 4.75 individuals/0.1 ha, 5 h), respectively.

## Discussion

Importance of birds in the Iban belief system has been reported in many studies (e.g., Richards 1971; Jensen 1974; Sather 1984). The results of the present study further supported this importance. The number of bird species included in the category of belief and story was larger than other cultural importance categories, and nearly half of the bird species in the category were named to species by a primary name. Religious practices related to birds were often observed during the study. Birds also had some importance as food. Villagers hunted birds during agricultural activities and ate them as snacks, though they were not for main meals.

Some birds were recognized as pests. However, they were not causing serious damage to the Iban life, and the people dealt with pest birds, except for hawks, in simple ways such as making smoke and throwing rocks. Furthermore, people knew that some pest species help agriculture by eating pest insects.

Different vegetations had different importance to the Iban in their avifauna. The primary forest was less rich than other types of forest in the number of culturally important species. It is difficult to observe birds in primary forest because of limited sight and the height of the canopy. Furthermore, the Iban do not usually enter primary forest (Kaga et al. in this report). They only have very limited chances to observe bird species that are mostly found in the canopy. The relationship between the Iban and birds in primary forest is not so strong. Some species, especially hornbills, however, have special importance to the Iban culture.

Fragmented primary forests and primary forest around Lambir Hills National Park have similar vegetation structure (Momose et al. in this report), but the composition of bird species was different. Birds observed in the former habitat were usually using a habitat mosaic, while about a half of bird species observed in the latter habitat were found only in primary forest. The fragmented primary forests were somewhat richer than the primary forest in the number of species and number of individuals of birds related to the Iban belief system and stories. The result in the old fallows was similar to that of the fragmented primary forest. In the middle-aged fallows fewer species and more individuals were observed than in the old fallows, but the proportion of bird species and individuals of each importance category was similar.

The rubber gardens were richest in the number of species having cultural importance. Individuals of culturally important birds were also relatively abundant. Rubber was not being collected during the study period because of the low price. Villagers, however, were growing fruit trees, collecting wild vegetables, and hunting birds there. Rubber gardens had a mixed vegetation of trees and herbs. Fruit orchards are probably playing a similar role for birds to rubber gardens; birds hunted by villagers in orchards were similar to those hunted in rubber gardens.

Most of the birds seen in the village open space and the young fallows had some importance to the Iban, though only limited species were coming to these habitats. Birds can easily be observed in these habitats, and people often pass these habitats. This may help people to develop cultural recognition of the birds there. Pests were abundant in these habitats and rubber gardens. They are probably attracted to the habitats made by human activities.

## Conclusions

Secondary environments were important both for the Iban culture and for the biodiversity of birds. Many bird species and individuals were utilizing habitats or a habitat mosaic made by human activities, and the Iban readily recognized the birds in their living places and the birds that were important to Iban culture and life. On the other hand, primary forest was generally less important for the Iban culture related to birds, though there were some culturally important species there.

A relatively large area of primary forest around the study site is protected as Lambir Hills National Park. Land use of secondary vegetations, however, changes according to social circumstances and people's decisions. A plantation company was inviting the study village to make oil palm plantations in the village land. Leaders of households were discussing the invitation. The land use pattern of oil palm plantation is different from that of orchards and rubber gardens in its monocropping over a large area. If the land use changes the avifauna, it will also affect the Iban culture.

Furthermore, the key informant worried most that present young people did not want to go to the forest and that they could not learn about birds. The young generation is attracted to city life, and only some old people in the study village knew birds well. Social change itself is affecting the Iban culture.

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**Table 1** Cultural importance of birds to the Iban and their Iban names

| Importance | Named to species: By primary name | Named to species: By secondary name | Not named to species: By primary name | Not named to species: By secondary name | No name (not known) | Total |
|---|---|---|---|---|---|---|
| *Culturally important* | | | | | | |
| Belief and story | 17 | 7[b] | 9[c] | 6 | 0 | 39[bc] |
| Food | 7 | 6 | 14[c] | 7 | 0 | 34[c] |
| Decoration | 2 | 0 | 0 | 0 | 0 | 2 |
| Pet (sold) | 2[a] | 0 | 0 | 0 | 0 | 2[a] |
| Pest | 3[a] | 5[b] | 2 | 1 | 0 | 11[ab] |
| Subtotal | 30 | 17 | 24 | 14 | 0 | 85 |
| *Culturally unimportant* | 8 | 12 | 26 | 8 | 11 | 65 |
| Total | 38 | 29 | 50 | 22 | 11 | 150 |

Note: Data are compiled from the plot census and other observations during the study.
For the total and subtotal, a species included in more than one category is counted as one.
[a] One species is included in the categories of "pet (sold)" and "pest."
[b] One species is included in the categories of "belief and story" and "pest."
[c] One species is included in the categories of "belief and story" and "food."

**Table 2** Habitat types and bird species having different cultural importance to the Iban

| Importance | Primary forest | Fragmented primary forest | Rubber garden | Old fallow | Middle-aged fallow | Young fallow | Village open space |
|---|---|---|---|---|---|---|---|
| Belief and story | 14[a] | 23[ac] | 29[ac] | 21[ac] | 18[a] | 6[ac] | 8[c] |
| Food | 20 | 18[c] | 22[c] | 19[c] | 15 | 8[c] | 5[c] |
| Decoration | 2 | 2 | 2 | 2 | 2 | 0 | 0 |
| Pet (sold) | 1[b] | 1[b] | 1[b] | 0 | 0 | 0 | 0 |
| Pest | 2[ab] | 4[ab] | 9[ab] | 4[a] | 4[a] | 4[a] | 3 |
| Not used | 27 | 27 | 28 | 24 | 18 | 4 | 1 |
| Not known | 5 | 2 | 0 | 1 | 0 | 0 | 0 |
| Total | 69 | 74 | 88 | 69 | 56 | 20 | 16 |

Note: Data are compiled from the plot census. For the total, a species included in more than one category is counted as one.
[a] One species is included in the categories of "belief and story" and "pest."
[b] One species is included in the categories of "pet (sold)" and "pest."
[c] One species is included in the categories of "belief and story" and "food."

**Table 3** Habitat types and the Iban names of birds

| Name type | Primary forest | Fragmented primary forest | Rubber garden | Old fallow | Middle-aged fallow | Young fallow | Village open space |
|---|---|---|---|---|---|---|---|
| *Named to species* | | | | | | | |
| By primary name | 17 | 23 | 27 | 19 | 18 | 1 | 6 |
| By secondary name | 15 | 20 | 23 | 17 | 16 | 7 | 4 |
| *Not named to species* | | | | | | | |
| By primary name | 22 | 17 | 22 | 20 | 14 | 6 | 5 |
| By secondary name | 10 | 12 | 16 | 12 | 8 | 6 | 1 |
| *No name (not known)* | 5 | 2 | 0 | 1 | 0 | 0 | 0 |
| Total | 69 | 74 | 88 | 69 | 56 | 20 | 16 |

Note: Data are compiled from the plot census.

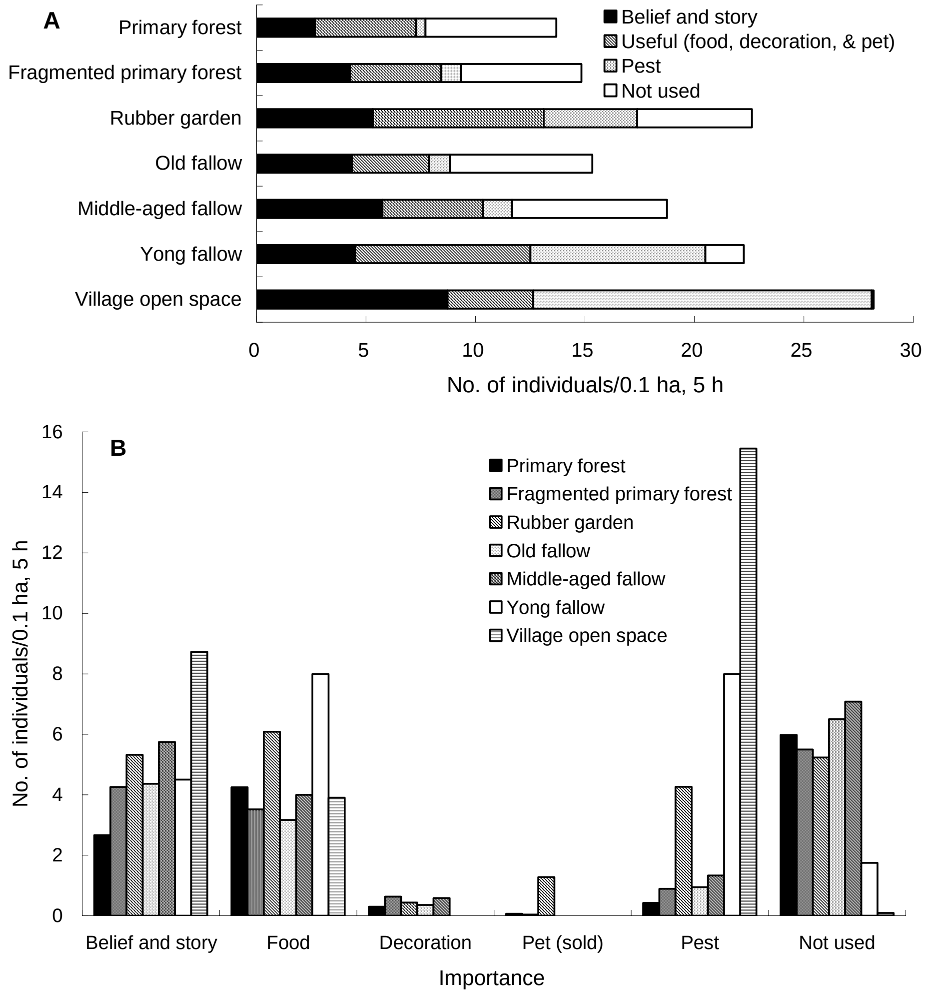


**Fig. 1** Habitat types and abundance of birds having different cultural importance to the Iban, sorted by (A) habitat types and (B) cultural importance categories.