ITTO
Borneo Biodiversity Expedition 1997
Scientific Report

Collaboration between the Governments
of Indonesia and Malaysia
Sponsored by
International Tropical Timber Organization (ITTO)

The 1997 Borneo Biodiversity Expedition to the Trans-boundary Biodiversity Conservation Area of Betung-Kerihun National Park

(West Kalimantan, Indonesia)

and

Lanjak-Entimau Wildlife Sanctuary

(Sarawak, Malaysia)

September - November 1997

Scientific collaboration between the Governments
of Indonesia and Malaysia
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PREFACE

The presence of two adjacent nature conservation areas, the Lanjak Entimau Wildlife Sanctuary (LEWS) in Sarawak, Malaysia, supported by the ITTO Project PD 106/90 and the Betung Kerihun National Park (BKNP) in West Kalimantan, Indonesia, which is also supported by the ITTO Project PD 26/93, covering a total area of about one million hectares of primary forests straddling the Indonesian-Malaysian boundary on the island of Borneo, has prompted the ITTO to promote the establishment of the Lanjak Entimau/Betung Kerihun Biodiversity Conservation Area as an entity, which was launched by both governments on 7 October 1994. This is perhaps the largest transboundary conservation area of tropical rainsforests providing a unique opportunity for joint management to enhance its conservation value.

Discussion among members of the ITTO and during the Indonesia/Malaysia bilateral forestry cooperation dialogue gave birth to the idea of conducting a joint scientific expedition as a first concrete step in implementing cooperation in the biodiversity conservation area. As an Organization dedicated to promote the conservation, management and sustainable development of tropical forests, the ITTO approved and provided financial resources to undertake such a scientific expedition at its Twentieth Council Session held in Bolivia in May 1996. The venture was then named *ITTO Borneo Biodiversity Expedition 1997* or **IBBE '97**.

The IBBE '97 was designed to provide a better understanding of the rich flora and fauna of the area and the cooperation forged amongst scientists from the two countries together with a better appreciation and knowledge of the lives of the local communities in the area, will provide a stronger basis to formulate a realistic strategy and plan to manage this transboundary coservation area.

The Expedition involved scientists of several disciplines in the fields of flora and fauna, as well as social scientists and anthropologists. It was conducted at the Betung Kerihun National Park, from 1-29 September 1997, in the middle of a heavy haze and smoke due to the rampant forest fire occuring in the region during that time. The start of the Expedition at the Lanjak Entimau Wildlife Sanctuary and the Batang Ai National Park, on the Sarawak side was delayed for about six weeks while waiting for the haze and smoke to abate; it was finally conducted between 12-27 November 1997, where the IBBE '97 formally ended in a closing ceremony at Kuching, Sarawak.

The Expedition was conducted in a very high spirit of cooperation among the scientists of the two countries as well as scientists from the World Conservation Union, the International Plant Genetic Resource Institute, and the Royal Geographical Society of London. The assistants and field workers, boat operators and drivers formed a cohesive team with the scientists in contributing to the success of the Expedition.

The IBBE '97 could never have materialized without the staunch support of both the Governments of Indonesia and Malaysia, particularly Ir. Djamaludin Suryohadikusumo, Minister of Forestry of Indonesia, Datuk Patinggi Tan Sri Abdul Taib Mahmud, Chief Minister of Sarawak, and H. Aspar Aswin, Governor of West Kalimantan who acted as Patrons to the Expedition.

Results of the Expedition are most heartening. Notes on the vegetation and flora reveal richness in biodiversity, some of which are of rare, unknown and perhaps new species. Special notes were recorded on the rich palm flora, enumeration were done on the orchids and the mosses. Tree species richness and vegetation types were described as well as the use of plants by the local communities for food, medicinal and other purposes.

Habitats of primates including the orang utan, were observed and bird diversity were counted and studied. Many species of fish were caught, BKNP showed a higher number of endemic species than at LEWS. Observations of the herpetofauna, the creeping animals of the forest floor, show that of several species of frogs, lizards and snakes, some might be new species.

Assessment of the socio-cultural aspects of the communities living near the forest area and surveys on socioeconomic aspects were also undertaken, revealing interesting sides of their lives. It was noted that 365 plants were used by the local people for various purposes, some of which are cultivated. The presence of these people near the park is not considered a threat to biodiversity conservation because of the small scale of the disturbance.

It is our ardent hope that the results of the Expedition, published in this scientific edition jointly prepared by Robert B. Stuebing and Christopher P.A. Bennet as rapporteurs, could find application in the joint management of the biodiversity area. This Expedition is also the beginning of a fruitful cooperation among the scientists of the two nations which will later hopefully be developed through more joint activities to enhance the management efforts of the trans-boundary conservation area, the Betung Kerihun National Park in Indonesia and the Lanjak Entimau Wildlife Sanctuary and the Batang Ai National Park in Malaysia.

Needless to say, the proper management of this conservation area will benefit not only the scientific world and sustainable tropical forest development, but also and most important, it will and should benefit the local people living within and in its surroundings. Equally, ITTO's success in helping to establish this transboundary conservation area and the experience gained in organizing IBBE '97, will hopefully inspire similar exciting developments in other tropical regions of the world.

March 1, 1999
Yokohama, Japan

Dato' Dr. Freezailah Bin Che Yeom
Executive Director
International Tropical Timber Organization

EXECUTIVE SUMMARY

1. GOALS AND OBJECTIVES OF THE EXPEDITION

The joint scientific expedition took place in selected sites within the two protected areas of Betung Kerihun National Park (BKNP) and Lanjak Entimau Wildlife Sanctuary (LEWS), and conducted observations on biodiversity resources, land forms and unique features as well as the socioeconomic characteristics of communities living adjacent to the forests. This information was for the formulation, implementation and strengthening of management plans for protection and conservation of biological diversity, while ensuring that the needs of local communities are met.

Specific objectives of the Expedition included:

- ❑ Surveys of topography and water courses of the study areas
- ❑ Inventories of flora and fauna along with their habitats
- ❑ Inventories of major timber tree species for breeding potential
- ❑ Biophysical inventories of the expedition sites
- ❑ Socioeconomic analyses complemented by studies of ethnobotany and ecotourism potential

The expedition was also intended to train young scientists, to identify areas for further study and follow-up action and to create awareness among local people about the value of safeguarding natural resources. In BKNP, the expedition aided the formulation of strategies for involvement of local communities in conservation management (LEWS is a totally protected area). Some socioeconomic research was, however, done in Batang Ai National Park, adjacent to LEWS in Sarawak.

2. ORGANIZATION

The patrons of the expedition were the Minister of Forestry, Indonesia; the Governor of West Kalimantan, Indonesia; and the Chief Minister, Sarawak, Malaysia. The Joint Steering Committee for the expedition, chaired by the Executive Director of the ITTO, appointed a National Coordinator from Indonesia and from Malaysia to work with an Expedition Coordinator for planning and implementation purposes.

Participants included Malaysian and Indonesian ITTO members, representatives from IUCN, IPGRI and the Royal Geographic Society (U.K.).

Malaysian partners included Sarawak Forest Department (responsible for logistics in LEWS), Sarawak Museum, Sabah Museum, Forest Research Institute of Malaysia (FRIM), Malaysia Nature Society (MNS) and the Sarawak Timber Association (STA). Indonesian participants included the Department of Forestry and its Forestry Research and Development Agency (FORDA), the Indonesian Institute of Sciences (LIPI), Tanjung Pura University, Gadjah Mada University, Padjadjaran University, the University of Indonesia, the Bandung Institute of Technology (ITB), the Indonesian Biodiversity Foundation (KEHATI), the Indonesian Forestry Community (MPI) and the Worldwide Fund for Nature (WWF) responsible for logistics in Bentuang Karimun).

3. PLANNING AND IMPLEMENTATION

The joint expedition was launched formally on 1 July 1997, and by 4 September, Indonesian and Malaysian scientists entered BKNP. Scientific methodologies maximised data and specimen collection while minimising impact on habitats. Logistics were handled by the WWF (Indonesia) in BKNP and the Sarawak Forest Department in LEWS. Comparable field methodologies were used in both research areas.

The first phase of the Expedition was undertaken from 1-29 September in BKNP, while the second phase in LEWS was conducted from 12-27 November 1997. Originally planned to run immediately after the BKNP phase, the LEWS phase was postponed for approximately six weeks because of adverse weather conditions and the low river levels in Sarawak.

Phase I of the expedition (1-29 September 1997), took place in the western part of BKNP, the upper Embaloh River of the upper Kapuas region. It included the park and some nearby villages, extending from the village of Sadap (60 m. a.s.l.) to the summit of Bukit Condong (1,244 m. a.s.l.). Field sites included four camps in riparian and lowland dipterocarp, hill dipterocarp, and sub-montane habitats.

Phase II in LEWS (12-26 November, 1997) was conducted from camps reached via the Katibas River from Song, in Sarawak. The two camps were established in lowland dipterocarp forest and riverine forest habitats at approximately 120 m. a.s.l.

The expedition was officially closed in Kuching on 27 November 1997.

4. SCIENTIFIC FINDINGS

The expedition yielded abundant scientific data, including documentation of many new records, rare and new species. Important preliminary comparisons between floral and faunal communities in BKNP and LEWS have been made.

a) Vegetation

The Botany teams found immense diversity in BKNP-LEWS, represented by new species, new records for plant localities and observations of rare species. Potentially new species were found from the genera *Loxocarpus*, *Ardisia*, *Lepisanthes* and *Microtropis*. *Jarandersonia parviflora* from BKNP, is a new record for Kalimantan. The rare plant, *Cyrtandra mirabilis*, was also recorded in BKNP.

Approximately 62 species of palms were identified, of which two are new to science. *Pogonotium ursinum*, a rattan palm from Sarawak was recorded for the first time in Indonesia. Altogether, there were 13 new palm records from BKNP, and three new records from LEWS.

A total of 50 genera and 120 species of orchids were collected, including 105 living specimens of 61 species. The rarest of them was *Dimorphorchis lowii*.

A total of 168 species of Bryophytes were found, two to three times the number of species characteristic of tropical areas in other parts of the world. Ten fungal samples were collected by the botanists, amongst them a *Cordyceps* sp., parasitic on an ant (mycological samples were not systematically sampled).

The Forest Ecology group evaluated plots at various elevations in lowland dipterocarp, hill dipterocarp, sub-montane and montane forests. Forest plots showed high diversity, where about 80% of all individuals sampled belonged to different species. Both BKNP and LEWS were rich in the Dipterocarpaceae (excellent for gene banks), although densities were higher in LEWS. Dipterocarps were less abundant in old secondary forests, and essentially absent from montane habitats. LEWS was rich in wild fruit trees.

An important ecological observation was the encouraging recovery of the forest ecosystem after shifting cultivation plots were abandoned some thirty years ago. Full recovery may, however, be decades away.

b) Fauna

Fish surveys revealed both high diversity and endemism, recording 125 fish species from 12 families (91 species from BKNP and 61 from LEWS), of which about one dozen are endemic. A total of 21 species are being compared with museum specimens; many are probably new to science. Two species of *Glaniopsis* and a species of *Gastromyzon* were observed for the first time in Kalimantan. *Tor* spp., an important food resource, also indicators of relatively undisturbed forest and good water quality, were abundant.

Herpetologists recorded a total of 65 species of herpetofauna (41 amphibians and 24 reptiles) in BKNP-LEWS. More than half of the frogs were endemic, two are probably new species. Some interesting differences were seen between herpetofaunal assemblages of the two areas. Drought conditions apparently suppressed breeding activity of amphibians in BKNP and LEWS, despite the rains during November.

Ornithologists recorded 291 bird species from 39 families, including at least two-thirds (20) endemics and 17 migrant species, representing approximately 70% of Borneo's lowland forest avifauna. Oddly, a commensal (town-dwelling) tree sparrow (*Passer montanus*), was observed in Derian camp. Hazy atmospheric conditions probably affected some species, particularly at higher elevations. *Zoothera interpres,* an uncommon lowland thrush, was mist-netted on Bukit Condong. *Pitta nympha* (Fairy Pitta) was a new record for Lanjak Entimau. Several individuals of three different species ringed in 1994 were recaptured in LEWS.

Hazy conditions in BKNP seemed to subdue primate activity. Despite this, Expedition primatologists recorded six primate species (orangutan, gibbon, maroon and white-fronted langur, pig-tailed and long-tailed macaque) in BKNP-LEWS. In primary forests there were signs that densities of *Presbytis frontata*, *P. rubicunda* and *Hylobates muelleri* were high. Orangutans (*Pongo pygmaeus*) were detected in forest areas recovering from the impact of past shifting cultivation. Macaques (*Macaca nemestrina* and *M. fascicularis*) were commonly observed in riparian and ex-shifting cultivation areas. BKNP-LEWS is estimated to contain about 3,000 orangutans and more than 50,000 gibbons, and forms an extremely important area for primate conservation in Borneo.

c) Ethnobotany

The Ethnobotany team identified 323 species of plants useful to the Tamambaloh and Iban Dayaks in the longhouse and village settlements adjacent to BKNP and LEWS. There were 41 plants recorded for medicinal use, 144 for food (including 24 varieties of rice), 38 for ritual and ceremonial use, 30 for building purposes and 60 for miscellaneous use. One of the most interesting plants was the *bunga padek* flower, cultivated with rice plants to reduce damage from birds. Also, plants of *Hornstedtia* spp. are used as indicator species to indicate when shifting cultivation plots can be cultivated again.

d) Genetic Resources

A scientist from the International Plant Genetic Resources Institute (IPGRI) participated in the Expedition on the Sarawak side, and identified the local olive-like *dabai* fruit (*Canarium odontophyllum*), rich in oil and protein as having potential for further development of new varieties. The economically important pepper plant (*Piper* spp.) was also identified for the development of new genetic strains, to produce disease and pest resistant stocks.

e) Socio-Economy

Anthropologists and sociologists concentrated their efforts in nine Iban and three Tamambaloh Dayak villages at the perimeter of BKNP and in several Iban longhouses in the vicinity of Batang Ai National Park (adjacent to LEWS). The concept of *kampung galau* (Iban) or *toan palalo* (Tamambaloh), a natural forest kept intact for future use or daily needs, represents a local ethnocultural theme in harmony with the conservation of BKNP-LEWS.

f) Ecotourism

Ecotourism is increasingly perceived as playing a major role in conservation. A comparative ecotourism study was conducted in Batang Ai National Park with application to BKNP where ecotourism programmes are an integral part of future management. Ecotourism can provide alternative land use to curb further forest degradation, and can be integrated with other management programmes, although the remoteness of BKNP raises questions about its future significance to park management.

5. CONCLUSIONS

This pioneer expedition should mark the beginning of a wider programme of scientific studies. Future research and monitoring should have the following focus:

- Systematic inventories of the flora and fauna designed to sample all the major habitat types, including river systems via standardised methodologies;
- All samples must have GPS records so that the biological data can be integrated with other geophysical and climatic data using GIS;
- Data from the above should be utilised to identify important habitats on the basis of species richness, species diversity or endemicity;
- Important environmental gradients need to be assessed for changes in biodiversity, which will include altitudes, topography/landscapes, hydrological systems, etc.;
- An essential component of trans-boundary conservation areas must be further explored, that is migration of people and animals as well as global dispersal and the impact these movements have on maintaining biophysical integrity of the combined protected areas;
- The above data will be used to identify important areas for biodiversity conservation and for identification of management zones;
- Institutional research should explore mechanisms of information exchange amongst expeditionary scientists and protected area management authorities. This should include an assessment of future training needs.

The interaction between the Indonesian and Malaysian scientists and between institutions and agencies was extremely valuable. The scientific information acquired provided essential information for both conservation and strengthening of protected area management. The Expedition has enhanced the scientists' understanding of the value of initiatives for the management of trans-national protected areas and the importance of future scientific efforts as well as the necessity of integrating the aspirations and abilities of local communities for the success of conservation and management programmes. Although challenges remain, ultimately an appreciation of the close relationship between ecology and economics can be harnessed to provide balanced and effective conservation and management.

GLOSSARY

Local Word / Abbreviation	Definition
KEHATI	Indonesian Biodiversity Foundation
BANP	Batang Ai National Park (Sarawak)
BKNP	Betung-Kerihun National Park
Bukit (Bkt)	Hill
Dbh	tree diametre at breast height
FORDA	Forestry Research and Development Agency (Indonesia)
FRIM	Forest Research Institute of Malaysia
IPGRI	International Plant Genetic Resources Institute
ITB	Institute of Technology,Bandung (Indonesia)
ITTO	International Tropical Timber Organization
IUCN	International Union for the Conservation of Nature (now the World Conservation Union)
Kawasan (Kw)	Area (administrative)
Kerangas	Distinct forest of poor, sandy soils where "rice will not grow" (Iban)
LEWS	Lanjak-Entimau Wildlife Sanctuary
LIPI	Indonesian Institute of Sciences
Ma	Million years ago
m a.s.l.	Metres above sea level
mm	Milimetres
MPI	Indonesian Forestry Community
Ng or Nanga	River Mouth
Rh or Rumah	House (used in conjunction with the name of the headman for Iban longhouses)
Sg or Sungai	River
TR or Tuai Rumah	"Leader", or head of a longhouse
Ulu	Upper reaches of river
WWF	Worldwide Fund for Nature

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I

INTRODUCTION

I. INTRODUCTION

1. A BRIEF GEOLOGICAL HISTORY OF BORNEO

Borneo is the world's third largest island with a land area of 451,865 km^2. It is located at the eastern edge of the Sunda shelf as part of the Sundaic portion of the Old World Tropics. The South China Sea separates it from Peninsular Malaysia and Sumatra at depths rarely exceeding 200 m. Borneo is an important area of Palaeotropical biodiversity, with more than 1,000 species of land vertebrates. This diversity has arisen through a complex history of geographical isolation derived from tectonic activity and changes in climate and sea level.

Borneo is part of the Sunda Shield of Cretaceous or older age (> 60 million years old). The precursors of today's mountain ranges of Kapuas Hulu, Iran, Apo Duat and others formed the central craton or rigid crustal fragment of this entity. The only areas of present-day Borneo that were above sea level were parts of what is now western Sarawak, western and southern Kalimantan. Other parts of the island are of late Cretaceous age, and therefore are of more recent origin. The collision of the northward-moving Australian Continent with the Southeast Asian plates about 50 Ma, caused the Bornean fragment to begin a gradual counterclockwise rotation, pivoting at a point just northeast of present-day Pontianak[1]. This rotation had a profound impact on the development of the aquatic and terrestrial biota of Borneo. The counterclockwise movement resulted in increased volcanic activity, uplift and orogeny (mountain building). Accumulation, followed by uplift of sedimentary rocks, led to the appearance of most of what is now Sarawak, Sabah and Brunei, while igneous and metamorphic activity contributed to the formation of the central mountain ranges. In upper Kapuas, the Embaloh Complex was formed during post-Eocene and originated from volcanic activity. The youngest portion, between the Apokayan and Nieuwenhuis Mountains (northeast of the Embaloh River) is part of a Plio-Pleistocene volcanic complex. The Embaloh River basin itself is slightly older, and embedded in a steeply folded region of basaltic and andesitic rocks, giving the rivers their dramatically steep valleys and smooth, black bedrock bottoms. Generally, the rocks of Borneo become younger as we proceed towards the northeast. Borneo's highest mountain, Mt. Kinabalu, is in fact very young, from one to ten million years old.

[1] Hall & Blundell (1996)

The soils of the Malaysian portion of the island are derived primarily from Tertiary to recent alluvial deposits in its coastal areas, and a mixture of early to late Tertiary sandstones and shales, with some metamorphic content in the interior Belaga Formation.

One of the most significant geological events influencing the biota of Borneo was the severing of the terrestrial connection between Borneo and Sumatra. This event was caused by increased sea levels, which rose during interglacial periods from the beginning of the Pleistocene (2 Ma) until about 10,000 years ago after the last ice age. During this time major habitat changes also took place as a result of alternation of warmer, humid and cooler, drier climates. This gave rise to further cycles of dispersal, contraction and isolation of floral and faunal elements, contributing to the rich endemism characteristic of Borneo's biological communities.

Climate, rainfall and watersheds

The climate of Borneo is equatorial, with constant high temperatures and heavy, well-distributed rainfall. These conditions may not have been constant over the last several million years. Currently, rainfall is concentrated during two monsoons. The Southwest Monsoon is weak and occurs from May to early July. The heaviest rainfall for the northern and western portions of Borneo occurs during the Northeast Monsoon from December through February, usually causing localised floods in the interior, and flooding in coastal areas every few years.

In most parts of the island, annual rainfall ranges from 2500 - 4000 mm, though lower (< 800 mm) or much higher (> 5000 mm) amounts fall in particular areas. In the extreme northeastern (7° N) or southern (4° S) portions of the island, variations in the usual stable climate can occur in the form of moderate to severe droughts which have been reported to occur at least as far back as the mid 19th Century. In modern times, these droughts have occurred in conjunction with the El Niño-Southern Oscillation phenomenon and have resulted in serious forest fires, particularly where the original forest canopy has been disturbed.

Major drainages in Borneo include the Kapuas, Barito and Mahakam Rivers in Kalimantan, the Kinabatangan and Padas in Sabah and the Baram, Rajang and Batang Lupar in Sarawak. The largest of these are the Rajang and Kapuas, the hinterland of which includes much of the central portion of the island. All these rivers originate as swift rocky streams in the interior, at altitudes above 1000 m a.s.l., carrying large quantities of silt as they cut a meandering course through the lowlands, forming broad deltaic areas of mangrove at their seaward boundaries.

2. EARLY DOCUMENTATION OF BORNEAN NATURAL HISTORY

Among the earliest written accounts of Borneo's exotic natural history is that of Rumphius, who arrived in 1623, a German citizen employed by the Dutch East India Company. His accounts of poison trees and other exotic flora and fauna spurred the imagination of a generation of European naturalists and explorers to seek new discoveries in Borneo. During the later period, when the Dutch and British were at the height of their colonial domination of Southeast Asian trade, a wave of these adventurers followed naval or trading ships to explore what was then an extremely mysterious and unknown world, the Borneo rainforest. Among the foreign explorers of the 19th century were the naturalists Kuhl, van Hasselt, Schweiner and Bleeker in Indonesian Borneo. One of the greatest field naturalists of all, Alfred Russell Wallace, visited and collected specimens in Sarawak in the mid-1800s[2]. Other famous figures were professional collectors such as Charles Whitehead, civil servants such as Sir Hugh Low (a former Governor of Labuan) and in this century, F.N. Chasen. In 1894, one of the first trans-Borneo Expeditions, led by the Dutch Explorer Anton W. Nieuwenhuis (accompanied by his wife, Ms. M.J.T. Nieuwenhuis-Uexküll Guldenband) passed through the Ng Menyakam area in what is now Bentuang-Karimun National Park.

Flora

Until the 20th century, approximately 90% of Borneo was under natural forest cover. At present, forests still cover more than 60% of the land area, though most have been disturbed by human activities. Coastal mangrove forests dominate the deltas of major rivers, while other coastal areas have patches of heath or *kerangas* vegetation on elevated sandy substrate, with peat swamp forests growing inland in poorly drained areas. On lowland podzolic soils mixed forests are dominated by the family Dipterocarpaceae, which extend into hilly areas forming dipterocarp forest of a different species composition on slopes from 300-900 m a.s.l. Above 1000 m, the forest canopy is lower and a submontane (oak-dominated) forest type is increasingly common above 1300 m. Stunted and gnarled trees of *Dacrydium* and *Leptospermum* become the dominant trees above 1500 m. Truly alpine vegetation is found only on Mt. Kinabalu above 3000 m. From the standpoint of floral diversity Borneo forms the richest portion of the Sundaic sub-Region, approaching the numbers of species recorded in other extremely

[2] Wallace (1869)

species rich areas such as New Guinea or parts of the Neotropics (South America)[3]. Borneo is the centre of distribution for the paleotropical Dipterocarpaceae, a family of trees with 262 known species (34% of which are endemic) and 59 genera unique to the island. Dipterocarps dominate Borneo's lowland and hill forests and form the bulk of the valuable timber species. Besides trees, Borneo possesses a wealth of other unique plants including at least two thousand species of orchids, and numerous other rare endemics including seven or more species of the parasitic giant flower, *Rafflesia*.

Fauna

The greatest diversity of the Bornean fauna lies overwhelmingly with the invertebrates, the majority of which remain little studied. Research on some taxonomic groups indicates that there are hundreds of undescribed species, many of which are endemic. The vertebrate fauna of Borneo is also extremely rich. It bears close resemblance to the other Sundaic fauna and probably shares a common origin on the Asian mainland. Strangely, faunal similarities between Borneo and its near neighbours, Sulawesi and the Philippines, on the other side of the so-called Wallace Line are few, probably because these areas have never been connected by dry land. There are 119 indigenous species of mammals, excluding bats and marine mammals, of which approximately one-third are endemic, compared to 4.5% for Peninsular Malaysia and 10% for Sumatra[4]. Borneo is also a natural centre of diversity for birds, about 36 endemics representing about 5% of the approximately 600 known resident and migrant species. The Bornean avifauna is an integral part of the Indo-Malayan realm, which is mostly Asian in character, with a few groups (*e.g.*, hornbills, pheasants and sunbirds) shared with tropical regions of Africa. Affinities with Australian Region to the south are weak.

For herpetofauna (amphibians and reptiles), Borneo possesses the highest species richness in Southeast Asia (Irian/Papua New Guinea excluded). Endemism is high, and about 40% of amphibians and more than one quarter of all snakes and lizards are restricted to the island. The fish fauna is by far the most diverse among the vertebrates of Borneo, with 99 families possessing a total of 394 species of which nearly 40% are endemic.[5] New species of freshwater fish are still discovered with every new scientific survey from the lesser known rivers of the Bornean interior.

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[3] MacKinnon et al (1996)
[4] Payne (1985)
[5] Kottelat (1993)

3. THE ROLE OF ITTO IN RECENT CONSERVATION EFFORTS

The involvement of the International Tropical Timber Organization (ITTO) in efforts to conserve biodiversity in Borneo dates from the findings of the ITTO Mission to Sarawak, 1989-1990. In their report entitled, "The Promotion of Sustainable Forest Management: A Case Study in Sarawak, Malaysia", the ITTO Commission concluded that the conservation of biological diversity in Sarawak was best served through the *in situ* preservation of the State's natural heritage. The measures that were recommended towards the accomplishment of this goal included preservation of :

- ❑ a complete series of representative widespread habitats (various forest types, for example) to be accomplished by ensuring that a full range of soil types and altitudes is included;
- ❑ examples of all unusual habitats or areas with rare or endemic species;
- ❑ viable populations of animals, especially large mammals and birds which require large home ranges;
- ❑ species which are naturally rare or endangered, or subject to intensive harvesting, such as orchids.

These recommendations were consistent with the policies of the Government of Malaysia and the State of Sarawak, to preserve areas of significant geological, biological or historical value for the benefit, education and enjoyment of present and future generations. Lanjak-Entimau had already been recognized as early as the 1980s and gazetted as a Wildlife Sanctuary in 1983 for conservation of wildlife in general, and for the orangutan in particular. The boundaries on the ground were demarcated by the Sarawak Forest Department. Thus, the Development of Lanjak-Entimau as a Totally Protected Area [ITTO Project PD106/90 Rev.1(F)] was implemented by the Forest Department of Sarawak in early 1993, and completed in 1996. This Project, subsequently identified as Phase I, involved compilation and analysis of data derived from scientific surveys of the primates, birds, herpetofauna, forest ecology and socioeconomy of the area. In addition, a detailed plan was written for protection of the area, plans for the extension and use of the area by local people. Plans were put forward suggesting further research on the flora and fauna, as well as formulation of recommendations on the locations of research centres and subcentres, manpower needs with inclusion of a detailed financial plan. A follow up Project [PD 15/95 Rev. 3(F)], known as Phase II, based on these recommendations and the management plan, was approved in 1996 and inaugurated in early 1997. During Phase II, construction of new facilities for protection, management and research, is currently underway.

In conjunction with the Projects in Sarawak, the ITTO Council also approved a sister project in West Kalimantan, Indonesia for funding the development of the approximately 800,000 ha Betung-Kerihun National Park. The Project [PD 26/93 Rev. 1(F)] was funded through the Department of Forestry of Indonesia; implementation by WWF Indonesia began in November, 1995. The primary objective is to develop a model of natural forest management through a national park system that will serve both species and ecosystem conservation and assist in the socioeconomic development of local and regional communities. The main components of this effort are:

- ❑ development of BKNP as a national park by conserving the biodiversity values of the area with its research, education, recreation and tourism potential
- ❑ initiate regional development, and promote bilateral cooperation in economic, scientific, educational, cultural fields and tourism between Indonesia and Malaysia, particularly between West Kalimantan and Sarawak.

The ITTO Betung-Kerihun National Park Project was concluded in 1998 with the submission of a management plan and proposals for future development based on the original objectives.

The Betung-Kerihun National Park (BKNP) Project

Betung-Kerihun National Park[6], the largest conservation area in West Kalimantan, was established on 5 September 1995 by the Ministry of Forestry of Indonesia, within the administrative district of the Upper Kapuas River. The Park is located between 112° 15' E to 114° 10' E and 0° 40' N to 1° 35'N, covering an area of almost 800,000 ha. The average annual rainfall is ca. 4,500 mm per year, at altitudes ranging from less than 100 m in the west and south to 1,960 m in the interior. Most of the habitat is composed of primary lowland dipterocarp forest. The areas around the Mt. Condong (1,244 m) complex include parts of swamp and hill forests, montane and mossy forests. There are also areas of regenerating or secondary forest in various stages of succession in the Embaloh watershed where slash-and-burn agriculture by temporary illegal settlers was abandoned during the 1960s. Preliminary surveys of the flora and fauna indicated a rich diversity, and the

[6] For additional details, see Soedjito (1997)

presence of significant populations of endemic or threatened Bornean species such as the bulwer's pheasant and orangutan. The river systems abound with fish. A 1996 survey of a single watershed, the Sibau, identified 81 species. Insect species, though only causally surveyed, also held some surprises since 25 species of ants were found in a relatively small area.

Three sites have been identified for permanent facilities for headquarters or field stations in the future, namely, Tekalan Camp in the Embaloh, Menyakan in the Sibau and Bungan in the Kapuas Koheng watersheds. Tekalan is intended for research in rainforest ecology, where a large altitudinal gradient provides ecosystems from lowland dipterocarp to montane forests. A history of traditional agriculture also provides many successional stages for the study of forest regeneration. There is also a substantial population of orangutans in the area which is ideal for primatological studies. The Menyakan site possesses long undisturbed lowland forest, and is intended for research into the dynamics of this primary habitat. The Bungan station, with a distinctly different geological history than the above areas, besides lowland dipterocarp forest, has both the highest elevational zone (1,960 m) and a limestone forest on Mt. Kerihun.

The Lanjak-Entimau Wildlife Sanctuary (LEWS) Project

Lanjak-Entimau Wildlife Sanctuary lies within the rugged topography in south-western Sarawak between 111° 53' E to 112° 281/2' E and 1° 19' N to 1° 51' N, in parts of the Kapit, Sarikei, Sibu and Sri Aman Divisions. Administratively, it is part of the Districts of Song, Kanowit, Julau, Lubok Antu and Sri Aman. The total area of the Reserve is about 168,000 hectares, composed principally of rugged, hilly terrain from about 60-1200 m above sea level. Lanjak-Entimau rock formations are roughly between 40-60 million years old (Cretaceous to Upper Eocene), consisting mainly of sandstone, shales and slates. Soils are generally poor, and the majority (86%) are unsuitable for agriculture.

The watersheds of the Batang Lupar and Rajang rivers lie within the Sanctuary boundary. Annual rainfall ranges from 2000-4000 mm.

Based on preliminary studies in 1993-94, there are seven basic forest types in Lanjak-Entimau: alluvial; lowland dipterocarp; hill dipterocarp; summit ridge; submontane mossy; montane mossy; and old secondary forest. The Sanctuary also contains secondary forest from 30-130 years old. The rare, giant flower *Rafflesia* has been reported from several of these old secondary forest areas. Several new species of plants have been discovered during recent surveys. Also, at least 140 different kinds of medicinal plants have been identified. Lanjak-Entimau's primate fauna includes one of the few viable populations of the orangutan in Borneo, and substantial numbers of the rare white-fronted langur, and the bornean gibbon. A total of 203 bird species have been recorded, and seven of the eight Bornean hornbill species breed there, as well as the spectacular great argus and rare bulwer's pheasants. Seventy-five species of herpetofauna have been recorded, with four previously undescribed ones reported in 1994. Fish diversity is high; at least two new species were discovered among the 35 species collected in 1994.

A research station currently exists at Nanga Segrak in the southern area of ulu Engkari. A Headquarters is now under construction in ulu Katibas in the north, at Nanga Bloh. A ranger station for the Sanctuary has been constructed at one of the most densely populated areas near the boundary, at ulu Mujok in the west, while another ranger station will be built in 1998 in ulu Skrang, to curb intrusions of illegal hunters, and others.

Local Communities

There is a unique assemblage of cultures around BKNP. Dayaks groups include the Bukat Mendalam, Bukat Metelunai, Iban, Kantu', Kayan Mendalam, Tamambaloh and Taman Sibau; hunter-gatherer Punan are also represented. There are four local village groups, in the form of longhouses, near BKNP with a total of about 2,300 inhabitants. Although this low number reduces the threat of human incursions into the Park, it also can limit human resources available for development of sustainable use programmes such as ecotourism. Currently, indigenous activities that are carried out near the boundary, and sometimes within the Park, are collection of saleable forest products such as *gaharu* wood (*Aquilaria malaccensis*, *A. beccariana*). Some illegal commercial activities, such as gold mining and *gaharu* collecting by outsiders, take place within the park boundary; this requires action for the future protection of certain watersheds such as Kapuas Koheng and Bungan.

An estimated 12,400 Iban people live in the periphery of LEWS. A socioeconomic study has shown that only about half of this population has a formal education, and virtually all are involved in shifting agriculture. Most households are still without electricity and face a chronic shortfall of rice production, which must be supplemented with purchases from towns. Cash crops are not popular because of high-cost maintenance (fertilizers, pesticides, etc.) and poor infrastructure, resulting in high transportation costs. Average incomes for individuals living near the boundaries of LEWS are well below the State Government's official poverty line. Local communities still depend on the Sanctuary for supplies of forest produce, fish and wild game. A majority of local residents, however, approve of the existence of the Sanctuary, and its status as a Totally Protected Area.

4. BACKGROUND OF THE 1997 IBBE

The unparalleled significance of the tropical regions to biodiversity conservation is well known. Rainforests may contain half of all living species, with lowland tropical rainforests harbouring the greatest number of different species. While centres of biodiversity are the focus of many conservation efforts, it is also important to recognize the existence of a biodiversity continuum across geographical regions. Rarely are the boundaries between species as sharp as the borders between countries. Trans-national park management can provide a solution to potentially contradictory approaches of separate management schemes. In Borneo, Malaysia and Indonesia with the support of the International Tropical Timber Organization (ITTO) are developing the concept of trans-national protected area management. The BKNP-LEWS Biodiversity Conservation Area was jointly launched on behalf of the Government of Malaysia by His Excellency Datuk Patinggi Tan Sri Haji Abdul Taib Mahmud, The Honourable Chief Minister of Sarawak, and on behalf of the Government of the Republic of Indonesia by His Excellency Bapak Djamaludin Suryohadikusomo, Minister for Forestry, at the Hilton Batang Ai Resort on 7 October 1994. This historical ground-breaking ceremony inaugurated one of the first transnational conservation efforts in tropical Asia. The ceremony underlined the serious commitment of Indonesia and Malaysia to conserve the great endowment of biological diversity in their tropical forests. It also demonstrated the determination of the ITTO to assist its member countries to promote sustainable forest management and to encourage them to join in wider efforts for sustainable forest management at the international level.

Fortunately, because of generous financial support from ITTO since 1993, the Governments of Indonesia and Malaysia have been able to initiate new surveys of the biota and the various ethnic groups, filling some of the gaps in previous knowledge. The most recent of these surveys, the subject of this report, was the 1997 ITTO Borneo Biodiversity Expedition, an ITTO-sponsored cooperative effort between the Governments of Malaysia and Indonesia to make an inventory of the flora and fauna of this under-explored region of Borneo and to initiate long-term field studies to promote sustainable protected area management. The Expedition was also a vehicle to enhance cooperative relations between scientists and researchers from the respective countries, providing an excellent opportunity for mutual exchange of information on research techniques, staff training and the development of long-term ties between scientific and management staff of both countries. The development of such close working ties will undoubtedly result in the improved conservation and management of the huge (ca. 1,000,000 ha) Betung - Kerihun / Lanjak - Entimau Biodiversity Conservation Area.

The preparation of management plans for the protected forest areas of BKNP (West Kalimantan, Indonesia) and LEWS (Sarawak, Malaysia) has illustrated some of the most important challenges of biodiversity conservation (ITTO Projects, No. PD 26/93 Rev.1(F) and PD 106/90 Rev.1(F), respectively). These areas not only have the rich biodiversity and endemism characteristic of Borneo, but they also create bilateral opportunities to strengthen protected area management as well as scientific endeavours in general.

Preliminary studies in Lanjak-Entimau from 1993-1995 had provided the basis for belief that this area of Borneo is one of the richest and diverse biomes on earth, and as such should be conserved. To strengthen bilateral research and development ties related to achieving successful trans-national collaboration in park management, the Government of Malaysia and the Government of the Republic of Indonesia agreed in 1996 upon the need for a joint scientific expedition of the above ITTO projects in the Betung Kerihun National Park and the Lanjak Entimau Wildlife Sanctuary. The proposal for The ITTO Borneo Biodiversity Expedition was made at the twentieth session of the International Tropical Timber Council's Committee on Reforestation and Forest Management at Santa Cruz de la Sierra, Bolivia, 21-29 May 1996. A Joint Steering Committee was subsequently set up in February, 1997 to organize and implement a collaborative expedition, which came to be known as the 1997 ITTO Borneo Biodiversity Expedition. The ITTO sponsored expedition took place from September to November 1997.

5. OBJECTIVES AND ORGANIZATION OF THE EXPEDITION

The principal aim of this joint scientific expedition was to study selected sites within BKNP and LEWS, making observations of flora and fauna, natural resources, land forms and unique features as well as the socioeconomic characteristics of communities living in and around the forests. Findings in

BKNP were to contribute to the preparation of the management plan whereas those in LEWS would add to the growing knowledge of value to park managers.

Specific objectives towards this aim were[7]:

Scientific Research for BKNP-LEWS

(1) Inventories of flora and fauna along with their habitats.
(2) Socio-economic and ethnobotanical surveys.
(3) Assessment of ecotourism potential in view of the above.
(4) Expedition results as inputs to protected area management.

General Educational Value

(5) Opportunities for young scientists to learn from senior scientists.
(6) Increase public awareness about biodiversity value.

Future Activities

(7) Identification of issues for further action and follow-up action. (See section V on trans-boundary protected area management).

The Expedition was divided into small teams of experts or specialists from the relevant disciplines in Indonesia and Malaysia, accompanied by assistants drawn from local communities near the Reserves. A Team Leader, who coordinated the work in the field, was responsible for producing a technical report of scientific findings. A list of the organizers and participants from the Expedition and their respective affiliations is given in Appendix 10.

6. SELECTION OF REPRESENTATIVE EXPEDITION SITES

Expedition sites in BKNP and LEWS were selected as far as possible to be both representative of the BKNP-LEWS conservation area and of unique scientific value.

BKNP

Research in BKNP was conducted from the lowlands at approximately 100 m elevation in the watershed of the Embaloh River, all the way to the 1,244 m

[7] ITTO (1997)

summit of Bukit Condong. Four camp sites were selected and facilities constructed for accommodation of the Expedition members. These camps, which were occupied from 4-26 September, 1997, comprised:

Pakararu camp (01 ° 23.85' N, 112 ° 28.056' E) - located on the Embaloh river, next to Nanga Pakararu, at approximately 100 m a.s.l. It was characterized by a mixture of lowland dipterocarp, mixed dipterocarp and hill forest communities. There were also nearby areas of secondary forest 30-40 years old both by the river and along small spurs or ridges. Three shelters were constructed for sleeping, cooking and eating.

Aur camp (001 ° 24' N, 112 ° 28' E ; GPS not available) - a subcamp of Pakararu on the Embaloh River, surrounded by alluvial and hill forests, with areas of secondary growth from 5-10 years old. This camp was erected for the faunal group, who conducted bird ringing, herpetofaunal and fish collecting there from 20-23 September.

Derian camp (01 ° 26.646' N, 112 ° 28.196' E) - located from one to four hours, depending on water levels, upriver on the upper Tekelan at the mouth of the Pajau River, in a steep valley at about 130 m a.s.l. The surroundings consist of primary and hill forests, with some old secondary growth. Three shelters were built for storage, cooking and sleeping.

Pait camp (01 ° 28.557' N, 112 ° 27.998' E) - located approximately five hours overland from Derian, at an elevation approximately 250 m a.s.l. The surrounding habitat is alluvial, primary dipterocarp and hill forests and also contains some secondary forests about 30 years old as well as an area which was cultivated about 5 years ago.

Bukit Condong camp (01° 29.742' N, 112° 27.809' E) - located approximately four hours overland above Pait, at an elevation of about 1,000 m a.s.l. The habitat consists of primary lowland and hill dipterocarp and submontane forests. There was also a cleared helicopter pad near the summit of Bukit Condong about one hour above the Condong camp. The actual summit, about 1,244 m a.s.l., is about 30 minutes walk above the helicopter pad.

LEWS

The research in LEWS was conducted from 12-26 November, 1997 at two different locations, both of which could be reached by longboat. Both camps had cooking and sleeping quarters under canvas, with space for cooking, washing and bathing.

Nanga Menyarin camp (001 ° 39.212' N, 112 ° 13.568' E) - located beside the Katibas River near Bukit Guning downstream from the Bedawak River at approximately 120 m. a.s.l. The highest elevation near the camp was about 480 m. The habitat consists of old secondary and primary forests, with some active shifting agriculture plots nearer to the junction of the Katibas and Bloh Rivers.

Nanga Joh camp (001 ° 37.513' N, 112 ° 17.845' E) - located on the Bloh River at the junction of the Joh, a moderate-sized stream. The nearest hill (about 400 m a.s.l.) is Bukit Pelanduk. The forest here is mainly old to medium-aged secondary forest along the river, though downstream hills can be found which have primary forest. There is some active shifting agriculture downstream nearer to the Katibas-Bloh junction.

Weather conditions in BKNP were dry and hazy, and deteriorated further as the Expedition progressed. By late October, extremely low river levels forced postponement of the Sarawak part of the Expedition until mid-November. Work resumed on 12 November, and because of the improvement in weather conditions, was completed without hindrance by 26 November, when the teams departed from the ulu Katibas camps in Lanjak-Entimau.

Draft field reports were submitted by members to the respective team leaders by mid-January. Team leaders forwarded their final reports to the Expedition coordinators in mid February 1998. Because of the time needed to sort through the large collection of botanical specimens the flora report was submitted in July 1988. Executive summaries of expedition findings were presented to the ITTO in November and an updated version in May 1998. The final report was submitted to the ITTO in August 1998.

II

VEGETATION

A. FOREST CLASSIFICATION

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1. INTRODUCTION

In Lanjak-Entimau, ecological surveys first carried out during Phase I of Project PD106/90 Rev.1(F) identified seven major forest formations. These are the alluvial forest, lowland dipterocarp forest, hill dipterocarp forest, summit ridge forest, submontane or lower montane forest, montane forest and old secondary forest. Three plots of 50x50 metres were established in each of these forest types in three study areas, giving a total of 63 plots. This plot size was reduced to 30x50 meters in the lower montane and montane forests where the terrain was difficult and steep and the forest much denser.

Altogether 8,586 trees attaining breast height diameters of 10 cm and over were enumerated representing about 1,075 species from 67 families. 791 species of trees are below 10 cm dbh, while non-tree flora comprising lianas, palms and herbs are represented by about 177 species.

In Betung-Kerihun, ecological study was initiated in Hulu Bungan and Sibau by Indonesian ecologist Tukirin Partomihardjo and his team just before IBBE (1997). A plot size of 20x50 metres with duplicates were established at regular intervals of 100 metres. Apart from recording all species present, distinct communities showing species dominance were identified. The survey recorded 551 species of trees from 68 families and 175 genera up to diameters of 10 cm dbh and over were identified. 50 species are believed to be endemic to Borneo. Dominant communities encountered were identified as *Dryobalanops* forest, *Hopea* forest, *Shorea* forest and *Tristania* (=*Tristaniopsis*) forest. In addition, two plots were established in the upper montane forest on Bukit Condong.

2. STUDY AREAS

The forests of BKNP and LEWS are typical of the inland forests of south-western Borneo. Each forest type is essentially similar in stature and structure. In the case of LEWS, the seven forest types have been recognized based on factors of soils and altitude. Ashton[1] has observed that there is a strong forest type-soil relationship in northwest Borneo which obscures altitudinal zonation. The shallow soils in much of the north-western and southern parts of Borneo have been caused by successive periods of uplift and erosion which led to loss of clay minerals and nutrients. The classification of forest types in Peninsular Malaysia into lowland dipterocarp, hill dipterocarp, lower montane and montane forests based on altitudinal sequence is believed to be either not recognizable or inconsistent in Sabah and Sarawak.

Forest-soil relationships for the seven forest types in LEWS are shown in Table 1. The soil physical properties show a wide variation between the localities particularly in texture and depth. On this basis, the classification into lowland and hill dipterocarp forests (LDF and HDF) is less precise. It has been similarly reported that the two forests in Mulu National Park are continuous and overlap floristically[2]. The dipterocarp forest here grows to an altitude of 800 m a.s.l. before it meets the lower montane forest at the transitional zone.

For planning and management purposes in Sarawak, the forest is classified by terrain classes ranging from Class 1 to Class 4. Terrain Classes 1 and 2 (3) refer to land that is low and gentle to undulating and steep, and is occupied by the lowland dipterocarp forest. Terrain classes 3 and 4 are deeply dissected and very steep and occur at an elevation of over 500 m a.s.l. Hill dipterocarp forest is predominant here. Terrain Class 3 often marks the transition between the two forest zones. From the practical viewpoint, this system of classification has been found to be satisfactory.

Although the results in Table 1 show no clear distinction between the soils of LDF and HDF, it is often possible to notice an obvious transition into HDF with the forest showing a decrease in tree heights and diameters. Inventory data also show a change in species associations as dipterocarp species are reduced and non-dipterocarp families increase in dominarnce. For example, in the family Dipterocarpaceae, the LEWS surveys in 1995 recorded 56 species in LDF, 43 in HDF and 20 in SRF (summit ridge forest).

[1] in Soepadmo & Wong (ed), 1995
[2] Anderson and Chai (1982)

Table 1 : Relationships between forest formations and soil types in LEWS

Forest Type	Soil Type
1 Alluvial	Alluvial soils mainly with sandy clay loam (Bemang Family)
2 Lowland dipterocarp	Red-yellow podzolic (RYP) of sandy clay, 75-100 cm deep (Merit), or RYP of sandy clay loam 100 cm deep (Bekenu) on Entimau except for Plot 3 with skeletal soil 40 cm deep (Kapit)
3 Old secondary	Sengayoh : Skeletal soils of sandy clay and sandy clay loam 45-70 cm deep Entimau : RYP of sandy clay 60-100 cm deep
4 Hill dipterocarp	Sengayoh : Skeletal soils of sandy clay 33-45 cm, Except Plot 2 of RYP with sandy clay loam to 100 cm deep Entimau : RYP of sandy clay 60-100 cm, except Plot 3 with skeletal sandy clay loam,15 cm deep Lanjak RYP of sandy clay or sandy clay loam, 53-75 cm
5 Summit Ridge	Skeletal soils of sandy clay 20-45 cm (Sengayoh) or sandy clay loam 25-45 cm (Entimau)
6 Submontane	Skeletal sandy clay loam, 34-42 cm
7 Montane	Skeletal sandy clay loam, 8-40 cm

The occurrence in BKNP of a summit ridge forest similar to that in LEWS is not known, but all the other forest types are encountered in the study areas. The summit of Bukit Condong is topped by a montane forest similar to that on Bukit Lanjak (LEWS), except that the environment on Condong is drier and mosses are relatively poorly developed. Riparian and alluvial forests occur in the low-lying river basins where sediments continue to be deposited with each flash flood. These forests are much more extensive in LEWS. Beyond the alluvial plains, the terrain gradually rises to an extensive mixed dipterocarp forest (MDF). MDF covers Bukit Condong to an altitude of 800 to 900 m a.s.l. where it merges into the lower montane vegetation.

BKNP lies between 112°15' to 114°10' East and 0°40' to 1 835' North. The study sites in Betung-Kerihun cover the forest of the ulu Embaloh River where camps were established at Pakararu, Derian (along Sg Tekelan), and Sg Pait (a tributary of the Tekelan in the lowland), and Bukit Condong north-west of the Park .The first camp at Pakararu was reached by a four-hour longboat journey from Kampung Sadap, an Iban longhouse along the Embaloh. Derian camp was also reached by river, whereas Pait and Condong camps were accessible only on foot. The altitude ranges from 80 m at Pakararu to about 1,244 m a.s.l. at the top of Condong.

LEWS is located between 112° 28' to 115° 53' East and 1° 19' to 1° 51' North. The study area in ulu Katibas is near the eastern boundary at 112° 10'' to 112° 18' East and 1° 33' and 1° 40' North. The longboat journey from the town of Song along the Rajang River to the camp sites in ulu Katibas took about six hours. Two camps were established. Camp A was located at Sg Menyarin along the Katibas River, and Camp B at the confluence of Sg Bloh and Sg Joh. Bloh is a main tributary of the Katibas. The studies here covered a number of lowland forest formations which included riparian forest and secondary forest.

3. METHODOLOGY

The forest ecosystems of BKNP and LEWS are structurally and floristically complex. This is due to the occurrence of a wide range of habitats which are related to terrain and soils. Climatic changes with increasing altitude is locally important, such as on Bukit Condong.

This preliminary survey covered all the main forest types encountered in the study areas in BKNP and LEWS to collect baseline information and provide observations for further research.

The survey involved the establishment of ecological plots to record and identify the flora and their characteristics. In each selected site, two plots each of 20x50 m in size were set up. The plots were established either along the slopes or across ridges depending on the nature of the terrain. Each plot was further divided into ten subplots of 10x10 m each. Poles tied with yellow or orange flagging were planted at the corners of each main plot and subplot to mark out the boundaries.

In each main plot, all trees attaining the diameter of 10 cm dbh and over were measured and identified. Two 10x10 m subplots were randomly selected to record all woody species below 10 cm dbh, palms, lianas and herbaceous flora. Total heights and stem heights were estimated, the latter measured from the ground to the first or lowest branch. A count was made of the tree seedlings and non-woody flora and lianas and their seedlings; and their heights estimated. Whenever necessary, leaf samples were collected for identification in the herbarium. These were pressed in old newspapers back at the camp and preserved in 55% methylated spirit in plastic bags.

4. OBSERVATIONS

It is aimed, to present, as much as possible in this report, all the findings and observations obtained from the study. These findings and observations represent much of the information and knowledge that are so far known from the BKNP-LEWS Transboundary Conservation Area, and provide the necessary ground work for future research.

Altogether six forest types were identified. Of this number, three are common to both BKNP and LEWS. These are the alluvial forest (AF), secondary forest (SF) and lowland dipterocarp forest (LDF). Hill dipterocarp forest (HDF) and montane forest (MF) occur on Bukit Condong in BKNP, and riparian forest in LEWS. In LEWS, HDF and MF may be found on Bukit Lanjak in a different watershed in the south-west. Results from the various forest types are described as follows:

4.1 Alluvial and Riparian Forests

In BKNP the site for the alluvial forest is located in the flood plain of ulu Sg Pait about 250 m a.s.l. The alluvial forest of LEWS in ulu Katibas was studied in 1995 and was excluded from the present survey. The riparian vegetation along the major river systems was surveyed instead. Although both forest types occur within the periodic flood zones, they are distinctly different in structure and species composition.

Riparian forest was sampled to a width of 20 m along the river banks, although the actual extent of this ecotype may be no more than ten m wide. At 20-m width, riparian species were seen to overlap with those in the alluvial forest. This preliminary survey has enabled the boundaries between the two forest zones to be more accurately determined.

a) Alluvial Forest, Sg Pait

The main river system of Sg Pait and its tributaries drain into the deep valleys between Bukit Condong to the west and a long and steep quartzite ridge to the east. The extent of the alluvial forest is limited by these hills on both sides which begin to rise steeply a short distance beyond the river. Sg Pait at this point is rocky and shallow with extensive pebble bars where the river widens out in the flat area. The alluvial flats of ulu Katibas are not limited by these topographical features and are much more extensive.

The alluvial sediments include a rich mixture of clay, sand, and gravels of various sizes and shapes. Drainage is good when the river is at its lowest. The soil pH is near neutral at 6.7.

The forest is moderately dense and shows a fairly distinct three-layered canopy structure. The emergent canopy is irregular as the trees are widely scattered, with estimated heights of 35 to 46 m. *Duabanga moluccana* is the most common, and attains a maximum breast-height diameter of 96 cm. The huge plank buttresses are very characteristic of this species. Two other species recorded from Plot 2 are *Alstonia scholaris* and *Ficus* sp., which are absent from Plot 1. The tallest trees from Plot 1 are shorter at about 35 m and belong to *Artocarpus* sp. and *Pterospermum javanicum.*

Trees in the middle storey form a more even canopy at heights of 15 to 25 m. The number of trees in the two plots are 12 and 16 representing 7 and 12 species respectively. The net number of species is 16. *Saraca declinata* and *Eugenia* sp. 1 are the most common. *Lithocarpus* sp. is the only other species common to both plots. *Aphanamixis* sp., *Alseodaphne* sp., *Anthocephales chinensis* and *Endospermum* sp. occur only in Plot 1, while Plot 2 is richer with *Artocarpus* sp., *Castanopsis* sp., *Campnosperma* sp., *Dacryodes* sp., *Grewia fibrocarpa, Ptychopyxis arborea,* members of Celastraceae, Meliaceae and Rubiaceae.

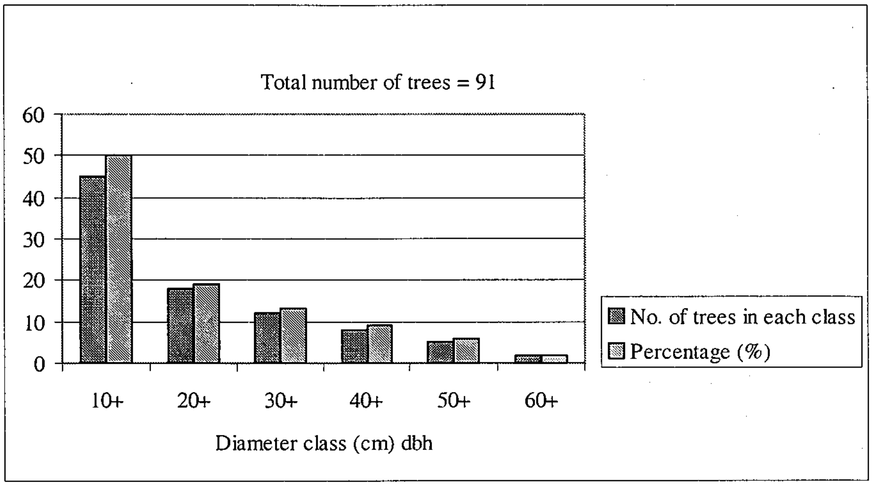
The lower or third storeys comprise individuals all of which are below 15 m in height. Densities vary from 36 trees in Plot 1 and 16 trees in Plot 2. Each plot has 7 species while the net number is 11 (Table 2). *Eugenia* sp. 1 is the most common with a total of 19 trees. *Baccaurea racemosa* and *Nephelium* sp. are two other species common to both plots but are recorded only once in Plot 2. *Anthocephales chinensis, Endospermum* sp., *Litsea* sp. and *Saraca declinata* are present only in Plot 1, while *Grewia fibrocarpa, Garcinia* sp., one Rubiaceae and one Sapotaceae occur only in Plot 2.

Table 2: Tree densities and species richness in Alluvial Forest, Sg Pait, BKNP

Plot / Canopy	No. of trees			No. of spp.		
	Plot 1	Plot 2	Mean	Plot 1	Plot 2	Mean
Emergent	2	5	3.5	2	3	5
Mid-storey	12	20	16	7	12	16
Lower storey	36	16	26	7	7	11
Total	50	41	45.5	Not available		

There are about 500 trees per hectare in Plot 1 and 410 trees in Plot 2, with a mean of 455. Tree distribution by diameter class shows an average of 22.5 trees or 49.5 % between 10 and 20 cm dbh, while 17% belong to individuals attaining dbh of 40 cm and over (Figure 1). Basal area for all measured trees of 10 cm dbh and over is 36.407 m^2/ha.

Figure 1 : Tree distribution by diameter classes in Alluvial Forest, Sg Pait, (250 m a.s.l.)



The number of species recorded from the plot is estimated to be 20. The Myrtaceae is the single most common family with 13 and 18 trees respectively, all belonging to the genus *Eugenia*. The Euphorbiaceae, the next most common family, is more unevenly distributed with 10 trees from Plot 1 and only 3 from Plot 2 (Table 3).

Table 3 : Dominant families, species numbers and tree densities in Alluvial Forest plots at Sg Pait (250 m a.s.l.)

	Plot 1			Plot 2			
Family	Gen	Spp	No. of Trees	Family	Gen	Spp	No. of trees
Myrtaceae	1	1	18	Myrtaceae	3	3	13
Euphorbiaceae	2	3	10	Euphorbiaceae	2	2	3
Rubiaceae	2	3	4	Rubiaceae	2	2	3
Fagaceae	2	2	2	Fagaceae	2	2	3
Moraceae	2	2	2	Moraceae	1	1	2

A similar study[3] in Lanjak-Entimau forest using 50 x 50 m plots in three replicates show that the Euphorbiaceae is the single most dominant family, while the Myrtaceae is much less common. Members of the Dipterocarpaceae

[3] Chai (1995)

are very common in one locality adjacent to a lowland dipterocarp forest in the ulu Ensirieng. A lower basal area of 30.98 m^2/ha is recorded from this forest. The LEWS forest contains a total of 132 and 161 species from two different localities. Although this higher number may be partly due to the larger sampling size of 0.75 hectare compared to the 0.2 hectare used in the present study, the LEWS forest is undeniably the richer of the two forests.

The ground flora comprises mainly tree seedlings and saplings which are largely below 2 m in height except for a few individuals of *Baccaurea* sp. which are up to 9 m, and constitute a significant part of the tree population below 10 cm dbh. Altogether about 13 tree species are encountered. The more common species, apart from *Baccaurea* sp., are *Saraca declinata, Eugenia* sp., *Endospermum* sp. and Rubiaceae. Herbaceous flora is represented by species of *Pilea, Begonia*, Zingiberaceae (*Globba* sp. and *Zingiber* spp.), Gesneriaceae, Araceae (*Arisaema* sp. and *Richardia* sp.), and the ferns *Microsorium* sp. and *Selaginella* sp. Palm flora includes one *Calamus* sp. and one *Pinanga* sp. Lianas are reprsented by two species of *Spatholobus* and one *Phanera,* both in the Leguminosae. These non-woody plants together number about 17 species. In LEWS, up to 160 species of woody flora and 61 non-woody flora are known from the ground flora. This large number maybe partly due to the larger plot size and richer ground flora community extending to higher ground further inland.

Apart from the topographical conditions that limit the distribution and development of the alluvial forest and its flora in ulu Sg Pait, there is also evidence of human disturbance by the local communities dating back to the 1960s. A part of the forest had been cleared for temporary settlement and growing of rice, vegetables and fruits.

b) <u>Riparian Forest, ulu Katibas</u>

This vegetation is subject to periodic flash flooding when the rivers swell beyond the banks during heavy rain. In the ulu Katibas, a few hours of heavy downpour can cause the rivers to suddenly rise by two m or more. A recent big flood occurred there in December 1997, one month after the Expedition as a result of two days of continuous heavy rain. The rivers rose by up to two m, and deposited about 3 cm thick layer of fine silty sediments on the Expedition's camp ground at Sg Joh.

The forest has a two-storey structure. A row of emergent trees of *Dipterocarpus oblongifolius* line the river fringes in a slanting position with their crowns overhanging the river. Their massive trunks and strong root systems are adapted to withstand the forces of the swelling rivers. These trees are often up to 30 m in height and over 90 cm in diameter. They are an important micro-habitat for no less than 35 species of epiphytes.

Other emergents occur immediately behind the banks and comprise individuals of *Koompassia malaccensis, Parashorea macrophylla, Shorea macrophylla, Pometia pinnata, Tristaniopsis whiteana* and *Durio zibethinus*, all with a scattered distribution. Individuals of *Koompassia* and *Shorea macrophylla* are the tallest among these, and reach a size of 45 m in height and 150 cm in diameter.

Non-dipterocarps dominate the lower storey at 7 to 15 m, comprising members of the Euphorbiaceae (*Aporusa* sp., *Baccaurea* sp. and *Mallotus muticus*), Melastomataceae (*Pternandra* sp), Celastraceae (*Bhesa paniculata*), Leguminosae (*Saraca declinata*), Anacardiaceae (*Pentaspadon motleyi* and *Swintonia* sp.) and Rubiaceae (*Nauclea* sp.). Altogether about 70 species were recorded representing 31 families and 62 genera (Table 4), whereas between 132 and 161 species are known from the alluvial forest[4]. The Dipterocarpaceae, Sapindaceae, Euphorbiaceae, Lauraceae, and Rubiaceae are among the most common families both in terms of species numbers and frequency of occurrence. (Table 5).

Table 4 : Species richness and tree densities (dbh 10 cm and over) in Riparian Forest (ulu Katibas)

	Plot 1	Plot 2	Plot 3	Plot 4	Total
Families	16	17	12	18	31
Genera	26	27	22	25	62
Species	27	28	24	27	±70
Trees	41	44	64	64	213
Density/ha	410	440	640	640	Mean 533

[4] Chai (1995)

Table 5: Dominant families, species numbers and tree densities in Riparian Forest

Families	No. of genera	No. of species	No. of trees
Dipterocarpaceae	4	5	56
Sapindaceae	4	5	23
Euphorbiaceae	5	6	14
Lauraceae	5	6	12
Rubiaceae	5	5	7
Leguminosae	3	3	12

There is a much higher proportion of large trees in this forest compared to the alluvial forest immediately behind it. Individuals above 50 cm dbh represent 16% of the total compared to 4.1 to 6.7% in the alluvial forest. Of the 16%, 8.4% are from 18 trees of the Dipterocarpaceae which all exceeded the diameter of 70 cm. The result also indicates a more even tree size distribution compared to the alluvial and mixed dipterocarp forests.

The majority of woody species below 10 cm dbh are seedlings and saplings. These and the non-woody flora show a wide difference in species numbers and densities in all the eight randomly selected subplots. Between 11 and 32 woody species were recorded, with the total number of individuals varying from 22 to 90. The most common species, based on the frequency of occurrence, are *Parashorea macrophylla, Dillenia suffruticosa, Aglaia odoratissimus, Diospyros malayana, Baccaurea* sp. and *Aporusa* spp.

Herbs and lianas also show an uneven distribution between subplots, the former from 4 to as many as 20 species, and the latter 2 to 7 species. *Phrynium capitatum, Cyrtandra* sp., *Alpinia* sp., *Pandanus* sp. and *Costus speciosa* are often present as small colonies. Two species of *Spatholobus* are the most common lianas and are present in all the subplots. Others are *Tetracera akara, Ficus* sp., *Zizyphus* sp., and members of the Annonaceae. Palms are relatively rare and include *Pinanga* sp., *Caryota mitis* and *Calamus* sp. The total number of woody and non-woody flora in the undergrowth is estimated to be 50 species. This constitutes only 25% of the total recorded from the alluvial forest.

Species associations in the riparian fringes are seen to vary along the different sections of the river. This is believed to be caused by the differences in soil and water properties but require more detailed studies. *Dipterocarpus oblongifolius* is adapted to colonising newly-deposited and loose sediments and the water along this section of the river is invariably murky with heavy suspensions. *Shorea macrophylla* is more common on firmer ground further upriver where the water is normally also very clear.

Based on the present study on the species associations and habitats and on the information collected from the alluvial forest, the riparian forest may be more accurately defined as that narrow belt of vegetation along the river fringes that is usually no more than 10 metres wide.

4.2 Lowland Dipterocarp Forest

The terrain of the transboundary conservation area is typical of that in central and inland Borneo, often described as highly undulating, deeply dissected and rugged. Bukit Condong in BKNP and Bukit Lanjak in LEWS are the highest peaks in the study sites at about 1,200 m a.s.l. A very substantial portion of the land is situated below 400 m a.s.l. In LEWS this is estimated to cover about 70,000 hectares or 40% of the total area. This is largely occupied by the lowland dipterocarp forest. In BKNP, the area below 500 m a.s.l. is estimated to cover 343,300 hectares or 43% of the total area.

In BKNP sampling was carried out in the forest on Bukit Pakararu behind the first expedition camp, and on Pajau ridge behind the second expedition camp at Derian, at altitudes of 200 and 250 m a.s.l., respectively. In LEWS, two sites were also selected, both in the vicinities of the Menyarin camp (Camp A). Site 1 is located about 0.5 km across the Katibas River from Camp A in a south-easterly direction, on a ridge between the Nyungan and the Katibas Rivers. Site 2 is about 2 km south-west of Camp A, on a hill called Bukit Guning. Ecological plots were established at about 210 m a.s.l. at both sites.

a) <u>BKNP Plots</u>

The lower slopes of Bukit Pakararu is occupied by a forest that is believed to have been at least partially disturbed long before Betung-Kerihun became a National Park. The age of the forest, based on the species composition and tree size, and on information provided by the local people, is estimated to be about 35 years old. Emergents are up to 35 m tall, while very few trees have attained diameters of over 50 cm. Members of the Euphorbiaceae and Fagaceae are common. The presence of a number of dipterocarp species of *Shorea parviflora, Shorea pinanga, Shorea beccariana* and *Shorea macroptera* in a relatively very young regrowth points to the possibility that the original forest was only partially cleared and then abandoned. A number of open areas at between 200 and 250 m a.s.l. are completely colonised by *Dicranopteris linearis* which is seen to spread towards the edge of the forest.

Two plots were located beyond this within the undisturbed forest on a higher ridge, which was reached by a very steep climb of a 35° slope from a small rocky stream. The forest here is generally open and dry. A short distance from the plots is an old forest gap caused by tree fall. It is colonised by numerous lianas and small-sized trees.

The Pajau ridge forest also shows evidence of human disturbance. According to Jelayan anak Augustinus Saputradinata, a labourer from Kampung Belimbis, this forest had been partially cleared during the 1960s for temporary settlement. This had evidently resulted in some damage to the surrounding forest. Lianas are much less common here than at Pakararu.

Two other plots on Pajau ridge were established on a gentle hill slope near a small cave called Gua Pajau. The forest here is more open, and the emergent and main canopy layers are irregular and poorly defined in the lower slopes, while the forest on the upper slopes nearer to the cave is more intact and better stocked with larger trees. Gaps in the forest are filled by numerous tree seedlings.

At Pakararu, members of the Dipterocarpaceae are dominant and are present in all the canopy layers. They represent a mean of 59.5% of the total trees exceeding 10 cm dbh recorded from the plots. The tallest dipterocarps have attained a height of 40 to 50 m to form the emergents, with *Shorea macroptera* and *Shorea rubra* as the two main species. The majority of the dipterocarps occur at heights of 30 to 40 m, and comprise mainly species of *Dryobalanops oblongifolia, Shorea macroptera, Shorea parvifolia, Dipterocarpus mundus, Dipterocarpus crinitus* and *Vatica umbonata*. Non-dipterocarp associates are *Artocarpus odoratissimus, Xanthophyllum* sp., *Calophyllum* sp., *Nephelium* sp. and *Pentace borneensis*. In addition to the above, another eight dipterocarps are known from the middle and lower storeys, represented by four species of *Shorea (S. faguetioides, S. hopeifolia, S. amplexicaulis* and *S. pinanga), Dipterocarpus caudatus, Hopea dryobalanoides, Vatica micrantha* and *Anisoptera* sp.

Dipterocarps are less common in the Pajau forest. Two species of *Shorea* share the emergent canopy at 40 to 45 m with *Koompassia excelsa* (at 50 m, the tallest), *Mangifera* sp. and *Myristica* sp. *Shorea leprosula* and *Vatica maingayi* are present in the middle layer together with species of *Eugenia*. The Dipterocarpaceae is the second most dominant family in the lower layer after Euphorbiaceae. Species of *Vatica* sp., *Aporusa* sp., *Diospyros* sp., *Elaeocarpus* sp. are common. *Jarandersonia parvifolia* (Tiliaceae) is present as a very rare species. It is previously known only from the type locality in Segan F.R. in Bintulu, Sarawak. Species compositions and densities of the five most dominant tree families are shown in Tables 6 and 7.

Table 6 : Dominant tree families in LDF plots at Pakararu (210 m a.s.l.)

Plot 1				Plot 2			
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Dipteocarpaceae	5	16	55	Dipterocarpaceae	5	9	52
Euphorbiaceae	5	5	5	Euphorbiaceae	3	3	4
Anacardiaceae	2	2	4	Anacardiaceae	3	3	4
Lauraceae	2	2	2	Lauraceae	2	2	2
Verbenaceae	1	2	3	Verbenaceae	1	1	4

Table 7 : Dominant tree families in LDF plots at Pajau (240 m a.s.l.)

Plot 1				Plot 2			
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Dipteocarpaceae	3	4	16	Euphorbiaceae	4	5	8
Euphorbiaceae	3	3	9	Leguminosae	4	4	5
Myrtaceae	1	3	3	Annonaceae	4	4	4
Ebenaceae	1	1	5	Dipterocarpaceae	1	2	2
Polygalaceae	1	1	2	Elaeocarpaceae	1	1	3

In both sites, the Euphorbiaceae and Dipterocarpaceae continue their dominance among the woody components of the undergrowth flora with stem diameters of below 10 cm. The Euphorbiaceae is represented by 9 species in Pakararu and 8 species in Pajau, while the numbers for the Dipterocarpaceae are 10 and 5 respectively. *Shorea leprosula* is the most common species in Pajau and occurs as numerous seedlings. Members of the Annonaceae are also frequently encountered, while ferns (Polypodiaceae) are the more common of the non-woody plants.

The mean tree density in the Pakararu plots is more than twice that in the Pajau plots (Table 8). In species, out of the total of 127, only 19 are common to both sites.

Table 8 : Numbers of species and densities of trees 10 cm dbh and over in Pakararu and Pajau LDF plots

	Pakararu		Pajau		Total
	Plot 1	Plot 2	Plot 1	Plot 2	From 4 plots
Families	18	20	14	11	32
Genera	28	29	19	19	61
Species	41	42	22	22	108
Trees	87	93	46	30	256
Density/ha	870	930	460	300	640 (mean)

Diameter class distribution of the two forests are compared in Figures 2a and 2b. The denser forest of Pakararu gives a higher basal area of 58.44 m^2/ha compared to 53.30 m^2/ha in Pajau.

Figure 2a: Tree distribution by diameter classes of 180 trees in 0.2 ha plots in LDF in Pakararu

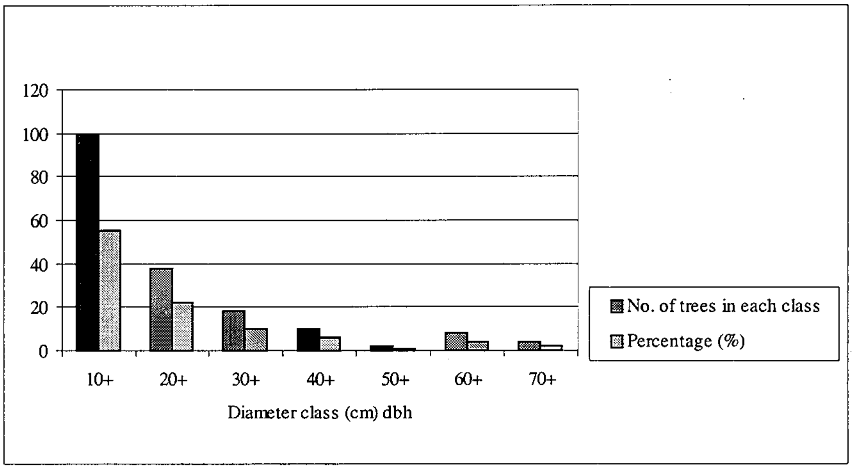
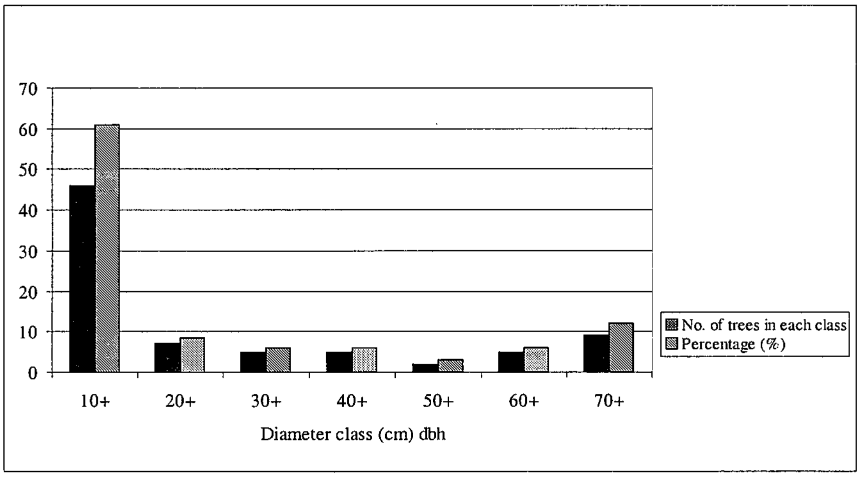


Figure 2b: Tree distribution by diameter classes of 76 trees in 0.2 ha plots in LDF in Pajau



b) <u>LEWS Plots</u>

The access to the first study site on the ridge between Sg Nyungan and Sg Katibas is through an old secondary forest which extends from the river bank inland to a distance of about 700 metres. This forest has an abundance of pole-sized trees and lianas. From here, the terrain towards the ridge top is gentle but slopes rather steeply to the sides. The forest beyond this where the plots are located is not unlike lowland dipterocarp in appearance but may in fact be a very old secondary forest of about 200 years. According to the Iban Headman and residents of Rumah Api longhouse, the first Iban migration from the Batang Ai in the south-west to the ulu Katibas occurred about 200-300 years ago. These people were nicknamed *lancham*, referring to their practice of sharpening their teeth to a pointed shape to facilitate their meat-eating habit. Some of them settled in the forest around Expedition Camp A. An old durian tree at the camp compound was believed to be planted by them, the tree is now about 120 cm in diameter. Old secondary forests are also common along the banks of the Katibas River and its major tributaries.

Bukit Guning is situated off Sg. Bedawak, a small river further upstream from Camp A. It is reached by a short steep climb from the river along a very narrow ridge passage of about two metres wide with exposed sandstones and loose shallow sandy clay soils. The forest has a similar pole-like appearance as on Ngungan ridge, with big trees being relatively few and widely scattered. At least eight species of Dipterocarpaceae were encountered along the way. The narrow ridge eventually widens and gently rises to 210 m at the plot site. Owing to the much bigger extent of this forest type, eight plots were established in the two sites.

The forests in both areas show much similarity in structure. Members of the Dipteocarpaceae and *Koompassia malaccensis* are dominant among the emergents. Dipterocarps are represented by *Shorea argentifolia*, *Shorea rubra, Shorea sagittata* and *Shorea quadrinervis*, with individuals up to 40 m in height. Other common associates are *Tristaniopsis whiteana* and *Cratoxylum arborescens*. *Tristaniopsis whiteana* occurs singly or in small communities of up to ten trees. Both the *Tristaniopsis* and *Cratoxylum* are important indicator species that colonise cleared and disturbed sites with thin soils. They provide evidence that clearing had indeed been carried out in the past, and the forest is at least partly secondary in nature.

The middle storey has a higher concentration of trees and the canopy is more compact. Dipterocarps up to 30 m in height are poorly represented by *Shorea sagittata* and *Vatica umbonata*. Dominant non-dipterocarp families include the Burseraceae (*Dacryodes* sp.), Moraceae (*Artocarpus integer*), Sapotaceae (*Palaquium* sp. and *Payena obscura*), Leguminosae (*Koompassia malaccensis*) and Hypericaceae (*Cratoxylum arborescens*). Non-dipterocarps continue their dominance in the third or lower storey at below 20 m, with members of the Dipterocarpaceae increasing in dominance as young trees. Among the common dipterocarps are *Shorea parvifolia*, *Shorea quadrinervis*, *Vatica* sp. and *Hopea* sp.

Overall, there is little difference in the total number of species between the forests in the two localities, although tree densities are more irregular, ranging from 54 to 92 individuals per plot (Tables 9 and 10). On the Nyungan ridge, plot 2 with a high density of 92 individuals is situated on a spreading and gentle hill slope. On Bukit Guning evidence of natural tree falls and possibly also selective tree-felling by the local inhabitants to collect timber for boat building or house construction could have resulted in the forest being poorly stocked. There is a higher number of medium-sized trees of mainly *Shorea* spp. in Plots 3 and 4.

Table 9 : Numbers of species and individuals in LDF on ridge between Sg Nyungan and Sg Katibas

	Plot 1	Plot 2	Plot 3	Plot 4	Total
Families	23	26	26	25	40
Genera	37	34	39	34	75
Species	53	37	46	36	103
Trees	69	92	74	70	285
Density/ha	690	920	740	700	762 (mean)

Table 10 : Numbers of species and individuals in LDF on Bukit Guning

	Plot 1	Plot 2	Plot 3	Plot 4	Total
Families	22	21	25	27	37
Genera	27	33	39	37	74
Species	33	34	49	40	96
Trees	54	64	72	75	265
4.2.1.1 Density/ha	540	640	720	750	663 (mean)

In both forests, the Euphorbiaceae is the most dominant tree family with the highest number of species and individuals. Other dominant families such as the Dipterocarpaceae, Fagaceae, Myrtaceae and Burseraceae are poorer in species but more common in occurrence (Tables 11 and 12). Among the dominant families, the Euphorbiaceae, Dipterocarpaceae, Myristicaceae and Burseraceae are common to both forests. Other important associates are the Fagaceae and Myrtaceae on Nyungan ridge, and the Rubiaceae and Lauraceae on Bukit Guning.

The Dipterocarpaceae and Euphorbiaceae are the two most important families in Betung Kerihun and Lanjak Entimau. The Betung Kerihun forest is much richer in dipterocarps with up to 16 species and 107 individuals recorded from Pakararu. The Euphorbiaceae, on the other hand, is more common in Lanjak Entimau with at least 14 species and a total of 34 individuals recorded from the Sg Nyungan ridge plots.

Tree diameter class distribution shows a similar trend to that in Pakararu and Pajau, with up to 60% in the 10-20 cm diameter range, while less than 8% are over 50 cm (Figures 3 and 4).

Table 11 : Dominant tree families in LDF plots on ridge between Sg Nyungan and Sg Katibas

Family	No. Of Genera	No. of Species	No. of Trees
Euphorbiaceae	10	14	34
Dipterocarpaceae	2	6	25
Myristicaceae	3	7	13
Fagaceae	2	5	18
Myrtaceae	2	4	16
Burseraceae	3	4	8

Table 12 : Dominant tree families in LDF on Bukit Guning

Family	No. Of Genera	No. of Species	No. of Trees
Euphorbiaceae	8	11	27
Rubiaceae	7	7	9
Lauraceae	5	6	10
Myristicaceae	3	6	12
Dipterocarpaceae	2	4	21
Burseraceae	3	4	20

Figure 3 : Tree distribution by diameter classes in Sg Nyungan ridge plots

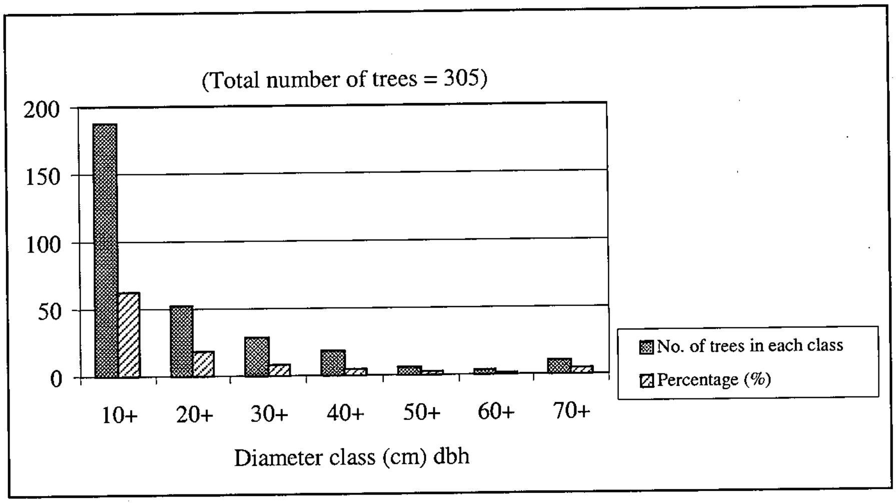
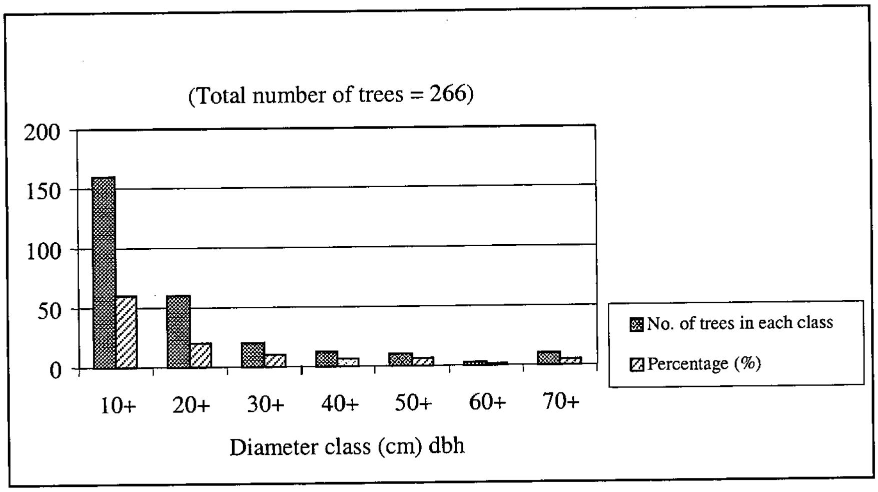


Figure 4 : Tree distribution by diameter classes in Bukit Guning plots



Species structure and density of the undergrowth are often dependent on the number of tree seedlings present, and this in turn is determined by the fruiting seasons. The number of species ranges from 34 at Pajau (BKNP) to 57 on the Sg Nyungan ridge (LEWS). The proportion of tree and non-tree species is also highly variable depending on the site conditions. Between 57% and 78% of the undergrowth flora are trees, while non-tree species make up the remaining 22% to 43%. The tallest tree saplings with diameters still below 10 cm dbh are 8 metres, while the majority fall within the range of 1 to 5 m. Herbs belonging to the Gesneriaceae, Zingiberaceae and Marantaceae often occur in clusters under cool and moist conditions.

4.3 Hill Dipterocarp Forest

Altogether six plots were established in three selected sites. The first two plots were located near the top of Bukit Pakararu at about 410 m a.s.l. The terrain towards the summit is moderately steep to steep with slopes of up to 25° to 35° angles. The sandy clay loam is well-drained and has a pH of 6.5.

Site 2 was located at 530 m a.s.l. on a quartzite ridge behind the Pait Camp in a more or less north-easterly direction from it. This long ridge is reached by a fairly long and steep 30° climb from Sg. Pajau behind Derian Camp to an altitude of 450 m a.s.l. The ridge is at first fairly broad but becomes more narrow and steep-sided towards the Pait Camp where it rises to 580 m a.s.l. The soils along the narrow sections of the ridge are thin (pH 6.6) and exposed to reveal a mixture of sandstone, shale and quartz materials. Landslides are common along the steep sides. The environment is dry throughout and no leeches were encountered.

A very good dipterocarp forest develops on deeper clay loam at the beginning of the ridge, with species such as *Dryobalanops oblongifolia, Shorea macroptera* and *S. parvifolia.* The forest becomes pole-like after an altitude of about 500 m a.s.l. where *Shorea amplexicaulis, S. ochracea* and species of *Lithocarpus* are encountered. *Shorea macroptera, S.beccariana, S.coriacea, Dryobalanops beccarii* and *Dipterocarpus* spp. are seen along the narrower sections of the ridge towards the Pait Camp. Also present are *Anisophyllea* sp., *Quercus* sp. and *Agrostistachys longifolia.* Small communities of *Tristaniopsis obovata* are associated with erosion sites on the steep slopes. When new, these sites are seen to be colonised by secondary pioneers of *Adinandra dumosa, Nauclea calcarea, Macaranga* spp. *Dillenia suffruticosa* and the *Gleichenia* fern.

Bukit Condong is the third site for HDF plots. The southern slopes of the mountain rise steeply from the Pait River at angles of over 30°. The rich yellow clay soils here supports a very good lowland dipterocarp forest with numerous big trees mostly above 40 cm in diameter, including at least ten species of dipterocarps e.g,. *Shorea beccariana, S. macroptera* and *S. amplexicaulis.*

A transition between LDF and HDF is reached between 450 and 600 m a.s.l. where the trees are mostly below diameters of 35 cm. Above this and into the HDF, the ridges in places become narrow with exposed thin soils. The ecological plots at 620 m a.s.l. are located on a broader ridge slope. Soil pH is 6.6.

Results from the plots confirm the observation that, in all the three sites, the Dipteocarpaceae are dominant among the emergents and upper canopy. Of the trees above 10 cm dbh, this family accounts for 34.3 to 43.1% in the Bukit Pakararu plots, and 43.2 to 45.2% in the Pait quartzite ridge plots, but less common in the Condong plots with 20.5 to 23.9%. *Shorea* is the most common genus, its members alone representing 58% and 71% respectively of the total numbers of trees in Pakararu and Pait ridge. It has a more uneven distribution in Condong where it accounts for about 48.5%. Of the other dipterocarps, *Hopea* is recorded only in Condong, while *Dipterocarpus* and *Dryobalanops* are present only in the other two sites. Besides *Shorea*, *Vatica* is the only other genus common to all three sites. *Cotylelobium* is recorded once only from Bukit Pakararu. There are an estimated 15 species of *Shorea*, 4 species each of *Dipterocarpus* and *Vatica*, and 2 species of *Dryobalanops*.

Among the non-dipterocarps, the families Myristicaceae, Lauraceae, Myrtaceae and Clusiaceae begin to increase in dominance over Euphorbiaceae which is one of the most important families in the lowland dipterocarp forests. The quartzite ridge is also rich in Anacardiaceae (Table 13).

Table 13 : Dominant tree families in Hill Dipterocarp Forest plots at Pakararu, Pait ridge and Bukit Condong

(i) Pakararu

Plot 1				Plot 2			
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Dipterocarpaceae	4	8	35	Dipterocarpaceae	5	11	45
Myristicaceae	3	3	9	Myristicaceae	3	3	4
Lauraceae	4	4	4	Euphorbiaceae	3	3	3
Ebenaceae	1	3	8	Myrtaceae	1	3	3
Clusiaceae	2	2	5	Clusiaceae	2	2	5

(ii) Pait Quartzite Ridge

Plot 1				Plot 2			
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Dipterocarpaceae	4	13	41	Dipterocarpaceae	4	8	32
Burseraceae	3	3	8	Myrtaceae	1	5	11
Anacardiaceae	3	3	6	Anacardiaceae	4	4	7
Lauraceae	3	3	3	Burseraceae	2	3	4
Euphorbiaceae	2	3	3	Clusiaceae	2	2	3

(iii) Bukit Condong

Plot 1				Plot 2			
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Dipterocarpaceae	3	6	16	Dipterocarpaceae	3	6	13
Myristicaceae	3	3	7	Myrtaceae	1	5	5
Lauraceae	3	3	5	Myristicaceae	2	2	5
Fagaceae	2	3	4	Flacourtiaceae	1	2	5
Clusiaceae	2	2	5	Anacardiaceae	2	2	3

Between 67 and 77 tree species are recorded from the six plots, while the net number from the plots combined is 136 species (Table 14). 159 species are known from HDF in LEWS[5]. Table 14 also shows densities and basal areas of trees over 10 cm dbh, while diameter class distribution is summarized in Figure 5.

Table 14 : Number of species, densities and basal areas from three sites

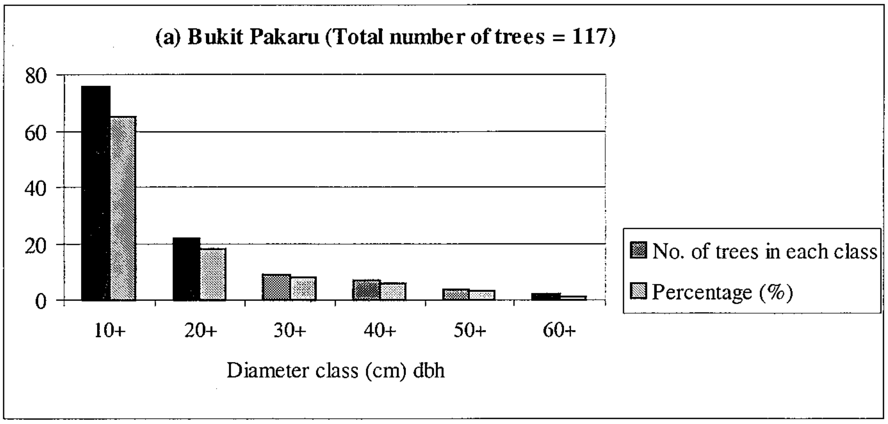
No. / Locality	Family	Genus	Species	Trees/ Ha	B.area $m^{-2}ha^{-1}$
Bukit Pakararu (410m)	33	54	77	1170	50.61
Pait Ridge (530m)	30	51	76	940	50.98
Condong (620m)	27	42	67	780	46.55

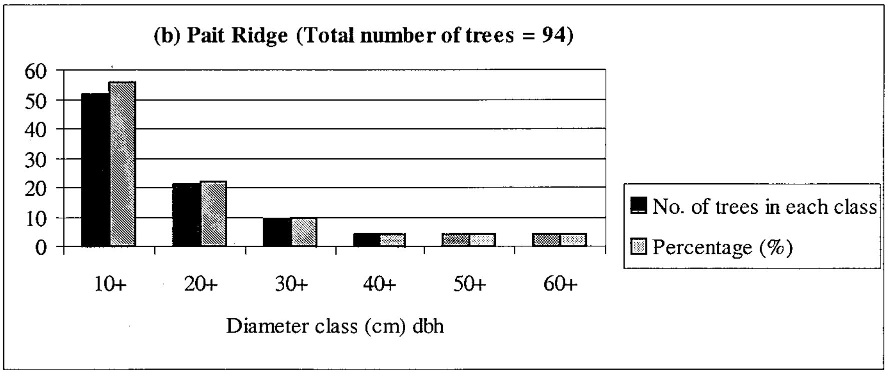
The undergrowth flora show a distinct variation in generic composition from 35 genera in Pakararu to 51 genera in Condong, with the Pait ridge plots in the intermediate range with 40 genera. Species numbers are not available at

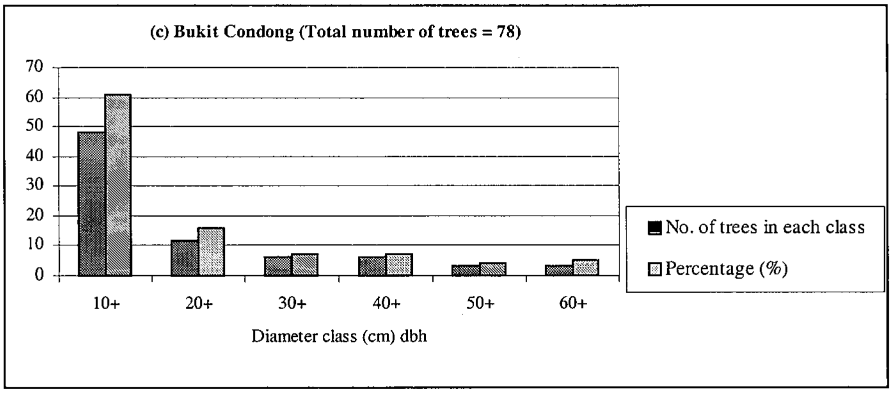
[5] (Chai 1995)

the time of writing this report. Dipterocarp seedlings (*Shorea* spp.) and palms (*Pinanga* sp. and *Daemonorops* sp.) are dominant in most of the plots. Condong has a greater abundance of seedlings and saplings of the Myrtaceae, Clusiaceae and Annonaceae, while the Euphorbiaceae, Anacardiaceae and Leguminosae are more common on the Pait ridge, where *Goniothalamus velutinus* also occurs. Of the epiphytes on the ridge, orchids are very common. Herbaceous flora are relatively rare in all the sites due to the fairly dry condition of the forest floor.

Figure 5 : Mean numbers of trees and percentages by diameter classes in hill dipterocarp forest plots in BKNP







4.4 Montane Forest

The appearance of mosses on the ground and tree trunks and the decreasing tree size mark the beginning of the lower montane forest at about 900 m a.s.l. on Bukit Condong. Though cooler, the environment is still fairly dry. This condition continues to the summit of the mountain (1,244 m a.s.l.) where the trees become shorter and more exposed. Mosses are better developed towards the top, but the situation is quite unlike that on Bukit Lanjak in LEWS which is of about the same elevation, and where the climate is much cooler and wetter. The moss flora has taken advantage of this to reach its full development, heavily draping tree trunks and branches and forming a thick carpet on the forest floor.

a) <u>Lower Montane</u>

The forest at 1,000 m a.s.l. marks the optimum development of the lower montane formation. From a tree height of 30 m here the forest is gradually reduced to 20 m towards the summit. The soils underneath the thick mosses are composed of soft, semi-decomposed organic peat that is typically dark chocolate brown in colour. The narrow ridges are gently ascending and undulating but slopes to 20 to 25° on the sides.

From two plots established behind the expedition's Condong camp at 1,000 m a.s.l., a mean of 84 trees (840 trees per hectare) were recorded. The number of species varies from 37 in Plot 1 to 13 in Plot 2, while the net number of species combined is 44 (Table 15), compared with 123 species on Bukit Lanjak[6].

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[6] Chai (1995)

Table 15 : Species and densities of trees 10 cm dbh and above in Lower Montane Forest plots at Bkt. Condong (1,000 m a.s.l.).

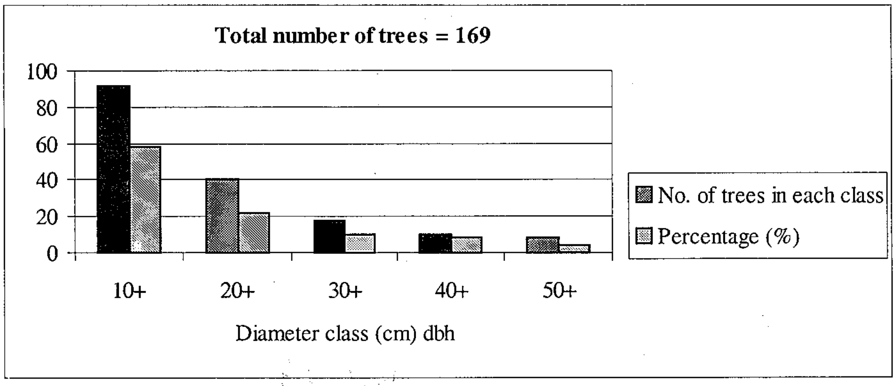
Locality	Plot 1	Plot 2
Families	16	11
Genera	26	12
Species	37	13
No. of trees	94 (940/ha)	74 (740/ha)

Members of the Dipterocarpaceae are becoming relatively rare at this altitude and are represented by two species of *Shorea* (including *Shorea umbonata), Hopea pedicellata* and *Vatica* sp. *Hopea pedicellatta* is very rare. At this altitude, the forest is dominated by members of the Myrtaceae, Clusiaceae, Sapotaceae and Theaceae as four of the most common families (Table 16). Mrytaceae is represented by *Eugenia* spp. and Clusiaceae by *Calophyllum* spp., while *Tetramerista glabra* (Tetrameristiaceae) and *Adinandra* spp. (Theaceae) are also present. Over 93.6 % of the trees are between 10 and 40 cm in diameter, these and the remaining 6.4% of larger individuals together contributing to a basal area of 46.05 m^2/ha (Figure 6). *Phyllocladus hypophyllus* is the largest tree in the plots with a diameter of 90.7 cm. This species and *Podocarpus neriifolius* have not been recorded from Bukit Lanjak in LEWS although a more typical montane condition exists there.

Table 16 : Dominant tree families in Lower Montane Forest plots at Bukit Condong (1,000 m a.s.l.)

Plot 1				Plot 2			
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Myrtaceae	1	2	20	Myrtaceae	1	9	15
Clusiaceae	1	1	19	Clusiaceae	1	3	28
Theaceae	2	2	5	Sapotaceae	3	3	14
Sapotaceae	1	1	4	Celastraceae	2	2	7
Melastomataceae	1	1	4	Theaceae	1	2	2

Figure 6 : Tree distribution by diameter classes in Lower Montane Forest plots at Bukit Condong (1,000 m a.s.l.)



The dense undergrowth comprises numerous tree seedlings, palms, herbs and lianas. A total of at least 90 species are recorded from inside and outside the plots. Lowland species which have extended to this altitude are *Cinnamomum javanicum, Eugenia bankense, Chionanthus* sp. and a species of *Terminalia* among the trees; and *Smilax* sp., *Spatholobus* sp., *Zizyphus* sp. and *Willughbeia* sp. among the climbers. Typical montane flora include species of *Sonerila, Lindera* and *Vaccinium,* and many orchids, in particular *Dendrochilum* sp. The palm *Engeissona utilis* is also present.

b) <u>Upper Montane</u>

The transition between the lower montane and upper montane formations is at about 1,100 m a.s.l., marked by the increasing abundance of moss and herbaceous flora and epiphytes, and a reduction in tree size.

A preliminary study of this summit vegetation was first undertaken by Indonesian ecologist Tukirin Partomihardjo just before the Expedition in July 1997. The following discussions are based on some of his results and on the observations obtained from the Expedition.

Trees on the summit are reduced to about 20 m in height and 20 cm in diameter. Larger trees are concentrated along the narrow ridges and upper slopes, and smaller ones occupying steep slopes and cliff edges. With the exception of two species of dipterocarps, *Shorea monticola* and *S. parvifolia*, the tree flora is completely dominated by non-dipterocarps. Among the most common groups are *Palaquium* spp., *Calophyllum* spp., *Tetramerista glabra, Bhesa paniculata* and *Adinandra* spp. The middle storey and undergrowth are dense and accessibility is often difficult without slashing. Common among the smaller woody species are *Alseodaphne oblanceolata, Tetramerista glabra, Elaeocarpus, Urophyllum* and *Calophyllum* spp.

The ground flora is rich in palms, represented by at least four species of *Pinanga* including one new to science, *Iguanura* sp. and *Areca insignis* var. *moorei.* Three species are recorded among the climbing palms, i.e. *Calamus flabellatus, C. tomentella* and *Daemonorops formicaria*, growing with other lianas such as *Zizyphus* and *Spatholobus* spp. Herbs are represented by species of *Alpinia, Dianella, Argostemma* and ferns. *Rhododendron* spp., *Vaccinium* spp. and *Nepenthes* spp., and the orchids *Dendrochilum* spp. and *Phalaenopsis maculata* are common near the summit.

4.5 Secondary Forest

The secondary forest at Pakararu is estimated to be about 35 years old. The common occurrence of members of the Dipterocarpaceae in a relatively young forest suggests that the forest might have been only partially cleared with no burning prior to any farming activities. Two plots of 50 x 20 m were established.

The old secondary forest in LEWS was first studied during Phase I of the Lanjak-Entimau Project from 1993 to 1995. The present study covered two forests which are 100 years old and 30 years old in age in the ulu Katibas near Sg Kelimau Besai at 170 m a.s.l. The younger forest was originally a part of the older forest. It was cleared by the father of Anjau anak Jala of Rumah Enggong with the intention of growing rice. Anjau, then about 17 or 18 years old and still a bachelor, assisted his father in the clearing with an axe. He is now 47. This puts the forest at about 30 years old. According to Anjau, who assisted the ecological team during the survey, the cleared forest was abandoned without burning and planting because of rainy weather.

a) Pakararu Plots

Structurally, the forest has a distinct pole-like appearance with over 90% of the individuals below 40 cm in diameter.

At least five species of the Dipterocarpaceae are present but the distribution of the more common species appear to be localised. *Shorea parvifolia* occurs only in Plot 1. Plot 2, located only a short distance away, is dominated by *Dryobalanops beccarii, D. oblongifolia* and *Shorea macroptera. Dryobalanops beccarii* is the most common of the three species as well as the most common dipterocarp in the plots. Other emergents belong to species of *Lithocarpus, Nephelium* and *Eugenia* in Plot 1, and species of *Swintonia, Cryptocarya, Castanopsis, Santiria* and *Anisophyllea corneri* in Plot 2.

Trees of intermediate height range from 20 to 28 m occupy the middle storey. Species associations between the two plots are again different. Plot 1 is dominated by *Shorea parvifolia, Eugenia* spp. and *Gironniera nervosa.* Also present are species of *Canarium, Castanopsis, Durio, Artocarpus, Baccaurea* and *Neoscortechinia.* In Plot 2, *Eugenia* spp., *Dryobalanops beccarii* and *Neoscortechinia* become the most common, while *Lithocarpus* sp. and *Xanthophyllum* sp. are each represented by one tree. Only *Eugenia* and *Neoscortechinia* spp. occur in both plots. Ten species are recorded in Plot 1 and 6 species in Plot 2.

The lower storey stands at below 20 m with the shortest trees at 13 m, and contains 43 individuals representing 22 species. Members of the Myrtaceae (*Eugenia* sp.), Burseraceae (*Dacryodes* sp.), Fagaceae (*Lithocarpus* and *Castanopsis* spp.) are more abundant in Plot 1 with about 16 species. Three species of dipterocarps dominate Plot 2, with *Dryobalanops beccarii* being the most numerous with 11 trees. The other two species are *Dryobalanops oblongifolia* and *Shorea macroptera. Eugenia* are the most common non-diptercarps in this plot. It is noted from Table 17 that the Euphorbiaceae is much less common here, although it is normally one of the most important components in other lowland forests. An estimated 47 species are known from this forest (Table 18).

Table 17 : Dominant tree families in secondary forest plots, Pakararu

	Plot 1				Plot 2		
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Myrtaceae	1	1	12	Myrtaceae	1	6	11
Dipterocarpaceae	2	3	9	Dipterocarpaceae	2	3	15
Fagaceae	2	3	6	Fagaceae	2	3	4
Burseracaeae	2	3	5	Euphorbiaceae	2	2	2
Euphorbiaceae	2	2	2	Lauraceae	1	1	2

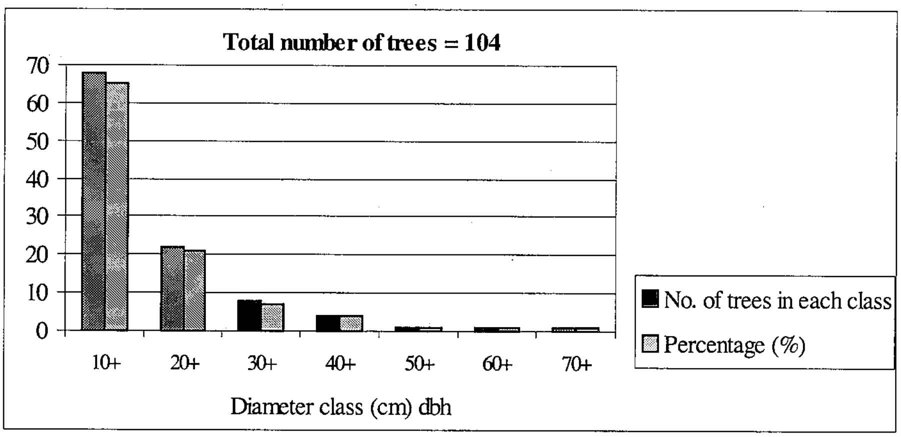
Table 18 : Numbers of species and individuals in secondary forest, Pakararu

	Plot 1	Plot 2	Total
Families	18	13	23
Genera	22	15	31
Species	36	25	47
Trees	61	43	104
Density/ha	610	430	520 (Mean)

Diameter class distribution shows that out of a total of 104 individuals recorded from the plots, 85.6% are between 10 and 30 cm dbh, while the remaining 14.4% are over 40 cm (Figure 7). They contribute to a basal area of 21.98 m^2/ha compared to 58.44 m^2/ha in the primary forest at Pakararu.

Ground flora comprises predominantly tree seedlings and climbers, while herbs are comparatively rare. Seedlings of *Shorea macroptera* and three species of *Eugenia* are the most numerous among the woody species which number about 50. There are at least ten species of climbers, the most common being *Rourea mimosoides, Tetracera* sp., *Strychnos* sp. and *Vitis* sp. Rattan (*Calamus* sp.) is represented by only three plants. Herbaceous flora total about six species, and include two gingers (Zingiberaceae), *Mapania* sp., *Pleomele* sp. and fern. They occur singly or in small colonies between the tree seedlings.

Figure 7 : Diameter class distribution in 35-year-old secondary forest plots at Pakararu (150 m a.s.l.)



b) Ulu Katibas Plots

(i) 100-year-old forest

The 100-year-old forest plots were located on a gently ascending hill slope about 210 m a.s.l. Apart from the abundance of medium-sized trees giving the forest a pole-appearance, the forest is essentially similar to the primary lowland dipterocarp forest in structure. *Tristaniopsis whiteana* is the largest tree in the forest with a maximum height of 60 m and a diameter of 132 cm. It is an indicator species of the secondary forest. Two species of *Shorea (S. parvifolia* and *S. parvistipulata), Hydnocarpus* sp., *Lithocarpus* sp. and *Aglaia* sp. make up the emergent storey together with *Tristaniopsis whiteana.*

Field data show a distinct difference in species composition between trees of the middle canopy at 22 to 28 m and the lower storey at 9 to 12 m. The mid-storey species include *Nephelium ramboutan-ake, Endiandra* sp., *Lithocarpus* sp., *Artocarpus* sp., *Dacryodes* sp., *Dyera costulata, Alstonia* sp. and *Macaranga* sp.. *Macaranga*, a pioneer species, is the most common with 11 individuals generally confined to open areas. The Euphorbiaceae is predominant in the lower storey with species of *Baccaurea, Blumeodendron* and *Macaranga,* growing in association with *Polyalthia* sp. and *Popowia* sp., *Gironniera nervosa, Tarenna* sp. and members of the Myrtaceae and Lauraceae. About 64 species occur in a combined area of 0.2 ha from two plots (Table 19).

Table 19 : Number of species and individuals in 100 year-old secondary forest at Kelimau Besai

No.	Plot 1	Plot 2	Total
Families	26	22	32
Genera	41	41	56
Species	44	47	64
Trees	65	81	146
Density/ha	650	810	730 (mean)

The Euphorbiaceae and Myrtaceae are very well represented in species and densities, while the Dipterocarpaceae shows a more localized distribution, being more common in Plot 2 (Table 20). Local variation is further evidenced from the occurrence of other dominant families in the plots.

Table 20 : Dominant tree families in 100-year-old secondary forest plots at Sg Kelimau Besai (220 m a.s.l.)

	Plot 1				Plot 2		
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Euphorbiaceae	5	5	7	Euphorbiaceae	6	9	9
Myrtaceae	2	5	11	Dipterocarpaceae	2	5	19
Rubiaceae	4	4	5	Myrtaceae	1	3	6
Lauraceae	2	2	5	Sterculiaceae	2	3	6
Annonaceae	2	2	4	Apocynaceae	2	2	4

Compared with the previous surveys of this forest in the vicinity[7], certain consistencies are observed in spite of the different plot sizes. Firstly, the Euphorbiaceae, Dipterocarpaceae, Myrtaceae and Lauraceae are among the dominant families present. Secondly, the total number of 146 tree species recorded here is close to that of 167 recorded previously.

Ground flora are made up of no less than 25 species of woody saplings and seedlings, 6 species of climbers and 8 species of herbs. The more common woody species belong to those of *Campnosperma, Urophyllum, Antidesma, Hydnocarpus* and *Popowia*. Palms are well represented by one species each of *Calamus, Daemonorops* and *Pinanga,* and *Salacca affinis. Begonia* sp., *Cyrtandra* sp., *Alpinia* sp. and ferns are seen among the herbs. Up to 159 species belonging to the ground flora are known from the previous surveys in 1995.

(ii) 30-year-old forest

The 30-year-old forest which has developed from a part of the cleared older secondary forest shows a marked difference in structure and species composition. Structurally, the forest is made up of only two main storeys. The upper canopy stands at 25 m, although a few trees such as *Lithocarpus* and *Parashorea macrophylla* are up to 29 m. The most common species is *Nephelium ramboutan-ake.* Other species mostly occur as single individuals, such as *Cryptocarya* sp., *Endiandra* sp., *Aglaia* sp. 2, *Eugenia* sp., *Pithcellobium* sp., *Artocarpus* sp. and *Gironniera subaequalis.*

The lower storey below 18 m is floristically much richer with at least 15 species most of which are represented by one individual each. The more common ones are *Saurauia glabra, Nephelium ramboutan-ake,* and the Borneo ironwood *Eusideroxylon zwageri.* The last species is coppicing very well from cut stumps. Many of the trees are seen to have been attacked and killed by termites.

The dense undergrowth is very much due to the presence of numerous saplings, climbers and herbs. Species of *Rinorea, Diospyros, Popowia* and *Baccaurea* are more common among the woody species. Palms are represented by one species of *Pinanga* and four species of rattan e.g. *Calamus pogonacanthus, C. scipionum* and *Korthalsia flagellaris* which all produce good quality canes. Other climbers besides the rattan are *Tetracera* sp., *Spatholobus* sp., *Fibrauea* sp. and *Willughbeia* sp. The cool forest floor

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[7] Chai (1995)

is also dominated by a species of *Hornstedtia* (Zingiberaceae) which grows in dense clusters to a height of 4 m. *Amorphophalus* sp. (Araceae) is present as a very rare herb.

The Dipterocarpaceae is represented here by only *Parashorea macrophylla,* while the most common families include the Lauraceae, Euphorbiaceae and Meliaceae (Table 21), replacing the Dipterocarpaceae, Myrtaceae and Fagaceae at Pakararu. The presence of 88.9% of the trees between the diameters of 20 to 30 cm, with only 5 trees over 40 cm, is indicative of the young age of the forest Altogether 115 individuals were recorded from the 0.2 ha plots.

Table 21 : Dominant families of trees over 10 cm dbh in 30-year-old secondary forest

	Plot 1				Plot 2		
Family	Gen	Spp	Trees	Family	Gen	Spp	Trees
Lauraceae	3	3	5	Lauraceae	3	5	12
Euphorbiaceae	2	2	4	Euphorbiaceae	3	3	12
Meliaceae	2	3	3	Meliaceae	3	3	8
Sapindaceae	1	1	7	Sapindaceae	1	2	3
Leguminosae	2	2	2	Burseraceae	1	2	2

Species colonization and succession are dependent on a number of factors such as history of the cleared sites and soil properties, the availability of seed source and favourable conditions for gemination. Between the 100-year-old and 30-year-old forests, the following differences are evident :

(i) Greater complexities in the older forest in terms of forest structure, densities and species richness;

(ii) Dominance of the Dipterocarpaceae, Euphorbiaceae and Myrtaceae in the older forest. *Parashorea* is the only dipterocarp encountered in the younger forest;

(iii) Up to 11% of the trees are above 40 cm dbh compared to only 4.3% in the younger forest.

5. SUMMARY AND CONCLUSIONS

In BKNP, altogether five distinct forest types in the localities of Pakararu, Pajau, Pait and Condong were sampled to study their structures, species richness and densities. In LEWS, similar surveys were carried out in the riparian forest, secondary forests and lowland dipterocarp forest all in the ulu Katibas. The results of these studies are summarised in Tables 22 and 23.

Table 22 : Number of species and densities of trees over 10 cm dbh in five forest types in BKNP

Forest Type	No. of Plots	Locality (altitude, m a.s.l.)	No. of Families	No. of Genera	No. of Species	Tree Density (per ha)
Alluvial	2	Pait (250)	19	29	35	455
Secondary 35 years old	2	Pakararu (50)	23	31	45	520
Lowland Mixed Dipterocarp	2	Pakararu (210)	27	46	76	900
	2	Pajau (250)	18	25	32	380
Hill Dipterocarp	6	Pakararu (110)	33	54	77	1145
		Pait Ridge (530)	30	51	76	725
		Condong (620)	27	42	67	905
Lower Montane	2	Condong (1,000)	21	28	44	850

Table 23 : Number of species and densities of trees over 10 cm dbh in three forest types in LEWS

Forest Type	No. of Plots	Locality (altitude, m a.s.l.)	No. of Families	No. of Genera	No. of Species	Tree Density (per ha)
Riparian	4	Ulu Katibas (100)	31	62	70	533
Secondary : 30 years old	2	Ulu Katibas (170)	29	42	52	620
100 years old	2	Ulu Katibas (220)	32	56	64	730
Lowland Dipterocarp	4	Nyungan Ridge (215)	40	75	103	762
	4	Bkt Guning (210)	37	74	96	663

Results from these preliminary studies show that each forest formation is highly variable and complex in species distribution and species richness. In almost all cases, totally different species compositions and numbers were recorded from two adjacent plots within the same forest type.

In all the forest types, species frequencies appear to be very low with up to 80% of the individuals in the plots belonging to different species. The highest numbers of species are recorded from the lowland and hill dipterocarp forests in BKNP and LEWS, with the exception of the lowland forest at Pajau where the low density is believed to be partly due to human disturbance in the past. The lowland dipterocarp forests of LEWS have the highest number of species but are lower in density compared to the lowland and hill dipterocarp forests of BNKP.

Similar studies in LEWS[8] using a bigger sampling size of 50 x 50 m in three replicates indicate a much richer flora of 265 species in the alluvial forest, 494 species in the lowland dipterocarp forests, 368 species in the hill dipterocarp forest, 123 species in the lower montane forest, and 376 species in the 100-year-old secondary forests. This trend is also observed among the ground flora although a full identification list from the Expedition is still not available.

This preliminary study merely covered a total area of 3.2 hectares from 16 plots each in BKNP and LEWS. This is insignificant compared to the total area of just under one million hectares. Nevertheless, much information has been collected that will form the basis for the preparation of a management plan for BKNP and for future work, while adding further knowledge to LEWS. Major forest types were identified and their structures and species compositions described. Observations were made regarding the terrain, soils and habitats and characteristics of the flora and their habits.

The study has also identified the mixed dipterocarp forests of Bukit Pakararu and Bukit Condong in BKNP as potential areas for gene banks as they contain many species of the Dipterocarpaceae that produce excellent timber. In LEWS, such areas have already been identified in the 1995 study.

The BKNP-LEWS Transboundary Biodiversity Conservation Area is important not only for Indonesia and Malaysia but also has global significance. The tropical rainforest is playing an increasing role in maintaining a healthy global environment as an absorber of CO_2, while its great wealth of largely untapped biological resources are a potential source for food and biotechnological research.

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[8] Chai (1995)

A proposal for a joint management of the Transboundary Conservation Area by Indonesia and Malaysia is expected to be drawn up. Effective protection and management of such a huge area would require a fuller understanding of the various aspects of the forest resources and their ecological characteristics. Forest ecological studies will contribute to our basic understanding of the forests and habitats which are homes for numerous varieties of plant and animal life.

In LEWS, studies have so far been confined to only three areas of ulu Katibas in the east, Bukit Entimau in the north-west, and Bukit Lanjak in the south-west. In BKNP, the present study under the Expedition is the first for the 800,000-hectare reserve. Systematic ecological studies will take many years of field work, but reliable information on the forest types and their distributions can be more easily obtained through field reconnaissance by experienced forest ecologists, when preliminary forest type maps containing interpretations from aerial photographs or satellite images are available. Further studies should be encouraged whenever human and financial resources permit.

The Expedition also reveals the need to train more young ecologists and botanists in field work and species identification, and to gain the necessary knowledge and experience to continue this important work in the future.

The basis for effective protection and management of the huge conservation area is to identify and map the forest resources, as far as possible, into distinct vegetation zones or units in relation to the topographical features, soils and altitudes. These maps can initially be prepared from aerial photographs and satellite images.

Detailed ecological surveys can be carried out for specific scientific purposes or confined to rare or sensitive habitats and selected sites identified for nature education and ecotourism development.

B. BOTANICAL SURVEYS

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1. INTRODUCTION

The flora of Borneo has been conservatively estimated to comprise 12,000 - 15,000 species of vascular plants (Merrill, 1950). About 5,000 species are endemic to the island. Borneo is also the centre of diversity for the economically valuable Dipterocarpaceae, and possesses 75% of all known species. This rich flora occurs from the sea coasts to inland mountain ranges, and includes numerous species important as timber, jungle produce, medicinal plants and ornamentals. A sizable portion of this diversity remains unknown.

However, the flora of a major part of Borneo, Kalimantan in particular, is represented by one of the lowest collection densities of herbarium specimens of any place in the world. In 1950 a collection density of 7.5 & 6 specimens per 100 km^2 in SW & SE and E & NE Borneo respectively was recorded[1]. By 1972 a total of 194,200 herbarium specimens had been collected in Borneo[2] representing a density of only 26 specimens per 100 km^2. Sarawak, however, has been relatively well collected, and even in 1950 had almost 2.5 times as many collections as W. Borneo and a collection density of 21 specimens per 100 km^2. As of 1997 more than 76,000 collections had been made under the Sarawak Forest Department label, giving a collection density of 61 per 100 km^2. This figure does not include the many other collections made in the state under the labels of others.

Botanical specimens have been collected in W. Kalimantan at least since 1822, when George Muller, acting Resident of Dutch W. Borneo and Pontianak, collected in the Kapuas valley. Various other botanists have collected in the general area of W. Kalimantan (P.W. Korthals, W.H. deVriese, E. van Martens, O. Beccari, Martin, J.E. Teijsmann, A.W. Niewenhuis & his associates, C.N.J. Delmaar, M. Dachlan, H. Winkler, F.H. Endert, B. Polak & Yoshimatsu Yamamoto). However, apparently no botanical collections have been made in the BKNP areas visited during the Expedition. Some ecological studies have recently been carried out in the area by Dr. Tukirin Partomihardjo and his team in Hulu Bungan and Sibau.

[1] Steenis-Kruseman (1950)
[2] Regalado (1990)

Lanjak-Entimau was visited for the first time by the Sarawak Forest Department's (SFD) Botany Unit in March 1974, during their annual collecting programmes. A total of 391 specimens were collected, and three of these have since been described as new species. A new species, of the genus *Polyosma* (Escalloniaceae), is yet to be described. LEWS was gazetted in 1983. In June and July 1993, botanists involved in the preparation of taxonomic accounts for the Tree Flora of Sabah & Sarawak Project made an expedition to LEWS. A total of 618 herbarium specimens, representing 550 different species, was collected, of which 392 were under the SFD label and the remainder under the labels of other Malaysian institutions (Sabah Forest Department, Universiti Kebangsaan Malaysia, Forest Research Institute Malaysia and Universiti Malaysia Sarawak). Till now, LEWS has been relatively under-collected compared to most other areas in Sarawak.

The aim of the botanical investigation was to make a general botanical collection of all available fertile (flowering or fruiting) material of vascular plants in the area, in order to obtain baseline data regarding the families, genera and species present, their habitats and habits. In addition, special collections of the palms, orchids (chiefly living collections) and bryophytes of the area were made by specialists in these plant groups. Separate accounts of the latter studies and that of the ethnobotanical study that was carried out at local longhouses have been included elsewhere in this volume.

Teams carrying out botanical collection included scientists from Indonesia and Malaysia (Table 1) as well as a supporting team of forest rangers, tree climbers and labourers. In the field, many supporting personnel were drawn from members of the local community in the BKNP and LEWS areas.

The locations of the sites for botanical exploration in BKNP and LEWS are shown in the maps section of this volume. Four Basecamps in BKNP, and two in LEWS, differed in altitude and to some extent forest types and habitats within reach of the daily forays were made to collect botanical specimens (Table 2; also see Section I).

Table 1 : Scientists and staff involved in botanical collection		
Indonesian scientists		
Dr. Johanis P. Mogea Dr. Harry Wiriadinata Dr. Djunaedi Gandawidjaja	Palm specialist Botanist Orchid specialist	Herbarium, Indonesian Institute of Sciences (LIPI), Bogor, Indonesia
Heri Sujadmiko	Bryophyte specialist	Universitas Gadja Mada, Lab Taksonomi Tumbuhan, Fakultas Biologi Sekip Utara Yogyakarta 55281
Ibu Suli	Biodiversity of orchids (student)	
En. Dafid Sembiring	Assistant to Suli	
Malaysian scientists	**(botany team)**	
Dr. Kit Pearce	Botanist	Sarawak, Malaysia
En. Stephen Teo Cik Mohizah bte Mohamad	Forest botanist Forest botanist	Sarawak Forest Dept., Sarawak, Malaysia
Cik Julia Sang	Botanist	Forest Research Inst. Malaysia, Kuala Lumpur, Malaysia
Malaysian scientists	**(ecology team)**	
Dr. Paul Chai P.K.	Ecologist	ITTO, Sarawak
Dr. Lillian Chua	Botanist	Forest Research Inst. Malaysia, Kuala Lumpur, Malaysia
Pn. Runi Sylvester En. Julaihi Abdullah	Forest botanist Forest botanist	Sarawak Forest Dept., Sarawak, Malaysia
Malaysian supporting staff (Sarawak Forest Department, Malaysia)		
Forest Ranger : Yahud bin. Hj. Wat		
Forest Guards : Rantai Jawa, Awang Enjah Awg. Kepli, Banyeng Ludong		
Tree Climbers : Tinjan Kuda, Shalih Rebi, Dami Jude, Army Kapi, Johnny Engkabau, Manggi Kapi		

Table 2 : Details of Forest and Habitat types at Basecamps in BKNP and LEWS

Basecamp	Forest types within reach of day trips	Habitat types within reach of day trips
Pakararu Basecamp. BKNP on Sg. Embaloh 90 m a.s.l.	Lowland Dipterocarp Forest (LDF), some disturbed 90-500 m a.s.l.	slope, ridge, riverside (riparian)
Derian Basecamp, BKNP on Sg. Tekalan 100 m a.s.l.	LDF, some disturbed 100-450 m a.s.l.	slope, ridge, riverside (riparian)
Pait Basecamp, BKNP on Sg. Pait 250 m a.s.l.	LDF, some disturbed 250-400 m a.s.l.	slope, streamside
Condong Basecamp, BKNP 1000 m a.s.l.	Hill Dipterocarp Forest (HDF) & Submontane Mossy Forest 900-1,300 m a.s.l.	slope, streamside, summit
Menyarin Basecamp (A), LEWS at Sg. Menyarin/Sg. Katibas confluence 150 m a.s.l.	Riparian Forest, Alluvial Forest (some disturbed), LDF (some disturbed), old secondary LDF, HDF Alt. 150-400 m a.s.l.	slope, riverside, streamside, ridges, summits
Ng Joh Basecamp (B),LEWS at Sg. Bloh/Sg. Joh confluence 150 m a.s.l.	Riparian Forest, Alluvial Forest (some disturbed), LDF (some disturbed), transition to HDF 150-400 m a.s.l.	slope, riverside, streamside, ridges

2. METHODOLOGY

For the purposes of plant collection the botanists worked in two teams, each team comprising both Malaysian and Indonesian scientists. Team BA was led by Dr. Johanis Mogea, while team BB was led by Dr. Katharine Pearce. The specialists in orchids and bryophytes (Dr. Djunaidi Gandawidjaja and Heri Sudjadmiko respectively) worked independently in order to be able to sample habitats where individuals of these plant groups were likely to occur. Some collections were made by the ecology team (BC) under the leadership of Dr. Paul Chai.

Standard herbarium specimen collection procedures were used, whereby each flowering and/or fruiting plant specimen collected, (up to six duplicates if possible) was tagged with a collection number in the field, and full notes were taken as to its location, habitat and such characters as habit, height, diameter, bark and flower and fruit colour. Where possible, specimens were identified to family and genus level in the field. For each specimen details of its local name, uses (if any) and potential as ornamental species (if any) was noted where available or relevant. In the field, specimens were pressed between sheets of newspaper, and preserved in spirit. By prior agreement, they were then separated into two sets. A full set, including all unicates (collections comprising a single specimen) was brought back to the host country's research facilities (Herbarium Bogoriense for specimens collected in BKNP, and the Forest Research Centre, Sarawak Forest Department, Kuching for those collected in LEWS) while a set of duplicates was brought back to the guest country's research institute. At the Herbarium Bogoriense the specimens were dried before being identified with reference to relevant literature and by comparison with the specimens in the herbarium collection.

3. OBSERVATIONS

3.1 Collections

A total of 1930 specimens was collected during the Expedition (Tables 3 & 4). This includes repeat collections made in the same area by different teams, or in the same area but from different forest types, as well as from the two different Expedition destinations, BKNP and LEWS.

The number of species represented in collections from BKNP was estimated to be ca. 600 while from LEWS ca. 500 different species are thought to have been collected.

Table 3 : Summary of status of collections as of June 1998

Location	BKNP	LEWS
Total number of specimens collected	1020	910
No. families represented (excluding ferns & fern allies)	75	73
No. genera represented (excluding ferns & fern allies)	206	187
No. species identified (excluding fern & fern allies and including those of cf. status)	326	92
Percentage identification as of June, 1998	c. 32 % *(45%)	c. 13%
No. (%) specimens representing repeat collections under different collection numbers	43 (14%)	NA

* percentage out of the total number of specimens available at Sarawak, not including 308 unicate specimens at Bogor

Table 4 : Commonly collected families

Family	Number of specimens		
	TOTAL	BKNP	LEWS
Rubiaceae	200	109	91
Euphorbiaceae	172	87	85
Arecaceae	127	59	68
Melastomataceae	114	72	42
Zingiberaceae	91	50	41
Gesneriaceae	84	46	38
Orchidaceae	79	27	52
Annonaceae	76	41	35
Begoniaceae	60	18	42
Meliaceae	42	22	20
Araceae	39	19	20
Dipterocarpaceae	33	18	15
Lauraceae	31	20	11
Myrsinaceae	31	19	12
Myristicaceae	29	12	17
Myrtaceae	29	14	15
Burseraceae	26	16	10
Clusiaceae	24	9	15
Ebenaceae	23	14	9
Acanthaceae	21	8	13

3.2 Habit types and lifestyles

Plants of various habits and lifestyles were collected during the Expedition. Habits distinguished included trees, shrubs, herbs, climbers and epiphytes, while lifestyles included autotrophs, parasites and saprophytes. The numbers of specimens of each plant habit and lifestyle are given below (Table 5).

Table 5 : Number of specimens of plants of different habits and lifestyles collected in BKNP and LEWS

Plant habit	Number of specimens * (% of total)			
	BKNP		LEWS	
Trees	448	(59)	371	(57)
Shrubs	34	(4.5)	49	(8)
Herbs	200	(26)	150	(23)
Climbers	52	(7)	50	(8)
Epiphytes	25	(3)	37	(6)
Parasites	2	(0.3)	0	
Saprophytes	0		0	

* These figures are from collection data for specimens so far entered into the database. The majority of specimens collected at each location were trees, with herbs the second most plentiful. Unexpectedly few shrubs were collected at either location. The proportions of epiphytes and climbers differ substantially if data for orchids collected by Dr. Djunaidi, and palms including climbing rattans collected by Dr. Mogea are included.

Among lifestyles, parasites were rare and saprophytes even rarer - represented only by *Burmannia* on Bukit Condong, BKNP and *Scyaphylla* (Triuridaceae) at LEWS.

Use of the above set of categories is unsatisfactory as individual categories are not necessarily mutually exclusive (epiphytic climbers, parasitic epiphytes and saprophytic herbs exist). Furthermore there is no category suitable for non-climbing palms, tree ferns etc.

3.3 Forest types and their floras

Various types of tropical rainforest occur in BKNP and LEWS. Each forest type can be characterised by:

a) the species which dominate it,
b) the size (diameter at breast height or dbh) of its constituents, and
c) its structure, including
   (i) densities of trees of different sizes
   (ii) vertical structure which can be expressed as a profile indicating the number of strata, the height of each stratum and the presence or absence of emergents.
d) the soil on which it occurs.

The forest types accessible for sampling during the Expedition (Table 2) comprised Lowland Dipterocarp Forest (LDF) (including Primary LDF and

Old Secondary LDF, Alluvial Forest and Riparian Forest) in the lowlands, and Hill Dipterocarp Forest (HDF), its variant Quartzite Ridge Forest, and Submontane Mossy Forest at higher altitudes.

a) Lowland Dipterocarp Forest

At both BKNP and LEWS botanical investigations were made chiefly in the lowlands thus the majority of the specimens were collected from Lowland Dipterocarp Forest (LDF) which occurs from ca. 100 m a.s.l. to around 500 m a.s.l. on moderate slopes and ridges. Lowland Dipterocarp Forest in the area included both Primary LDF and Old Secondary LDF. Secondary forest develops when primary lowland dipterocarp forest is disturbed, but varies greatly in species composition and forest structure, depending on factors such as the composition of the original forest, the degree of disturbance that occurred and the stage in plant succession reached. According to local informants at BKNP, considerable disturbance had occurred about thirty years previously, when the local communities had farmed rice in the area, cutting but not burning the forest to do so. Other informants suggested that the forest had been disturbed when timber had been extracted for local use, when it had been cut to encourage the growth of young vegetation to attract game to the area and during 'gaharu' (aloe wood) collecting expeditions. In LEWS local informants believed the forest had been cut 100 years ago or more for shifting cultivation, and then abandoned, during migration of Iban communities to the Katibas area from the Batang Ai area to the south. Both these forest types are referred to in this report as 'Old Secondary' LDF. Some areas sampled around the camps had undergone more recent disturbance.

Lowland Dipterocarp Forest typically has three strata as well as taller emergent trees. At BKNP Primary LDF was sampled on the slopes near Sg. Pajau (between Derian and Pait Camps), near Pait Camp and at the foot of Bukit Condong. The main canopy was at 30-40 m, the second storey at 20-30 m and the understorey of small trees and saplings at 10-20 m while the emergents were ca. 45 m tall.

The bulk of the area accessible from the three lowland camps in BKNP (Pakararu, Derian & Pait) and much of the forest at LEWS was occupied by Old Secondary LDF, therefore more collections were made from this forest type than from Primary forest.

Secondary LDF can be differentiated from Primary LDF by its lower species diversity and tree density, lack of large-diameter trees, lower strata height and presence of a well-developed understorey comprising a plethora of herbs, shrubs, treelets and climbers (all consequences of past clearing of the forest). Some species are good indicators of former disturbance, one of these, *Dicranopteris linearis* (*resam*), an indicator of severe, recent disturbance, was found on certain ridges near Pakararu Camp, BKNP. At BKNP large-diameter trees (dbh >= 50 cm) were uncommon in areas of old secondary forest and those > 70 cm dbh were seldom observed. Emergents were ca. 35 m tall, and the main canopy was at 20-30 m, and dominated by *Dryobalanops beccarii, Shorea macroptera, Sh. parvifolia* and *Eugenia* spp.

The flora of the LDF is analysed below, according to plant habit. While efforts have been made to compare the species occurring in Primary LDF with those in Old Secondary LDF such comparison was rather difficult in many of the areas investigated as it was difficult to be certain whether the forest was truly primary or very well-developed Old Secondary LDF.

(i) Trees

Lowland Dipterocarp Forest in BKNP was found to be fairly typical, the main canopy being dominated by dipterocarps such as *Dipterocarpus mundus, D. humeratus, D. cornatus, Dryobalanops oblongifolius, Shorea amplexicaulis, Sh. faguetiana, Sh. leprosula, Sh. pachyphylla, Sh. parvifolia* and *Sh. macroptera.* Emergents included *Shorea leprosula, Sh. parvifolia*, and non-dipterocarps such as *Koompassia malaccensis, Palaquium* sp., *Lithocarpus* sp., and *Mangifera* sp. Most of these species were not collected as the trees were large and infrequently flowering. The understory comprised mostly non-dipterocarps with *Vatica*, *Hopea* and young trees of *Shorea.*

Specimens of trees collected from LDF at BKNP represented a wide variety of families, including Anacardiaceae, Anisophylleaceae, Annonaceae, Bombacaceae, Burseraceae, Celastraceae, Clusiaceae, Convolvulaceae, Dipterocarpaceae, Ebenaceae, Elaeocarpaceae, Euphorbiaceae, Flacourtiaceae, Gonystylaceae, Lauraceae, Leguminosae, Melastomataceae, Meliaceae, Myristicaceae, Myrsinaceae, Myrtaceae, Polygalaceae, Proteaceae, Rosaceae, Rubiaceae, Sapindaceae, Sapotaceae, Saurauiaceae, Sonneratiaceae, Sterculiaceae, Theaceae, Tiliaceae, Ulmaceae and Violaceae. Particularly well-represented were trees of the main canopy from the families Burseraceae (*Dacryodes, Santiria* spp.) and Polygalaceae (*Xanthophyllum* spp.) while families well-represented in the understory included Annonaceae (*Goniothalamus, Polyalthia* spp.), Ebenaceae (*Diospyros* spp.) Euphorbiaceae (*Antidesma, Aporusa, Baccaurea, Croton, Elateriospermum, Macaranga, Mallotus* spp.), Melastomataceae (*Memecylon* spp.), and Rubiaceae (*Lasianthus, Pleiocarpidia, Porterandia, Praravinia, Urophyllum* spp.).

Old Secondary LDF and Primary LDF were found to be floristically highly similar. However, some differences could be noted:

a) In general, far fewer dipterocarps were found in old secondary forest than in Primary LDF. Thus at LEWS a very low number of dipterocarps was found around Ng Joh Basecamp, while other areas (e.g. Sg. Bedawak) were much richer in dipterocarps. Similar results were obtained in the ecological studies carried out as part of Phase I of the Development of LEWS as a Totally Protected Area (Chai, 1995).
b) Some families were represented by additional genera in old secondary forest: *Papualthia, Popowia* and *Pseudouvaria* (Annonaceae) and *Ixora, Pavetta, Psychotria* spp. (Rubiaceae) are additional genera not encountered in Primary LDF. More Rubiaceae genera were also found in Old Secondary LDF than in Primary LDF in LEWS.
c) Some families were represented by different genera in the two forest types (e.g. the Melastomataceae was represented by *Memecylon* sp. in Primary and *Pternandra* sp. in old secondary forest. (*Memecylon* was also more common in Primary, and *Pternandra* in Secondary LDF in LEWS[3].

These generalizations are based only on general observations and the fertile specimens collected over a very short period. More intensive collection in the area is required to determine any real differences in flora between the two forest types.

Lowland Dipterocarp Forest at LEWS was floristically similar to that of BKNP. Collections were made of a similar range of families and genera of trees, in similar proportions in both Primary LDF and Old Secondary LDF. However, a notable difference between the LEWS and the BKNP Lowland Dipterocarp Forest was the collection from LEWS of a number of tree species which produce edible fruits (*Alangium* sp., *Baccaurea macrocarpa, Castanopsis* sp., *Gnetum gnemon, Artocarpus integer, A. elasticus, A. sarawakensis, Dimocarpus longan, Garcinia bancana, Saurauia* sp., *Xanthophyllum amoenum*), whereas in BKNP only one edible fruit tree specimen was collected (*Elateriospermum tapos*). The presence of such trees in LEWS might be due to seeds of fruit trees having been discarded in areas once used for shifting cultivation by Ibans migrating through the area in the past.

Unusual trees found during the Expedition only in BKNP included *Meliosma* (Sabiaceae), *Aulandra* (Sapotaceae), *Gonocaryum* (Icacinaceae) and *Jarandersonia parvifolia*, a new record for Kalimantan.

3 Chai (1995)

One rare tree species from LEWS but not collected in BKNP was a Sapindaceae species (cf. *Guioa*) which may be new. In addition, differences were noticed in the dipterocarp flora of the two areas, and this is reflected in the dipterocarp specimens collected from BKNP which represented some different genera and species when compared to those collected from LEWS (*Shorea, Hopea, Dryobalanops* and *Vatica,* in BKNP and *Shorea, Hopea, Dipterocarpus* and *Parashorea* (not collected) in LEWS). *Agathis borneensis* (Araucariaceae), collected in LEWS at a low altitude, was observed but not collected on Bukit Condong in Submontane Mossy Forest.

(ii) Shrubs

In BKNP few specimens of shrubs were collected in Primary and Old Secondary LDF. Collections were chiefly from the Rubiaceae, with the Gesneriaceae, Melastomataceae and Piperaceae also represented. Other collections were from families which occurred in one or other forest type (Anisophylleaceae, Campanulaceae, Moraceae and Myrsinaceae). More genera and species of Rubiaceae were collected in Old Secondary LDF than in Primary LDF.

In LEWS shrub genera collected in Primary LDF belonged to the Euphorbiaceae, Gesneriaceae, Melastomataceae, Myrsinaceae, Ochnaceae and Rubiaceae, while in Old Secondary LDF the collections were of the Acanthaceae, Euphorbiaceae, Rubiaceae and Saurauiaceae. In LEWS, as in BKNP, the Rubiaceae were better represented in the Old Secondary LDF than the Primary LDF.

(iii) Palms

Palms of LDF collected at LEWS included many species in the understory, including *Areca minuta, Arenga undulatifolia, Licuala petiolulata, L. pygmaea, Pinanga mooreana, P. sessilifolia, Salacca affinis* var. *borneensis* and *S. vermicularis.* Rattans included *Calamus caesius, C. javensis, C. laevigatus* var. *mucronatus, C. paspalanthus, C. pogonacanthus, C. tenompokensis, Ceratolobus discolor* and a new species of *Korthalsia* (BA 1147).

(iv) Herbs

Herbs were a major component of Lowland Dipterocarp Forest in BKNP. Among the families represented in Primary LDF were the Acanthaceae, Araceae, Begoniaceae, Cyperaceae, Ferns, Gesneriaceae, Marantaceae, Melastomataceae, Rubiaceae, Urticaceae and Zingiberaceae. Of these the Gesneriaceae (*Cyrtandra* and *Didymocarpus* spp.) and Zingiberaceae (*Alpinia, Globba, Plagiostachys, Zingiber* spp.) were particularly well represented. In old secondary LDF almost exactly the same set of families were represented and in similar proportions. Of note is the larger number of Zingiberaceae genera (*Amomum, Boesenbergia, Costus, Etlingera, Globba, Plagiostachys, Zingiber* spp.) as well as the larger number of *Begonia* specimens.

In LEWS a similar range of families was collected from Primary LDF, with the Begoniaceae, Gesneriaceae and Melastomataceae being particularly well represented. In old secondary LDF a few more families were represented than in Primary LDF (Acanthaceae, Amaryllidaceae, ferns, Hypoxidaceae, Marantaceae, Myrsinaceae and Piperaceae). This is expected as secondary forest has better developed undergrowth than primary forest, disturbance of the main canopies resulting in more light reaching the forest floor, and the colonization of such new niches characterised by conditions of higher light intensity by species adapted to such conditions.

Of particular note among the herbs of BKNP were two gesneriad species, both found on a shale cliff. One of these was *Monophyllaea* sp., the somewhat rare 'one leaf plant' The other was the very attractive and ornamental species *Cyrtandra mirabilis*. This plant has an interesting habitat, clinging to a very damp vertical shale rock cliff, and its habit is remarkable - the plant hangs vertically against the rock, with its leaves forming an asymmetric fan. The upwards pointing leaves are shorter than the long, asymmetrically curved, pendant leaves. The flowers are a delicate shade of purple. This plant was locally abundant, though was seen nowhere else during the Expedition. It has great potential as an ornamental, and furthermore is rare, having only been collected twice before, once in Kalimantan, and once from Gunung Berumput, Sarawak. Among the Rubiaceous herbs the *Acranthera* spp. were particularly attractive, with dark green leaves and bright red flowers. An attractive Melastomataceous plant was *Cynandrium,* a low-growing species with white spots on its dark green leaves which has seldom been collected before. It was also collected from LEWS. At LEWS, the wide variety of *Begonia* species, differing in habit, leaf shape, leaf coloration, and flower features, was particularly remarkable. Among these was *Begonia* cf. *rajah*, a particularly decorative low-growing species. According to local informants leaves of all the begonias can be used as a vegetable, and are cooked with prawns or fish to give it a sour taste. At LEWS *Curculigo borneensis*, a somewhat uncommon species, was collected as well as two different small yet attractive species of *Boesenbergia* (Zingiberaceae) not seen at BKNP.

(v) Climbers and Epiphytes

In Primary LDF at BKNP, the climbers collected were both woody : *Gnetum* spp. (Gnetaceae), *Poikilospermum* sp. (Urticaceae), rattans and non-woody climbers (aroids), *Hoya* sp. (Asclepiadaceae) *Piper* sp. (Piperaceae), and an attractive *Pterisanthes* (Vitaceae) with a large flat pink rachis bearing green fruits. *Lycopodium* (a fern ally) was one of the few epiphytes collected. In Old Secondary LDF woody climbers included *Uvaria* sp. (Annonaceae), *Capparis* sp. (Capparidaceae) and *Uncaria* sp. (Rubiaceae) while non-woody climbers included aroids and *Piper*, and epiphytes included *Medinilla* sp. (Melastomataceae), *Vaccinium* sp. (Ericaceae), the fern *Platycerium*, the fern ally *Selaginella* and an attractive climbing herb, *Aeschynanthus* sp. (Gesneriaceae).

While *Piper* and *Hoya* spp. were also collected from Primary LDF at LEWS, the woody *Fibrauea* (a medicinal plant good for curing toothache) was found in BKNP only. In Old Secondary LDF at LEWS a much larger selection of climbers was collected, including the woody climbers *Uvaria*, *Kopsia* and *Willughbeia* spp. (Apocynaceae), *Gnetum*, *Bauhinia* and *Derris* spp. (Leguminosae), *Psychotria* sp. (Rubiaceae), *Sphenodesma* sp. (Verbenaceae), and the herbaceous *Pterisanthes* sp. As at BKNP, the epiphytes in both forest types included Ericaceae, ferns and orchids.

b) Alluvial Forest

This forest occurs in the lowlands on the flat ground in the flood zone of rivers and is subject to periodic disturbance due to flash floods. In BKNP this forest type was only encountered and sampled near Pait Camp, where the river flowed through an area of flat ground. Alluvial forest (disturbed) was also investigated at LEWS. Alluvial forest was found to have lower species diversity and lower tree densities than Primary LDF in the area, probably as a result of disturbance due to flooding and the inability of many primary forest species to withstand this.

Tree species characteristic of this forest type included *Saraca declinata* (Leguminosae), *Pterospermum diversifolium* (Sterculiaceae) and *Duabanga moluccana* (Sonneratiaceae). At LEWS a dipterocarp of alluvial forest (which also occurred on hill slopes further from the river) was *Parashorea macrophylla*. Some individuals of *P. macrophylla* reached giant size, and the species was found to be regenerating well in the area, with many seedlings observed. Many Euphorbiaceaeous plants were found in this forest type and *Eugenia* spp. were common.

Herbs associated with alluvial forest included *Begonia*, represented by as many as 12 species and numerous individuals at LEWS. Palms characteristic of alluvial forest included *Areca jugahpunya, Pinanga mooreana, Plectocomiopsis geminiflora, Salacca dransfieldiana and S. vermicularis* and climbers such as *Calamus* spp., *Daemonorops* spp, *Korthalsia rostrata, K. rigida,* and *K. robusta.* Non-palm climbers included *Tetrastigma lanceolata*, host of the parasitic *Rhizanthes*, seen in bud at Pait, BKNP. Alluvial forest, being associated with rivers, tends to be very humid and epiphytes are abundant. These included ferns such as *Asplenium nudus, Drynaria sparsisora, and Microsorium* sp., orchids and *Pandanus and Freycinetia* spp. (Pandanaceae)

c) Lowland Riparian Forest

Riparian forest, located on steep river banks from normal water-level to flood level, occurs extensively in the lowlands at BKNP. Many of the rheophytic shrub and herb species that occur here are superficially similar, most having tough, linear or lanceolate-shaped (stenophyllous) leaves or leaflets (an adaptation to reduce water- and debris-damage during flooding), and rooting tenaciously to streamside rocks or earthern banks. This morphological similarity belies the taxonomic distinctness of many of the species that occur here.

Riparian forest type was found in BKNP on the banks of Sg. Embaloh, Sg. Tekalan, Sg. Pajau and the upper reaches of Sg. Pait, and at LEWS on tributaries of Sg. Katibas and was well sampled both from the Menyarin Basecamp (Sg. Begua, Sg. Bedawak) and the Ng Joh Basecamp, (Sg. Bloh, Sg. Joh, Sg. Kelimau Besai)

In the specialized riparian zone at BKNP the most characteristic tree species was *Dipterocarpus oblongifolius*, which formed in many places a continuous avenue on either side of the river bank, trees occurring at ca. 10 m intervals and leaning out over the river. These trees were in flower at the time of the Expedition. *Eugenia* cf. *hirta* with large, attractive, pink flowers and *Pternandra azurea*, with its sky-blue flowers, were two attractive riparian trees found on the banks of smaller streams. At LEWS *Shorea macrophylla* (engkabang or illipe nut - Dipterocarpaceae) occupied a similar habitat to that occupied by *Dipterocarpus oblongifolius* in BKNP - being one of the most common large trees of the river bank. A variety of other riparian trees here included *Sandoricum koetjape* (Meliaceae), *Pometia pinnata* and *Eugenia* spp.

Shrubs were another characteristic element of this forest, often having a low, much branched habit. *Myrmeconauclea strigosa* was one of the most abundant in both BKNP and LEWS and in some areas formed almost pure stands, clinging to rocks in small islands in the river and at its margins. Other species superficially similar to *M. strigosa* included a *Diospyros* sp. with green fruits and *Eugenia* sp. *Leea indica* (Leeaceae), *Saurauia ferox* and *S.* spp. (Saurauiaceae) were common in the perpetually disturbed riparian zone in both BKNP and LEWS.

Riparian herbs at BKNP included Acanthaceae species (*Hygrophylla*), aroids (*Homalomena humilis*), the palm *Pinanga tenella* and *Elatostemma* spp. (Urticaceae), as well as *Globba* spp. and the very abundant *Boesenbergia burttiana* (its linear leaves arranged in a fan-shape) (Zingiberaceae). At LEWS the Araceae were well represented by *Alocasia* and *Homalomena* spp., and the Begoniaceae were particularly well represented in the damp, riparian areas. The riparian Zingiberaceae included various *Globba* species as well as *Alpinia*, but *Boesenbergia burttiana* was not observed.

Climbers in this zone at BKNP included *Dissochaeta* sp. (Melastomataceae), the uncommon *Alyxia* sp. (Apocynaceae) and *Mucuna biplicata* (Leguminosae) while at LEWS *Aeschynanthus* sp., *Tetracera* sp. (Dillenaceae), *Bauhinia* sp., *Smilax* sp. (Liliaceae), *Dissochaeta* sp., *Nepenthes* sp. (Nepenthaceae), *Poikilospermum* sp. and *Cayratia* sp. (Vitaceae) were collected. The rattans *Calamus, Daemonorops, Korthalsia* and *Plectocomiopsis* spp. (Palmae) were found in riparian habitats.

Riparian forest was found to have an abundance of epiphytes. These included mosses covering most of the trees of the river banks and ferns which are well adapted to the ever-wet microclimate. At BKNP ferns such as *Arthrophyllum, Asplenium nudus, Drynaria* spp., *Goniophlebium, Nephrolepis* and *Pyrrosia* spp. were observed while vascular epiphytes included *Schefflera* sp. (Araliaceae), *Pandanus epiphyticus, Freycinetia, Ficus deltoidea, Nepenthes, Medinilla, Rhododendron, Aeschynanthus* spp. and many orchids (particularly *Coelogyne* spp, such as *C. asperata, C. echinolabium, C. foerstermanii, C. incrassata* and *C. Pandurata*), and also *Dendrobium acuminatissimum, Eria* sp., *Flikingeria, Pholidota* and the giant *Gramatophyllum speciosum.* At LEWS besides the ubiquitous ferns, *Schefflera, Rhododendron* and *Vaccinium* spp. (Ericaceae) and *Medinilla* spp. were collected, as well as the attractive, orange-flowered epiphyte *Burbidgea* sp. (Zingiberaceae) which was not found at BKNP.

It must be noted that there are distinct differences in the flora of riparian forest depending on the size of the river, the altitude etc. Thus, certain species (such as the remarkable and distinctive *Ixora* sp. with its long, dark-green and white-edged, pendulous leaves) occur only in limited zones presumably differing in habitat characters. This account has condensed all the lowland types into one. An account of riparian species in Montane Mossy Forest is given separately.

d) Hill Dipterocarp Forest

Hill Dipterocarp Forest occurred at BKNP at ca. 550 m a.s.l. and above, on steep slopes and narrow ridges on Bukit Condong to an altitude of ca. 900 m a.s.l. This forest type was dominated by dipterocarps but Clusiaceae, (*Calophyllum* spp.), Euphorbiaceae, Lauraceae and Burseraceae were common and other large trees from the Fagaceae and Myrtaceae (*Eugenia* spp.) were observed. The trees of HDF were slender and pole-sized, the majority being <30 cm dbh, and occurring at greater densities than those of LDF. HDF has three strata with the main canopy ca. 23-28 m high and lower stories at 15-20 m and 8-14 m. The understory comprised saplings of *Shorea* as well as *Vatica*, various Euphorbiaceae spp. and *Ardisia* spp. The soil was peaty, with mineral soil not visible, and some moss.

Only 34 specimens were collected from HDF in BKNP and these included trees from the families Annonaceae, Burseraceae, Dipterocarpaceae, Euphorbiaceae, Fagaceae, Lauraceae, Myristicaceae, Proteaceae, Sapindaceae, Sapotaceae and Theaceae. There were very few herbs in the HDF but the rare ornamental palm *Pinanga salicifolia* as well as *Pogonotium divaricatum* was collected at Bukit Condong. *Eugeissona utilis*, locally abundant, was not collected.

Little HDF was sampled in LEWS during the Expedition, but results of ITTO Project PD 106/90 indicated that in the areas of LEWS sampled, the most common families are the Dipterocarpaceae, Euphorbiaceae, Clusiaceae, Myrtaceae and Myristicaceae. In LEWS, among the few specimens collected from Hill Dipterocarp Forest were *Shorea agami*, Euphorbiaceae, Myristicaceae, Clusiaceae and ferns.

e) Quartzite Ridge Forest

Quartzite Ridge Forest is a variant of HDF which was met with at an altitude of 550-610 m on the ridge between Derian and Pait. It is an open, dry pole-size forest on a very narrow, steep-sided ridge, with some moss occurring at the base of the trees. Under the dry, exposed conditions of this habitat peat had developed on the thin soils. While dipterocarps still dominate this forest, another characteristic species is *Tristaniopsis*. Similar open, dry forest with a lot of litter, roots and some moss occurred on other ridges such as that behind Derian Camp.

Trees collected specifically from quartzite ridge vegetation on the ridge between Derian and Pait included Annonaceae, Burseraceae, Ebenaceae and Euphorbiaceae while ferns, *Shefflera* sp. and a sessile species of *Daemonorops* with white spines were also observed here. A number of orchids in flower were collected from this forest, including a terrestrial *Dipodium,* at least 5 species of *Dendrochilum* including one with flattened pseudobulbs, *Bulbophyllum* and *Phalaenopsis maculata.*

In LEWS Ridge Top Forest with *Tristaniopsis* groves occurred at ca. 300 m a.s.l. at Bukit Guning, and forest transitional between LDF and HDF at altitudes of about 450 m a.s.l. at Sg. Ridan, but few specimens were collected from this type of forest.

f) Submontane Mossy Forest

Submontane Mossy Forest (SMF) is a forest type found at high altitudes, where the climate is cool and the humidity very high due to frequent cloud-cover. Due to the cool climate decay of fallen plant material is slow and a deep layer of peat had developed, with no mineral soil visible, and springy tree roots partly exposed.

SMF was only sampled in BKNP on Bukit Condong, where it replaced HDF at ca. 900-1000 m a.s.l. to the summit (1240 m a.s.l.). No SMF was accessible from the Basecamps at LEWS, although it does occur in the Sanctuary, much further south, on Bukit Lanjak.

SMF was characterised by its lower tree species diversity compared to that of other forest types in the area. *Calophyllum* sp. was the commonest tree, and the Myrtaceae (*Eugenia* spp.) the most diverse family. Representatives of the Sapotaceae (*Palaquium* sp.), Theaceae (*Tetramerista, Adinandra* spp.), Lauraceae and Clusiaceae (*Calophyllum* spp.) were also common. *Hopea, Shorea* and *Vatica* species occurred, but were slender (dbh <= 30 cm) and straight. SMF was found to have a very high density of trees, being almost as dense as LDF in the area.

The forest had only two strata, with the main canopy at 15-20 m and lower storey only ca. 10 m high at lower altitudes. The canopy was only ca. 8 m high at the summit. However, even at the summit, the trees, though slender (many < 10 cm dbh) were straight, not crooked and stunted.

In the short time available at Condong Camp this restricted and localized forest type was more intensively sampled than HDF due to better accessibility and the expectation of a greater number of interesting specimens. Collections by the Malaysian Botany Team numbered 166. Although the forest was found to be in a very dry condition, due to a 3-month long drought in the area still ongoing at the time of the Expedition, and many of the mosses had withered on the trees, the Orchidaceae were flowering well.

Specimens collected from SMF included trees of the families Celastraceae, Clusiaceae (*Garcinia nervosa*) Dipterocarpaceae, Elaeocarpaceae, Euphorbiaceae, Fagaceae, Flacourtiaceae, Hypericaceae, Lauraceae, Loganiaceae, Magnoliaceae, Melastomataceae, Meliaceae, Moraceae, Myrtaceae, Polygalaceae, Rosaceae, Rubiaceae and Symplocaceae. The Lauraceae and Rubiaceae were the best represented families among collections. Symplocaceae was not collected from other forest types during the Expedition.

The understory was dense, especially in gaps left by fallen trees, and comprised numerous palms, including abundant individuals of *Pinanga (P. aristata, P. tomentella, P. variegata* and a new species, *P. 'bifidovariegata'*, related to *P. pilosa*, with an entire, bifid, mottled leaf (BA 0593). There were also many rattans, (including *Calamus paspalanthus, C. flabellatus,* a sessile *Calamus* and *Daemonorops formicaria). Areca insignis* var. *moorei* and *Iguanura wallichiana* were found here. Two species of *Rhododendron (R. durionifolium* and *R. pneumonanthes*) with attractive orange and white, perfumed flowers respectively were collected. *Adinandra* (Theaceae) was also occurred. Many herbs were collected in this forest type, and included aroids, ferns (including various species of the filmy fern *Trichomanes*), gesneriads including a possible new species of *Loxocarpus*, Melastomataceae, including *Sonerila* sp. and *Cynandrium,* and Rubiaceae, including the delicate *Argostemma gracile* as well as *A. havilandii. Geostachys penangensis* (Zingiberaceae) was not found in other forest types during the Expedition.

Among the abundant climbers were ferns, *Gnetum*, *Nepenthes, Smilax, Dissochaeta* and *Psychotria* spp.

The epiphytes at the summit of Bukit Condong represented more species and were more numerous in terms of individuals than in any other habitat sampled during the Expedition. Non-vascular epiphytes included copious mosses on tree trunks, branches and exposed roots, but rather fewer ferns than in the lowlands. Vascular epiphytes included a large number of orchids, many of which were found away from, rather than close to streams, and often near ground level. Many of the orchids were in flower, including *Chelonistele lurida* (white flowers,) and *C. amplissima* (yellow flowers) which were flowering gregariously, *Bulbophyllum* spp. and *Coelogyne diana* and

C. echinolabium. Rhododendron, Vaccinium, Medinilla, Nepenthes and *Schefflera* spp. and *Lucinaea* sp. (Rubiaceae) were also collected. Parasites were represented by *Loranthus* spp. and *Scurrula* sp. (Loranthaceae) and the saprophyte *Burmannia* was collected.

In the specifically rheophytic submontane mossy forest habitat were trees including *Elaeocarpus* sp. (Elaeocarpaceae), *Aporusa* spp. (Euphorbiaceae) and *Clerodendrum* sp. (Verbenaceae) and a number of herbs including ferns, Gesneriads, Melastomataceae, Rubiaceae (*Argostemma bryophyllum*) and Zingiberaceae, including two species of *Globba* as well as *Haplochorea pauciflorum*, a low-growing herb with attractive white flowers with a yellow eye-spot.

Although Submontane Mossy Forest did not occur in the area of LEWS visited during the Expedition, it does occur, and has been studied near the summit of Bukit Lanjak in the southwest of the Wildlife Sanctuary (Chai, 1995). Thus it is possible to make some comparisons between this forest type as it occurs in BKNP and in LEWS. *Agathis* was found to occur at Bukit Condong, but not at Bukit Lanjak, though it was collected from LDF in LEWS during the Expedition. Rhododendrons were not found in submontane forest at LEWS (though they did occur in montane forest). *Podocarpus*, found at Bukit Condong, has not so far been observed at Bukit Lanjak. Overall, Submontane Mossy Forest at Bukit Condong appeared to be richer in the plant groups herbs, climbers and epiphytes, when compared with Bukit Lanjak. However, this may be partly due to the fact that the streamside environment was well sampled at Bukit Condong, whereas it was not covered in the ecological plots at Bukit Lanjak.

3.4 New Species and Records

Among the numerous different species collected during the Expedition are some which may never yet have been described. While it takes much research to establish that a specimen collected is actually a new taxon, a number of specimens from BKNP are apparently not represented by a named specimen in the Sarawak Forest Department (SAR) Herbarium, even though thoroughly searched for. Among such species are a *Loxocarpus* sp, an *Ardisia* sp, and a Celastraceae species from BKNP and a Sapindaceae (cf. *Guioa*) species from LEWS. Dr. Johanis Mogea of Herbarium Bogoriense has established that *Pinanga* cf. *bifidovariegata* and *Korthalsia* cf. *rostratiodes* collected during the expedition are new taxa.

Other specimens may represent new records, either for Borneo, Sarawak or W. Kalimantan. Three palm species are newly recorded from Sarawak while 13 are new records from Kalimantan. *Memecylon fruticosum* may represent a new record for Kalimantan as in Bremer's (1983) revision the distribution of this species in Borneo was limited to Sabah and Sarawak. *Agathis borneensis* appears to be a new record for LEWS.

Yet other species are rare and seldom collected (e.g. *Cyrtandra mirabilis*, a spectacular gesneriad found in BKNP in a small area of outcropping shale and collected only twice before, once in Kalimantan and once from Gn. Berumput in W. Sarawak) and *Phalaenopsis maculata* (epiphytic spider orchid) at Pait, BKNP and Sg. Joh, (LEWS). *Jarandersonia parvifolia* (Tiliaceae) and *Didymocarpus platypus* from BKNP and *Alyxia* sp. from LEWS are other rare species. *Dimorphorchis lowii*, a rare and highly decorative orchid was collected in LEWS. Thirteen of the palm species collected are considered rare.

3.5 Useful species

Various species collected during the Expedition are significant because they are currently useful to members of the local communities. These include 24 species producing edible fruits, 10 species used as vegetables, for drinks or other foodstuffs, 9 medicinal plants and 11 species with miscellaneous uses (Table 6) and 10 timber trees from the Dipterocarpaceae family (Table 7).

Some species may have economic potential in the future if industries such as ecotourism, the traditional medicine industry, traditional vegetable growing and the raising of ornamental plants are developed in the area. These include plants providing materials for handicrafts and souvenirs, plants that have curious shapes or lifestyles that would attract the interest of ecotourists (*Pterisanthes*), pitcher plants (*Nepenthes*), *Rhizanthes*, *Rafflesia* (reported to have been seen in the area in the past), orchids etc. and plants with attractive form, unusual leaf colouration or beautiful flowers (such as many Begonias and Cyrtandras, some palms, gingers, orchids etc.) that were collected during the Expedition (Table 8).

Many fine specimens of important timber tree species were encountered and these could become a valuable source of genetically superior seed for forest plantations.

Species related to important cultivated crops, notably *Durio* spp. *Nephelium* spp. and *Piper* spp. were also found in the TPA. These may be of use in the improvement of cultivated species by plant breeding and genetic engineering. Other species observed are important as the foodstuffs of the abundant wildlife in the area (e.g. *Aglaea, Litsea, Ficus* spp.) for birds and *Thottea* and *Aristolochia* (Aristolochiaceae), seen in both BKNP and LEWS, for the caterpillars of the Rajah Brooke Birdwing butterfly.

Table 6 : Useful species

Wild fruit trees and plants

Species	Local name	Place collected
Alangium sp.	*Midong*	LEWS
Alpinia sp.	*Lelemas*	LEWS
Artocarpus elasticus	*Terap*	LEWS
Artocarpus integer	*Cempedak*	LEWS
Artocarpus ? melinoxylus	*Kepala tupai*	LEWS
Baccaurea cf. *macrocarpa*	*Tampoi*	LEWS
Castanopsis sp.	*Berangan pipit*	LEWS
Curculigo sp.	*lemba babi*	LEWS
Dacryodes vostrata	*Kemayau*	LEWS
Daemonorops sp.	*Empunuk ruai*	LEWS
Dimocarpus longan	*Kakus*	LEWS
Elateriospermum tapos	*Kelampai*	BKNP
Etlingera sp.	*Tepus*	LEWS
Ficus sp.	*Entimau*	LEWS
Flacourtia rukam	*Rukam*	LEWS
Garcinia bancana	*Kunong*	LEWS
Lepisanthes amoenum		LEWS
Nephelium ramboutan-ake	*Pudun*	LEWS
Pometia pinnata	*Kasai*	LEWS
Sandoricum sp	*Kelampu*	LEWS
Saurauia sp.	*mata ikan*	LEWS
Uvaria sp.		BKNP, LEWS
Willughbeia sp.	*akar kubal*	LEWS
Xanthophyllum amoenum	*Langir*	LEWS

Plants used as food or drink (not fruits)

Species	Use	Place observed
Araliaceae (ITTO/BC 89)	Cooked	LEWS
Arenga pinnata (ijok)	sap from cut inflorescence stalk fermented to make alcoholic drink	BKNP (not collected)
Arenga undulatifolia	palm cabbage cooked	BKNP (not collected)
Athyrium esculentum	young shoots cooked	BKNP
Baccaurea (engkuni)	sambal and vegetable	LEWS
Begonia spp. (riang)	leaves cooked with prawns giving sour flavour	BKNP, LEWS
Eugeissona utilis	palm cabbage cooked	BKNP (not collected)
Gnetum gnemon	leaves eaten	LEWS
Poikilospermum sp.	young shoots cooked	BKNP (not collected)

Medicinal plants

Species	Use	Place collected
Boesenbergia burttiana	to treat stings and itches	BKNP
Calophyllum lanigerum	Potential AIDS treatment	LEWS - seen but not collected
Dipterocarpaceacae spp.	dammar ground to a powder and applied to dry sores due to rengas poisoning	BKNP
Eurycoma longifolia	infusion of root to treat toothache & fever	LEWS
Fibrauea sp.	to treat snake bites and drunkenness	LEWS
Goniothalamus velutinus	Mosquito repellent	LEWS
Strychnos sp. (kayas)	can be used for blowpipe dart poison	seen – not collected
Uncaria sp.	water from cut stem said to be good for stomach problems	BKNP

Construction materials and cordage

Species	Use	Place collected
Daemonorops sp.	cane for basketry	LEWS
Prunus arborea	bark of large trees to construct padi bins	LEWS

Miscellaneous uses

Species	Use	Place collected
Aporusa sp.	Wood used to dye cloth yellow	LEWS
Gnetum sp.	stem fibre for fishing lines, thread etc.	LEWS (not collected)
Goniothalamus sp. (selukai)	dried bark burnt to smoke out bees when collecting honey, and as insect repellant	LEWS
Nepenthes sp.	pitcher for cooking rice	LEWS
Phrynium sp. (ririk)	leaves to cook pulut rice	LEWS
Polyalthia ?glauca	bark to make thread	LEWS
Popowia sp.	stem used as pole to steer longboat	LEWS
Psychotria viridiflora (engkerabai)	leaves used to obtain red dye for cloth	LEWS
Shorea ochracea (raruk)	To ferment sap of *Arenga pinnata*	BKNP
Eugenia sp. (ubah samak)	bark used for tanning (formerly)	LEWS
Xanthophyllum amoenum (langir)	fruit used for shampoo	LEWS

Table 7 : Timber tree species (dipterocarps)

Species	Local Name	Place collected
Dipterocarpus borneensis	*keruing sindor*	LEWS
Hopea sp.	*Luis*	LEWS
Shorea acuta	*meranti kawang tikus*	LEWS
Shorea ?agami	*meranti putih timbul*	LEWS
Shorea brunnescens	*selangan batu tinteng*	LEWS
Shorea macrophylla	*engkabang jantung*	LEWS
Shorea macroptera	*meranti melantai*	LEWS
Shorea parvifolia	*meranti serang punai*	LEWS
Shorea rubra	*meranti merah kesumba*	LEWS
Shorea sp.	*meranti kawang tikus*	LEWS

Table 8 : Species with potential as ornamentals

Species	Ornamental features	Place collected
Begonia spp.	large, asymmetric leaves often with red coloration, some with attractive flowers or habits	BKNP, LEWS
Ficus deltoidea	climber with unusual-shaped leaves	BKNP, LEWS
Ixora spp.	large, colourful inflorescences	LEWS
Orchidaceae spp.	variety of flower size, shape, colour and construction	BKNP, LEWS
Pinanga spp.	interesting leaf colouration and form	BKNP
Rhododendron spp.	Large, colourful flowers	BKNP, LEWS
Zingiberaceae spp. Including *Burbidgea* sp., *Boesenbergia* spp.	Colourful flowers, fruits, interesting habit	LEWS
Gesneriaceae	Herbs, with colourful leaves, flowers	BKNP, LEWS

Table 9 : Species with potential to attract ecotourists

Species	Attraction	Place collected or observed
Polyalthia ? *cauliflora*	tree fruiting from branches at ground level	LEWS
Pterisanthes sp.	unusual flat, pink rachis bearing fruits	LEWS
Rhizanthes sp.	parasite with flowers only, on climber	BKNP

4. DISCUSSION

4.1 Collections

The area visited in BKNP has not previously been collected, while the area visited in LEWS has only been collected twice before. Collections made during the Expedition more than doubled the extant specimens from the area. Identification continues but will take time to complete because of the sheer number of specimens collected and because relevant botanical literature and herbarium specimens not represented in the Herbarium, Sarawak Forest

Department, need to be obtained and examined. This may involve borrowing herbarium specimens from regional herbaria, or visiting such herbaria especially when confirming suspected new records and species.

The present collections represent a baseline of what is present in the area, and will serve as a good basis for further work. While some species were collected more than once during the Expedition, the percentage of such repeat collections was not high (c. 14% at BKNP to date) and in many cases different collections of a single species came from different forest types.

4.2 Habitats

Lowland Dipterocarp Forest in the areas visited during the Expedition has been fairly thoroughly collected. Hill Dipterocarp Forest, Quartzite Ridge Forest and Submontane Mossy Forest on Bukit Condong were less thoroughly done, because of time constraints. Hill Dipterocarp Forest in LEWS was hardly sampled due to inaccessibility from the Basecamps.

Similar forest types in different areas, and different forest types have been compared in terms of the species occurring in each. However, some highly specific habitats of restricted distribution occur within the broad habitat types (LDF, OSLDF, HDF etc.) compared. These were sampled, and included isolated shale outcrops, some at river banks and others in dryer situations, almost-dry stream-beds, and the splash zone of waterfalls. Each such habitat has species specific to it which are not found in other habitat. Thus *Cyrtandra mirabilis* occurred on shale outcrops, aroids in the dry stream beds, and various ferns in the splash zone of waterfalls. Overall, many species appeared to have strict ecological requirements.

4.3 Species diversity and site to site floristic variation

Rather different species were found to occur in sites of similar forest type even when such sites were located within a few kilometers of each other and at more or less similar altitudinal ranges. A lot of floristic diversity from site to site in LEWS was noted, in particular a curious lack of dipterocarps in old secondary forest at Sg. Joh. All types of lowland forest did not necessarily contain a high proportion of dipterocarps, nor yet the same range of dipterocarp species. For example, *Dryobalanops* and *Hopea* cf. *sphaerocarpa* were very abundant at one site near Pakararu Camp (BKNP) but not observed at other sites nearby. Near Sg. Menyarin (LEWS) at least 11 species of dipterocarp were observed but in another area not far away (near Sg. Joh), dipterocarps were virtually absent, except for *Parashorea* *macrophylla*, which was fairly abundant and regenerating well. Many lowland areas were relatively poor in palms, but Aya Tapang, a lowland area near Pakararu (BKNP) was particularly rich in palms (*Iguanura elegans, Areca subacaulis, Nenga* sp. and various rattans (*Calamus* and *Daemonorops* spp.). Some lowland palm species were sporadically distributed - *Salacca dransfieldiana* for example, was spotted sterile in only one location between Pakararu and Derian Camps (BKNP). Palms (especially *Licuala* and rattans) were in general better represented at ridge-tops in the lowland forest. Among the gingers certain species were plentiful in a particular habitat in one area but absent from an almost identical habitat in other areas. *Haplochorea pauciflorum, Boesenbergia* spp. etc. (Zingiberaceae) were found to be common where they occurred, but to have very restricted distributions.

As expected, there were considerable differences between the different forest types sampled in terms of the species they contained. Dipterocarps were virtually absent from Submontane Mossy Forest. Some unusual palm species were found at forest of higher altitudes, such as a sessile *Daemonorops* species in the Summit Ridge Forest between Derian and Pait (BKNP) and two decorative *Pinanga* species (*P. tomentella* and *P. 'bifidovariegata'*) and *Iguanura wallichiana* at Bukit Condong (BKNP).

There are many floristic differences between BKNP and LEWS. Significantly, while a number of wild fruit species were collected in LEWS almost no such species were collected in BKNP. Other species were present in one but not the other area. *Boesenbergia burttiana*, for instance, such a characteristic element of riparian flora in BKNP, was not seen in LEWS. *Burbidgea* sp., an epiphytic ginger found on trees by small streams, was fairly common at Sg. Joh but was not observed anywhere in BKNP. Of the palms, 10 species found in BKNP were not found in LEWS, while 9 species found in LEWS were not found in BKNP.

Main canopy and emergent trees were under-represented in the collection in comparison to the understory trees, shrubs and herbs, because of constraints in spotting and reaching specimens.

4.4 New species, new records and rare or interesting species

New species collected during the Expedition include two species of palms. Other potentially new species belong to the genera *Loxocarpus*, *Lepisanthes*, *Microtropis*. The full tally of new species, new records and rare species will only be known once identification of the specimens has been completed. Many fruit tree species, useful species, and species with considerable potential as ornamentals were observed and collected.

Of particular interest at BKNP was the Submontane Mossy Forest flora whereas at LEWS the large number of *Begonia* species was interesting. Most of the Begonias were highly decorative with potential as ornamental plants. It is estimated that about 12 different species of *Begonia* were collected at LEWS. The gingers are a both diverse and unusual group in the BKNP and LEWS areas, with many species apparently restricted to rather specific niches, but common where they occur. *Globba* was particularly common in BKNP. Among the genera represented are *Alpinia, Amomum, Boesenbergia, Costus, Globba, Etlingera, Haplochorea, Hornstedtia, Plagiostachys and Zingiber.* One *Boesenbergia* sp. at LEWS had flowers emerging from a 'cup' of water, the cup being formed from the leaf-bases. Another ginger had highly decorative, scarlet, spindle-shaped fruits on a rhizome at ground level some distance from the shoot. Yet another was low-growing with spiny fruit. The Gesneriaceae is another group of herbs showing great diversity in both BKNP and LEWS. Often, two, three or four different species of *Cyrtandra* were found growing together in the same habitat. Some of the species have potential as ornamentals. Of particular note is the spectacular *Cyrtandra mirabilis* with a fan of unequal-sized leaves and attractive white to pale purple flowers, which appears to hang from the face of large boulders, and a climbing, hanging, riparian *Aeschynanthus* whose large, scarlet corolla tubes emerge from deep maroon calyx cups.

4.5 Endemic species

Among Bornean species 40-50 % are considered endemic to the island. Old World families for which Borneo is the centre of distribution and species diversity include the Dipterocarpaceae, *Durio, Mangifera,* the orchids, rafflesias, Anacardiaceae, Burseraceae, Celastraceae, Clusiaceae, Euphorbiaceae, Fagaceae, Myrtaceae, Rhizophoraceae etc. Many specimens from these groups were collected during the Expedition, notably dipterocarps, orchids, Burseraceae, Euphorbiaceae and Myrtaceae.

Palms endemic to Borneo collected during the Expedition numbered 19 species or ca. 30% of those collected though the true figure should be somewhat lower as some common species were observed but not collected. In earlier ecological studies at BKNP as many as 10% of the trees enumerated were considered endemic. Once identification of the specimens collected during the Expedition has been completed it will be possible to estimate the proportion of Bornean endemics among trees, shrubs, herbs and among various plant groups occurring in the Totally Protected Area.

4.6 Flowering and Fruiting

Only fertile specimens are collected for herbarium specimens as sterile specimens cannot be identified with certainty and are not suitable. While many fertile plants were encountered at both BKNP and LEWS, many more species were not collected because they were sterile at the time of the Expedition. The habitat with the most plants in a fertile condition was the riparian forest, where adequate supplies of water and high light intensities are conducive to flowering and fruiting. Flowering in other areas may have been affected by the ongoing drought. The dry Quartzite Ridge Forest between Derian and Pait (BKNP) had been so badly affected by the dry spell that a number of trees, including several individuals of *Parkia* sp. were observed to have undergone massive leaf-drop. At Bukit Condong, however, the drought may have encouraged many of the orchids at Bukit Condong to flower. The plentiful epiphytic orchids in lowland areas in BKNP were found to be mostly sterile at the time of the Expedition. In general, in BKNP during September, many of the specimens collected were in bud. In LEWS, about 6 weeks into the rainy season, many species had already formed young fruit. A number of dipterocarp species were found in fruit - an event that takes place at intervals of two or three years or longer.

Visits to the two protected areas at different stages in the dry and wet season may produce many further specimens.

The area sampled was only a very small part of the total area of the Transboundary Biodiversity Conservation Area. Within the areas visited, sampling was necessarily carried out only along the trails used. Time was another factor limiting the amount of collection that could be done.

5. SUMMARY AND CONCLUSIONS

Although only preliminary data is available, it is clear that the lowland areas visited in BKNP and LEWS are both extremely rich and extremely diverse in terms of species occurring there. Submontane Mossy Forest at Bukit Condong was also found to be extremely diverse. The full extent of this diversity will be apparent when all identifications have been done. As it was possible to sample only a small area during a short time period it is likely that the final biodiversity of the area will be much greater than is indicated from the collections made during the Expedition.

Considerable differences were apparent even within areas of similar forest types located close to one another (e.g. Katibas, LEWS), let alone between such very different forest types as occur in the area. Each of the several different forest types appeared to support some characteristic species, though other species were not so restricted to particular forest types.

- ❑ There appear to be significantly fewer dipterocarps in old secondary forest, especially in LEWS, compared to primary forest;
- ❑ Wild fruit trees are very common in LEWS but hardly encountered in BKNP;
- ❑ The importance of the Transboundary Biodiversity Conservation Area as a valuable resource area for biodiversity conservation (both the flora and the fauna they support) has been established. It will be an important area for future studies on the rich biodiversity of Borneo;
- ❑ Much has been learnt and much gained from the Expedition. One particularly encouraging result was the strong rapport established between scientists from Malaysia and Indonesia, which crossed the boundaries of scientific disciplines and which will facilitate working together in future. The importance of having enough local informants with a good knowledge of the flora, their local names and uses became apparent when a wide range of ability of some local field assistants was discovered.

6. RECOMMENDATIONS

For the rich biodivesity of the BKNP-LEWS area to be documented, the following prescriptions or strategies should be pursued:

- ❑ Collections from more parts of the Transboundary Biodiversity Conservation Area are required as during the Expedition only a very small area was sampled and the remote interior of LEWS and BKNP have not yet been investigated. Only a minute proportion of the total TPA area has actually been sampled. The considerable variation within and between forest types evident from the results of this Expedition could be further investigated by such collections;
- ❑ Specimens need to be collected at different times of year in order to sample species that flower during a range of seasons or at intervals of more than one year. Thus, further trips to the areas are required to more fully sample the flora at both sites;

- Furtner collection from less widely distributed forest types is required. Hill Dipterocarp Forest and Quartzite Ridge Forest (both under-collected during this study) need to be the focus of further collections. Quartzite Ridge Forest could be investigated where it occurs at Bukit Entimau and Bukit Sengayoh in LEWS. Submontane Mossy Forest in both BKNP (Bukit Condong and maybe other peaks) and LEWS (Bukit Lanjak) need further collection. Montane Mossy Forest, which occurs at the summit of Bukit Lanjak, needs further botanical investigation.

For ecological studies in the BKNP-LEWS, scientific efforts should emphasize:

- More detailed comparison of LDF in different areas is needed, as there seems to be considerable differences even between sites located close to one another;
- Further investigation on the community structure of Primary LDF and various types and ages of Old Secondary LDF that develop from it, since these may have a bearing on how LDF should be treated to encourage the maximum regeneration of useful species;
- Indicator species for various forest types should be investigated, as this is a little documented area.

Practical recommendations for botanical work include:

- Codify forest types better in future for computer analysis;
- Try to engage older, most experienced informants/assistants who know the names and uses of many of the plants, in order to obtain maximum information.

C. PALMS

Johanis P. Mogea

1. INTRODUCTION AND METHODOLOGY

A general collection of the flora was made primarily for fertile materials, using a modified Schweinfurth technique. For temporary preservation, the specimens were pressed with a strong plastic string in between old newspapers in a polythene bag. The collected specimens then were wetted with 70% alcohol. Collecting for palms, and specifically for rattans followed a standard method[1]. As soon as the collection arrives at the related institutions (BO and SAR[2]), they are sorted, dried, labelled and the identification process begins. Duplicates and collections for BO and SAR were separated in the field. Duplicates for other herbaria from the BKNP will be sent by BO and from LEWS will be sent by SAR. The three serial collection numbers were series ITTO/BA used by the author, ITTO/BB by Dr. Kit Pearce, and ITTO/BC by Dr. Paul Chai. In addition local tree climbers and field guides were provided to assist in the collecting activities.

The collecting locations (see Maps, Section VIII) in the BKNP were around Pakararu (alt. 90 m), Derian (200 m a.s.l.), Pait (250 m a.s.l.), and Condong (950 m a.s.l.), whilst in the LEWS were near Ng Joh (80 m a.s.l.) and Ng Menyarin (250 m a.s.l.). The highest elevation visited in the BKNP is at 1,200 m a.s.l. around Condong, and at 550 m a.s.l. in the LEWS near Ng Menyarin. In every location from 3 to 5 days of fieldwork have been conducted. The visited areas cover approximately 0.5% of the total protected forest of the BKNP and the LEWS *(ca.* 1,000,000 hectares). The exploration yielded 110 numbers of palm herbarium collections, each usually consisting of four duplicates namely for Herbarium Bogoriense, Herbarium of the Sarawak Forest Department, Kew (Herbarium of the Royal Botanical Garden), Rijksherbarium Leiden, and Forest Research Institute Malaysia Kepong (KEP). If only one specimen was collected, it was automatically property of the home country institution, namely BO for collections from the BKNP, and SAR for collection from the LEWS. A list of the observed palm flora comprised 65 species representing 18 genera (Appendix 2). A distribution, size of the population, use, and taxonomic notes are given for each species.

[1] Dransfield (1974)
[2] Herbarium Bogoriensis and Sarawak Forest Department Herbarium

2. OBSERVATIONS

A few native palms, though they occur in Borneo, are not discussed here as they are either well known as cultivars or secondly because their areas of distribution are not covered by the Expedition. Cultivated palms include coconut *(Cocos nucifera)* and betel palm *(Areca catechu).* Those outside the Expedition area are *lontar (Borassus flabellifer), bindang (Borassodendron borneense), kelubi (Eleiodoxa conferta), daun sang (Johannesteijsmannia altifrons), sagu (Metroxylon sagu), pinang pumila (Nenga pumila), nipah (Nypa fruticans),* and *rotan kuping (Retispatha dumetiosa).* Other palms, which were observed in the field around and inside the BKNP and the LEWS, are discussed as follows:

2.1 Areca

This genus comprises about 60 species, distributed from India, South China, Southeast Asia to New Guinea and Solomon Islands. The one species recorded from Australia is doubtful. A recent study of Bornean *Areca* by Dransfield in 1984 revealed 17 species. Preliminary identification of our *Areca* collections indicate that they consist of three species, *A. insignis* var. *moorei* (BA 0591), *A. minuta* (BA 0599, *0656), A. jugahpunya* (BA 0633, 0857), and two indeterminate ones, *Areca* sp. 1 (BA 0368, 0605, 0595), and *Areca* sp.2 (BA 0585). *A. insignis* var. *moorei* is apparently widespread in Sarawak and Brunei, said to be confined to Kerangas forest. Nevertheless, our collection (BA 0591) was from submontane rainforest on Bukit Condong at 950 m. The variety is endemic to Borneo and this collection is a new record for Kalimantan as well. As for the habitat *A. minuta* is widespread in Borneo and probably endemic. *A. jugahpunya* is an endemic species, previously known only from the type locality in the Kapit Div., Ulu Sg Kapit in Sarawak. Our collection has enlarged the area of distribution for Sarawak, since specimen BA 0857 was found near Ng Joh at 80 m a.s.l.; there is also a new record for Kalimantan as the specimen BA 0633 was found near Pait at 250 m a.s.l. The two indeterminate *Areca* mentioned above will require further study.

2.2 Arenga

This genus is distributed from India to the east through South East Asia to New Guinea and Australia, and from the Ryukyu Island of Japan in the north to the south to Christmas Island in the Indian Ocean. The genus consists of 22 species, Sumatra with eight species, followed by Borneo with six species. Borneo is considered the centre of diversity for this species. On the way from Benua Martinus to the BKNP, *A. pinnata* occurs particularly around the villages and ladangs but very rarely inside BKNP. *A. undulatifolia* occurs elsewhere, associated with riverbanks inside BKNP as well as in LEWS. As the plant is widespread and well known, it was not collected.

2.3 Calamus

The genus consists of about 370 species. A few species occur in Africa, otherwise most are distributed from South China in the north and south to India and Sri Lanka, through the Malay Archipelago to Queensland Australia and Fiji, at a wide range of altitudes. The centre of species diversity is in Borneo and to a lesser degree, New Guinea. About 20 species of this rattans are used intensively in the furniture industry. Sarawak has 54 species, but there is as yet no account for other parts of Borneo. The IBBE expedition collected 18 species (Appendix 1) including one indeterminate taxon, *Calamus* sp. 1 (BA 0017 and 0045). This taxon is apparently related to *C. paspalanthus.* The habit of *C. paspalanthus* is variable as shown by specimen JD 5971, from Lambir Hills National Park in Sarawak. This plant has huge knees whilst the habit of the species from BKNP is slender, leaves and leaflets are smaller and very narrow and there is a lack of hairs except for BA 0586 from Bukit Condong. This species is widespread throughout Borneo but found only locally in the Malay Peninsula from sea level up to 1,000 m a.s.l. (Dransfield, 1992). Our collections are from Pakararu (BA 0017 and 0045), Derian (BA 515), and Bukit Condong (BA 0586). The latter (BA 0586) is a dwarf form; the leaflets very rapid and nearly overlap, and the brown hairs in the rachis are very abundant.

Calamus blumei is a widespread species found in Sumatra, Borneo, Malay Peninsula and South Thailand, but always in very rare and small populations. It is distributed from the lowlands up to about 800 m a.s.l. *C. caesius* is widespread species as is *C. blumei,* though the former is found also in small populations. *C. conirostris* has the same area of distribution but is usually quite abundant from sea level up to 1,000 m a.s.l. *C. corrugatus* is similar to *C. javensis* and easily identified by the presence of a corrugated leafsheath, sessile leaves, and broad lanceolate leaflets. In Sarawak it is found in the Kuching Division, and on Mt. Hose in the Kapit Division. The plant is rare, and a new record for Kalimantan. Although *Calamus divaricatus* is reported to be widespread and endemic to Borneo, the population is very small and rarely seen. In BKNP it is found in and around Bukit Condong (BA 0607 and 0608) at 1,000 m a.s.l., but not found in the LEWS. *C. flabellatus* is widespread throughout Borneo, Malay Peninsular and Sumatra from sea level up to 500 m a.s.l. but usually in small populations. *C. javensis* is widespread all over the area above including Palawan in the Philippines and Java, from sea level to 1,000 m a.s.l. *C. laevigatus* var.

mucronatus is widespread elsewhere in Borneo from sea level up to 900 m a.s.l., but never abundant, endemic to Borneo. It is found in the BKNP at Pakararu.

C. mattanensis is found in the Kuching and Sibu Divisions of Sarawak, and also in West Kalimantan, at 700 - 800 m a.s.l. It is widespread, but endemic to Borneo. Collection BA 0611 was collected from Bukit Condong in the BKNP. *C. myriacanthus* is widespread in Borneo including Kalimantan, in small populations from sea level to 1,000 m a.s.l. Collections BA 0592 and 0618 are from Bukit Condong. The plant is solitary, slender, and up to 3 m tall, with no knee, leaflets broad and lanceolate, 2 - 4 leaflets on either side of the rachis, no cirrus and flagellum and the inflorescence pendulous. Collections BA 0592 and 0618 are also from Bukit Condong. *C. ornatus* is widespread, from Sumatra, South Thailand, Malay Peninsula, Borneo, Java, and Sulawesi to the Philippines; from sea level up to 1,000 m a.s.l. The Philippines and Sulawesi ones are varieties.

C. oxleyanus is widespread in the Malay Peninsula, Sumatra, and Borneo apparently in the lowlands. *C. pogonacanthus* is widespread in Borneo and quite abundant, the distribution apparently lowland, and endemic to Borneo. Our collections from BKNP are from Derian (BA 0546) and Pait (BA 0584). In LEWS collections were from Ng Menyarin (BA 880). *C. tenompokensis* is widespread in Sarawak, Sabah, and Kinabalu, distributed at mountain forests from1,200 to 1,800 m a.s.l. The collections from the BKNP are taken from Pakararu (BA 0020), Derian (BA 0516); and from Ng Joh (BA 0654 and 0686), and Ng Menyarin (BA 0887 and 0879) in LEWS. All are from the lowlands. This species is a new record for Kalimantan.

2.4 Caryota

The genus is found from India, Indochina, South East Asia to New Guinea, and consists of about 20 species. On the way to Sadap near BKNP there are many huge endemic solitary plants of this genus, such as *Caryota no*. Our collection (BA 0804) from Ng Joh is a solitary one, very close to the common and widespread *C. mitis*.

2.5 Ceratolobus

The genus is confined to the Malay Peninsula, Sumatra, Borneo and Java, usually in lowland rainforest. It comprises six species (Dransfield, 1979). It is recorded in Sarawak where it consists of three species, C. *subangulatus, C. concolor, and C. discolor*. During the Expedition, only *C. discolor* was found (in Pakararu: BA 0507 and 0510, in Pait : BA 0576, and in Ng Menyarin: BA 0877). The latter is widespread in Sarawak, West Kalimantan and Brunei, very rare in Sumatra and Sabah from the lowland up to 500 m a.s.l.

2.6 Daemonorops

The genus comprises about 114 species. In many respects it is similar to the rattan genus *Calamus* except for the form of the inflorescence. The distribution is similar to *Calamus* except that *Daemonorops* is not present in Africa. In Sarawak it consists of 27 species. Our collection consists of seven species (Appendix 1) which are among the 27 species mentioned above. Our collections of *Daemonorops atra* (BA 0660), the species recently described by Dransfield (1980) is a first record for West Kalimantan, and endemic to Borneo. The other endemic *Daemonorops* collected are *D. collarifera* (BA 0615, 0687, 0688, 1132, 1133), *D. fissa* (BA 0882), and *D. formicaria* (BA 0590 and 0609). The latter is also a new record for Kalimantan.

2.7 Eugeissona

The plants of this genus form massive clusters from moderate size to robust, pinnate leaves with many narrow leaflets on either side of the rachis. It comprises six species, two in Peninsular Malaysia and four in Borneo, mostly in the lowland. However, *E. tristis* is found up to 1,000 m a.s.l. *E.ambigua* is so far known only from the type locality at Lake Kapuas in West Kalimantan (though there is no lake named Kapuas, the lakes in the original description by Beccari in 1886 are the lakes formerly known as Danau Luar Danau Genali, and Danau Bekuan, the area now referred to as Danau Sentarum). *E. utilis* is the most common one, the plant is tolerant to open areas and often seen in secondary forests or ladangs. In the BKNP the plant also exists in abundance at 1,000 m. a.s.l. on Bukit Condong. In LEWS the population is found on the ridge top at 550 m near Ng Menyarin.

2.8 Iguanura

The genus is an undergrowth palm distributed from South Thailand to the Malay Peninsula, Sumatra, and Borneo, from lowland up to alt. 1,500 m a.s.l. It comprises 18 species. In Borneo they are about eight species, and at least five of them are endemic. Our collections (BB 0360 from Pakararu, and BA 0598, 0616, 0619 all from Bukit Condong) may be the widespread, polymorphic leaf form and common species of *Iguanura wallichiana* subsp. *malaccensis*. The plant from Pakararu (90 m a.s.l.) is stemless and the entire leaf is 1 m long, whilst the plant from Bukit Condong (1,000 m a.s.l.) has a full leaf when young and grows with a stem up to 4 m and 4 cm in diameter, with a pinnate leaf . Apparently in the

Malay Peninsula, this species is very common in south of the Genting Simpah in the main range and south of Kemaman in the east coast. In Sarawak, it is known from Gunung Matang in the Kuching Division.

2.9 Korthalsia

The genus is confined to South Thailand, Indochina, through the Malay Archipelago, the Philippines, to New Guinea and consists of about 26 species (Uhl & Dransfield, 1987). Apparently it may grow from sea level up to 1,200 m.a.s.l. Sarawak has 12 species of *Korthalsia* (Dransfield, 1992). Our collection shows 5 species which all have been mentioned previously, except for BA 1147 from Ng Menyarin in the LEWS. This taxon is considered as a new species of *Korthalsia* (Appendix 3). This rattan has a clustering robust habit, its stem climbing up to 15 m tall, 2.5 cm in diameter, leafsheath ca. 4 cm in diameter armed with rather scarcely spines; ocrea well developed grossly swollen with similar form of ocrea in *K. rostrata* but has a huge size up to 5 cm long, 7 cm in diameter, scarcely covered with short blackish brown spines; petiole up to 40 cm long, leaflets ca. 25 on either side of the rachis; leaflets lanceolate 25 by 2.5 cm, particularly the lateral leaflets at the base of the rachis. Infructescence up to 1 m long, comprises 4 to 6 partials, each with 6 to 8 rachillae; fruit young, globose 1 cm in diameter with long stigma remnant 0.5 cm long.

2.10 Licuala

The genus is an undergrowth species reaching moderate size, and comprises 108 species, distributed from India and southern China to Southeast Asia, Queensland, the Solomon Islands and New Hebrides. The greatest diversity of species occurs in the Malay Peninsula, Borneo, and New Guinea. Our collection however consists of four species namely, *Licuala borneensis, L. petiolulata, L. pygmaea,* and one indeterminate *Licuala.* Our collection of *L. borneensis* (BA 0895,) is rather peculiar as it has a terminal bifid leaflet not known in other species of *Licuala.* In the line drawing of the type specimen of *L. borneensis,* the terminal leaflet is entire as in the terminal leaflet of most species of *Licuala*, hence though it has been identified as *L. borneensis,* more in depth study for these specimens is needed.

2.11 Oncosperma

The genus consists of five species. One is endemic to Sri Lanka, two endemic to the Philippines, and two are widespread in Southeast Asia and west Malesia, to Sulawesi, the Philippines and western Moluccas (Uhl & Dransfield, 1987). The well known and common *Oncosperma* is called *nibung pantai* or *O. tigillarium* and *nibung darat* / *nibung gunung* or *O. horridum.* Both species are widespread in Borneo. The *nibung gunung* quite often occurs in the BKNP as well as in the LEWS. The herbarium specimen was not made as this plant is quite well represented in collections and very bulky and spiny, hence not convenient for field transport.

2.12 Pholidocarpus

The genus comprises about 6 species distributed from South Thailand, Peninsular Malaysia, Sumatra, Borneo, Sulawesi up to Moluccas. The common and well known species is *P. majadum.* This huge solitary tree palm often occurs in open areas such as in the secondary lowland forest, ladang, or swampy area. The plant may be seen along the way from Ngabang to Putussibau. However the plant is not seen near or inside the BKNP as well as in the LEWS.

2.13 Pinanga

The genus comprises about 120 species ranging from the Himalayas and South China to New Guinea with the greatest diversity in the rainforest of the west part of Wallace's line. It is poorly represented in Papuasia. The recent preliminary account on Bornean *Pinanga* is by Dransfield (1980) which included 12 species. Later Balint wrote of the beauty of this palm with four additional species. Our collection comprised 14 taxa including one new species and two indeterminate ones (Appendix 3). Seven species were mentioned by Dransfield, while some others such as *P. brevipes, P. patula* var. *borneensis, P. variegata, and P. tomentella* (BA 0602, 0614) were not. *P. tomentella* is one of the most beautiful *Pinanga* and a new record for Kalimantan.

The plants are sparsely found along the ridge top at 450 m a.s.l. in Derian, and rather abundant locally near the summit of Bukit Condong at 1,000 m a.s.l. It is a cluster with a short stem up to 30 cm long, superficially rosette with entire paddle-like deep glossy green leaves. The infructescence is short, up to 12 cm long bearing 2 - 5 small rachillas of 10 cm long, hidden in the forest litter; the mature fruits ellipsoid, 0.4 cm in diameter, bright red apparently turning black when it is properly ripe. The plant was first described by Beccari in 1886 from Gunung Matang of Sarawak and later reported from the Sibu Division. The new species of *Pinanga* (BA 0536) was found in Bukit Condong at 700 - 1,000 m a.s.l. It forms an undergrowth cluster slender palm up to 0.5 cm tall. The stem is up to 50 cm long, 1.2 cm in diameter; bearing 3 to 6 entire bifid leaves, crownshaft 20 cm long, leafsheath up to 16 cm long, pale whitish green. The petiole is slender, 2 cm long, blade yellowish bright green mottled by many pale to deep brown dots (Fig. 18 - 21). The inflorescence is short, 8 cm long bearing three slender rachillas, the flowers pale yellow. The fruit is unknown. *Pinanga mooreana* was formerly known only in Bintulu and Marudi Divisions. Now it is known from Ng Joh at ca. 100 m a.s.l. LEWS (BA 0651 and 0827).

2.14 Plectocomia

The genus is moderate to robust either solitary or as a cluster, climbing up to 30 m tall, and armed. It is included in the rattan group and consists of 16 species distributed from the foot of the Himalayas to South China, Indochina, Southeast Asia to Moluccas. A few species may be represented as well in New Guinea. The greatest diversity probably occurs in the Malay Peninsula, Sumatra and Borneo. Sarawak has two species, *P. elongata*, the more common one, and *P. muelleri*. On the way from Sadap to Putussibau the former is seen frequently in fruit. The species so far is not found in BKNP and LEWS.

2.15 Plectocomiopsis

The genus comprises five species, one in South Thailand, four in Peninsular Malaya, two in Sumatra, and three in Borneo. The latter three species occur in Sarawak. Our collection represented the three Bornean species, *P. geminiflora, P. mira, and P. triquetra* (Appendix 3). The latter species is endemic. Apparently all the *Plectocomiopsis* though widespread, is always scarce, therefore a subject for conservation.

2.16 Pogonotium

This is a recently described small genus which comprises three species, one *(P. ursinum)* from the Peninsular Malaysia and three in Borneo, including three in Sarawak, *P. moorei, P. ursinum, and P. divaricatum.* They are distributed from 700 - 1,000 m a.s.l. The latter species is represented in our collection (BA 0613 from Bukit Condong at 1,000 m a.s.l., and BA 0693 from Ng Joh at 80 m.). The species was known previously from small areas in Gunung Mulu National Park Sarawak in *kerangas* or lowland rainforest. Our collection then shows that the species may also be found at high altitude (around 1,000 m a.s.l.). It is a new record for West Kalimantan.

2.17 Salacca

The genus consists of 22 species occurring from west part of India to Assam to Burma (Myanmar), Indochina, and the Sunda part of the Malay Archipelago to the east as far as the Philippines, from the lowland up to at 1,000 m a.s.l. In

Borneo, there is one endemic, common species, *S. vermicularis* (BA 0072); one endemic common variety, *S. affinis* var. *borneensis* (BA 0073, BA 0657), and one new record for *S. dransfieldiana,* BA 0623, for West Kalimantan and BA 0830 for Sarawak. The latter species is also endemic to Borneo. Previously *S. dransfieldiana* was known only from its restricted type locality on foot of Gunung Meratus (G. Besar) in South Kalimantan.

3. SUMMARY AND CONCLUSIONS

The expedition yielded 126 collection numbers of 63 species belonging to 12 genera. The robust, well-known palms were not collected e.g., *Arenga pinnata, A. undulatifolia, Caryota no, Eugeissona utilis, Oncosperma horridum, Pholidocarpus majadum,* and *Plectocomia elongata.* About 19 species are endemic to Borneo and of these 13 species occur only in small populations and rarely seen (Appendix 2). A new species of robust rattan *Korthalsia* has been found, from Ng Menyarin in LEWS, and a beautiful slender new species of *Pinang* with brown and yellow mottled green, entire bifid leaves from Bukit Condong, BKNP. The description of these two species is in preparation. There were three new records for Sarawak: the first, *Arecajugahpunya,* previously known only from its type locality in Gunung Matang; the second was *Salacca dransfieldiana,* also previously known only from its type locality in South Kalimantan; and the third is *Pinanga brevipes* which is nowhere reported to occur in Sarawak. For the palms of West Kalimantan, there are 13 new records (Appendix 3). Among the 70 species of palms that were observed, 10 species from BKNP were not found in the LEWS, whilst nine species were found in LEWS, but not in BKNP. New ecological information was obtained for *Areca insignis* var. *moorei*, formerly known only from lowland *kerangas* forest but recorded in submontane forest in BKNP. *Calamus paspalanthus* and *Eugeissona utilis* , common in the lowland, was found at 900 m a.s.l. in the BKNP; Also, a typical minute *Licuala* was found with terminal bifid leaflets and ellipsoid fruits; and a distinct *Pinanga tomentella* with deep green pedal-like leaves on the upper surface and whitish at the lower surface. Both were found in Bukit Condong. The result above is the yield from an expedition which only covered 0.5% of the BKNP-LEWS area. Thus, further research on the palm flora, covering more habitats and land area is strongly recommended.

D. ORCHIDS

Djunaedi Gandawidjaja

1. INTRODUCTION

Borneo is known as an orchid-rich island, where there are from 2,500-3,000 species, equivalent to 75% of the orchids of Malaysia-Indonesia ("Malesia"), and about 10% of the world's species. Even though so many species are already known, because of their random distribution, orchids remain incompletely known, at best. Since in any one area not all orchids will be in flower, many may be overlooked, or unidentifiable.

The exploitation of tropical forests, initially for traditional use, and subsequently for timber and agricultural use has had a profound impact on orchid distribution and survival. Not only have the trees on which the orchids grow disappeared in many cases, but the opening of the forest has changed its microclimate, not always in a favourable way for orchid survival.

Orchids are also highly prized as ornamental plants, and it is therefore not surprising that some species are already endangered. Efforts taken to protect the plants have included banning the trade in them and conserving natural habitats within national parks and other protected areas. Even though enforcement of local laws is quite important for protection, enhanced public awareness is as crucial a component for success. The scientific value of national parks and protected areas can be better preserved also through public education on orchid conservation. Orchids are, of course, a valuable adjunct to ecotourism as well.

Documentation of the orchids of BKNP-LEWS is rather limited to a small number of herbarium specimens, or privately held photographs. Even though the orchids of Sarawak have been fairly well reported, information on LEWS is still somewhat sketchy. Much more information must be obtained before effective trans-boundary management can be a success.

2. METHODOLOGY

Details of collecting sites are given in Section I of this volume. In the field, explored areas included river banks, slopes, hills, ridges and hill summits. In

BKNP, it covered elevations ranging from 90 - 1,200 m a.s.l. while in LEWS explorations covered elevations from 200 - 450 m a.s.l. All orchids encountered were recorded and collected, either as a living plant or as a herbarium specimen in the Herbarium Bogorensis; identifications were made by using descriptive keys or through comparison with existing specimens at Bogor. Unfortunately, since fewer than 10% of specimens were in flower, identification between species was frequently difficult, since vegetative parts are often quite similar. Most plants have been identified at least to the level of genus.

3. OBSERVATIONS

BKNP

3.1 Pakararu

Most orchids were epiphytic, and only two species of the genera *Neuwedia* and *Tainia* were terrestrial. The epiphytic orchids were growing on riverside trees, and orchids became progressively fewer as the distance to the river increased. Orchids, which would serve as a valuable attraction for ecotourists, were species of *Coelogyne*, such as *C. asperata*. The few orchids found flowering were mainly *Bulbophyllum* sp. and *Dendrochilum* sp. During six days exploration, 119 specimens of 26 genera were collected.

3.2 Derian

Most of the forest around this camp is hilly, to about 350 m a.s.l. Though in the midst of a long drought, the forest remained quite humid. The thick haze of September caused difficulty in spotting orchids in the canopy, so most were obtained from lower levels of the forest.

Most orchids were epiphytic, and only three genera (*Macodes* sp., *Tainia* sp. and *Nervilia* sp. were terrestrial. Populations of *Coelogyne* sp., mostly *C. asperata* and *C. echinolabium* were found at slightly higher elevations than in Pakararu. Distributions were similar, with most orchids found nearer the river banks. This phenomenon may be the result of higher light levels and humidity nearer to the river, which is favourable to orchid growth.

A total of 47 specimens from 23 orchid genera were collected around Derian camp. Species of *Bulbophyllum*, *Eria* and *Agrostophyllum* were the most common in this location.

3.3 Pait

Pait camp lies at about 200 m a.s.l., separated from Derian by a hill 600 m a.s.l. The surrounding forest is apparently much more humid than around the two previous locations, as demonstrated by the abundance of bryophytes (mosses) almost everywhere. Above the Pajau River, however, conditions are similar to Derian.

At this site, a single *Phalaenopsis maculata* was found. Higher up along the ridge, where there was a habitat of "kerangas" forest, at about 500 m a.s.l., a number of flowering specimens of *Dendrochilum* and *Dipodium* were found, with at least five different species of the former observed. One species with flattened pseudobulbs (*Dendrochilum pubescens*) was seen only at this location.

Along the Pait River valley, where humidity was high, the genera *Bulbophyllum* and *Agrostophyllum* were the most common orchids. Also obtained were *Coelogyne asperata* and *Coelogyne incrassata*, the latter of which was much less common in the two previous localities.

3.4 Bukit Condong

The Bukit Condong camp was located at an elevation of approximately 950 m a.s.l. The path from the Pait camp follows steep slopes and ridges up to about 900 m a.s.l., where the trail flattens out somewhat. The forest trees are of small diameter and relatively short, and there is a small stream near the camp.

In contrast to the previous areas, orchid distributions occurred along the slopes and ridges, and not along the stream. Orchids were also much lower to the ground and found attached to tree trunks rather than upper branches as occurring in the lower elevations.

More orchids were found flowering, including *Chelonistele amplissima*, *C. lurida*, *Coelogyne echinolabium*, *Bulbophyllum uniflorum*, *B. disjunctum* and several others. Between *Chelonistele amplissima* and *C. lurida*, the latter was considerably more common, and found abundantly between about 1,000-1,100 m a.s.l. At the summit of Bukit Condong (1,200 m a.s.l.), only species of *Bulbophyllum*, *Dendrochilum* and *Eria* were found.

3.5 Ng Joh

The Ng Joh camp located on the Bloh River at a low elevation of about 80 m a.s.l. The explored area included a radius of approximately two km. surrounding the camp, including along the rivers upstream and downstream, and two locations between Ng Seggarugau and Ng Katibas (Bukit Satap to the south) at elevations about 200 m a.s.l. The most common orchids along these rivers were species of *Coelogyne asperata* and *Coelogyne foerstermanii.* These two species distributed along the rivers were both in flower at the same time.

The most significant orchids along river Katibas, Ng Bloh and Ng Joh are species of *Coelogyne asperata* and *Coelogyne foerstermanii.* The large-leafed *Coelogyne asperata* produces graceful inflorescenses with greenish yellow flowers while the stiff-leafed *Coelogyne foerstermanii* produces stiff inflorescences with white flowers. *Coelogyne asperata* can be found almost from ground level up to the middle of the canopy while *C. foerstermanii* always occupies a higher part of the tree. The sites for these two species were randomly distributed, but the plants were usually clumped within individual sites.

Two plants of *Dimorphorchis lowii* were found flowering at a single site 200 m a.s.l. However, during the entire ten days work in LEWS, no more individuals of this species was found. Finally, a few specimens of the large orchid *Grammatophyllum speciosum* were also found at this locality.

Common arboreal orchids of the Ng Joh area were *Bulbophyllum, Dendrobium, Eria* and *Agrostophyllum.* Common terrestrial orchids found in this location were *Plocoglottis acuminata, Nephelaphyllum pulchrum, Malaxis micrantha* and *Habernaria* cf. *setifolia.*

3.6 Ng Menyarin

Ng Menyarin Camp is located at the junction of Sg. Menyarin and Sg. Katibas at elevation around 100 m a.s.l. Explorations covered hills from 2-4 km up- or downstream along the Katibas, including the hills behind the camp and south of the camp, to an elevation of about 450 m a.s.l.

The species abundance and distribution of orchids at Ng Menyarin camp were quite similar to those around Ng Bloh. *Coelogyne asperata* and *Coelogyne foerstermanii* were frequently found in flower. The large *Grammatophyllum speciosum* was found, but in the vegetative stage only. Species of

Bulbophyllum, Eria and *Agrostophyllum* were common. Two saprophytic orchid species of the Genus *Lecanorchis* were also encountered.

4. SUMMARY AND CONCLUSIONS

Orchid biodiversity in BKNP and LEWS is relatively high. The number of epiphytic orchids in BKNP and LEWS is considerable, but that of terrestrial orchids seems low. Saprophytic orchids in both locations were generally rare.

Orchid distribution in general is influenced by altitude, and orchid diversity in Pait is the same as that in Derian and Pakararu, since the elevation of these three locations is about the same.

In all lowland sites most orchids could be found on riverside trees, indicating that the humidity and light conditions of this microhabitat are highly suitable for orchid growth. A few meters away from the river bank the orchid populations are scarce, especially in lowland forest. The opposite condition is found at Bukit Condong, where orchids are found entirely on the hill slopes and crests, and never along the stream. Abundant light in the high altitude forest with small diameter trees and thus little canopy is favourable for orchid growth. Most orchids found at Bukit Condong were different species from those found at low altitude.

A list of orchids collected in BKNP-LEWS is given in Appendix 3.

At the 500 m a.s.l. ridge between Derian and Pait several orchid species, which are not found at Derian or Pait, were found in flower. The *kerangas* forest at this site seems to have stimulated the growth of these particular orchids. The small *Dendrochilum pubescens* with flattened pseudobulb was found exclusively at this site.

Coelogyne asperata, abundant at Pakararu, Derian , is also found at Pait but not however at higher altitude (Bukit Condong). Some species of *Dendrochilum* were rare at low altitude but increased in abundance at higher altitude. At LEWS, orchid diversity around Ng Joh/Bloh camp and around Ng Menyarin camp is comparable.

Coelogyne asperata and *Coelogyne foerstermanii* are the most common species found both in both BKNP and LEWS. *Dimorphorchis lowii* was found once at LEWS but not at BKNP. *Phalaenopsis maculata* was found once at LEWS and once in BKNP.

The famous *anggrek hitam*, *Coelogyne pandurata*, is scarce both in LEWS and BKNP, but this species was oddly abundant at Sadap, the last village close to BKNP.

The most frequently found and abundant orchids at all elevations were species of *Bulbophyllum, Agrostophyllum* and *Eria.*

For purposes of ecotourism, perhaps the most attractive and abundant orchids are the greenish-yellow flowered *Coelogyne asperata* and the white-flowered *Coelogyne foerstermanii.* These were common along the river banks, either in Sarawak or Kalimantan, and the white-flowered *Chelonistele lurida* or orange-flowered *Chelonistele amplissima* at Bukit Condong which flower gregariously.

The ITTO expedition was able to survey only a small part of the tremendous wealth of existing orchids in both BKNP and LEWS. Further surveys of different areas, and at different seasons, are crucial to proper documentation, and the eventual development of any management plan.

Finally, to enhance progress in plant identification, the development of an orchid herbarium would be extremely useful. If such a facility were available, sterile specimens could be observed until flowering occurs. Otherwise, the majority of collections, which are based primarily on vegetative parts of orchids, do not impart much information.

E. BRYOPHYTES

Heri Sujadmiko

1. INTRODUCTION

Bryophyta, or "mosses", represent a transitional form between the aquatic and terrestrial plants. Though most live in terrestrial habitats, they still require water for fertilization. For this reason, bryophytes are sometimes called amphibious plants.

Based on the forms of gametophyte and sporophyte development, about 24,000 species of Bryophyta are known. These are divided into three classes, the Hepaticopsida, Anthocerotopsida and Bryopsida.

Hepaticopsida, or "liverworts", have a vegetative body shape somewhat like the human liver. They are considered one of the oldest and most primitive of all plants and are divided into seven orders (the Monocleales, Marchantiales, Sphaerocarpales, Calobryales, Metzgeriales, Treubiales and Jungemaniales).

Anthocerotopsida, or "hornworts", have disc-like thallus with a lobed margin and a very simple organization. The class Anthocerotopsida consists of the single order Anthocerotopsidales.

Bryopsida or, "real" mosses, have about 14,000 species, 675 genera and five orders (Sphagnales, Andreales, Polytrichales, Tetrapidales and Bryales).

Bryophytes differ from vascular plants not only in size but also in basic life processes, and thus form their own associations within vascular plant communities. Mosses occur in forests on shady rocks (epilithic), on the bark of forest trees (epiphytic), on leaves (epiphyllous), on decayed wood (epixylous) or on the forest floor. On free-standing trees they are photo-epiphytic, while on freestanding rocks they are photo-epilithic. Other associations exist in bogland (fens, high moors), on open mineral soil, and in water.

In tropical rainforests, the biomass of bryophytes performs a critical role in the water balance of the ecosystem, as the most effective interceptor of rain-water, as some bryophytes have been shown to absorb up to twelve times as much water as the weight of the dried plant.

An indication of the ecophysiological characteristics of bryophytes is given by their growth-forms. The growth-forms of rain-forest bryophytes have been classified into two major groups, *e.g.*, social forms and solitary forms. Both can be divided into more detail of structural types such as cushions, turfs and mats for the social forms, and unbranched or branched dendroids, feather forms, bracket mosses and hanging bryophytes for the solitary forms, protonemal bryophytes. Two growth forms which are particularly characteristic of tropical forests, *e.g.* epiphytic frond mosses and hanging or pendulous mosses.

In addition, forest bryophytes also form important microhabitats or support for certain animal species. Some invertebrates spend their entire lives in bryophytes (bryophilous), and spend only part of their life cycle there (bryoxenous). Invertebrates with close relationships with bryophytes are Protozoa, Rotifera, Nematoda and Tardigrada. Bryophyte-consuming organisms of the forest environment include the Rotifera, Nematoda, Mollusca, Tardigrada, Arthropoda (Insecta and Arachnida) such as ants, grasshoppers. Among the vertebrates which feed on bryophytes are mammals and birds, since bryophytes supply polyunsaturated fatty acids (such as arachdonic acid) which are not found in higher plants.

These are only some of the contributions of bryophytes in maintaining the essential functions, health and vigor of pristine habitats, and thus indirectly of great importance to the human species. Considering the essential role of bryophytes in tropical forests, it is unfortunate that knowledge of this group remains so limited.

Much information on tropical bryophytes is still lacking, especially from the rainforests of Borneo. Toww in 1954 made some of the most comprehensive collections of bryoflora in Borneo especially from parts of Sarawak, Sabah and Brunei and, some provinces of the Kalimantan. The results obtained from this exploration were 649 species of mosses (Musci). Around the same time, Meijer collected 50 species of mosses and hepatics in East Kalimantan, from old mangroves of the Mahakam delta to the summit of "Mount" Balikpapan.

Bryoflora from BKNP-LEWS have not been sampled until now and therefore will provide the valuable information for the bryologist, and for the development of plant taxonomy as well. This data can also facilitate the work of planning, development and management of the two parks.

2. METHODOLOGY

Field data was gathered via exploration of suitable bryophyte habitats in both BKNP and LEWS. There were four areas sampled in BKNP: Pakararu (about

90 - 340 m a.s.l.), Derian (150-500 m a.s.l.), Pait (about 250 m a.s.l.) and Bukit Condong (1,000 - 1,200 m a.s.l.). Two locations sampled in LEWS were: around Ng Joh (100 - 300 m a.s.l.) and around Ng Menyarin (100 - 300 m a.s.l.).

Collection of bryophyte samples was based on the morphological differences (in macroscopic appearance). Collected specimens were placed in bryophyte-envelopes and stored as dried herbarium specimens. Microscopic slides for identification were prepared using glycerin-xylol mounting medium and paraffin embedding. Identification, based on morphological and anatomical characters, was carried out in Laboratory of Plant Taxonomy, Faculty of Biology, Gadjah Mada University.

3. OBSERVATIONS

The identification of samples from six locations of BKNP and LEWS (Malaysia) revealed 168 species of bryophytes from three classes: Hepaticopsida, Anthocerotopsida and Bryopsida. The number of species obtained for each class above was: 78, 2 and 88 respectively. Results are given in Appendix 4.

From BKNP alone 133 species were found. The number of species at the localities were: Pakararu, 34; Derian, 38; Pait, 40; and Bukit Condong, 62 (Appendix 4). Bukit Condong had the highest bryophyte diversity, undoubtedly because of its high altitude compared with the other three sites.

The species diversity in LEWS was lower than in BKNP, perhaps because of the restricted altitudes sampled (all below 300 m a.s.l.). There were 68 species of bryophytes from only two classes, Hepaticopsida and Bryopsida in the former area. Despite fewer species, LEWS had 35 species that were not found in BKNP, including *Blepharostoma trichophyltum, Mastigobryum gibbum, M. venezueleanum, Cephalozia* sp., *Calypogeia* sp., *Fruleania reflexistipula, Plagiochila propinqua, P. drepanophylla, Pragmicoma polymorpha, Pragmicoma* sp. A, *Pragmicoma* sp. B, *Leptotejeunea* sp., *Lejeunea diversiloba, L. serpyllifolia, L. decursiva, Fissidens papillous, Mitthyridium repens, Calymperes* sp., *C. afzellii, C. lanchophyllum, Arthrocormus schimperi, Syrrhopodon loreus, S. albovaginatus, S. confertus, S. spiculosus, Chaetomitrium elongatum, C. laevifolium, Leucomium* sp. A, *Leucomium* sp. B, *Thuidium invense, Ectropothecium* *ferruginianum, Ctenidelphus* sp., *Isoptengium* sp., *Taxiphyllum* sp., *Himantocladium plumusa, H. scrobiculatum* and *Neckeropsis gracilenta.*

The IBBE inventory of bryophytes species from BKNP and LEWS produced only about one sixth of that recorded by Toww in 1955, in Sarawak, Sabah, Brunei and parts of Indonesia, but were three times larger than the subsequent (1997) inventory by Meijer in Mahakam delta and Balikpapan.

Seventy-five per cent of the bryophytes species collected were epiphytes (BKNP, 87 species; LEWS, 44 species). These two sites have very high species richness compared with other areas of the tropics. For example, the rainforest on Mt.Kilimanjaro and other volcanoes in East Africa have only 20 species of epiphytic bryophytes, while rainforests of the Bolivian Andes, Latin America and the Sierra Maestra of Cuba possess just 28 species, from the classes Hepaticopsida and Musci.

Epilithic bryophytes were found along the river banks where they form a carpet-like growth, which acts as a filter for soil erosion and can also act as an important seed bed for flowering plants. Seeds of some flowering plants apparently germinate most successfully in moss tufts. Epilithic bryophytes found were *Bazzania trilobata, Calypogeia* sp., *Chyloschypus polyanthus, Jungermania* sp., *Hygrolejeunea* sp., *Aneurs multifida, A. ambrosoides, Pallavicinfa hibemica, Pallavicinia* sp., *Dumortiera hirsuta, Fissidens zippelianus, F. nobilis, Syrrhopodon* sp., *Hyophylla involuta, Bryum* sp., *Philonotis mollis, Rhizogonium spiniforme and Himatocladium scrobiculatum.* There were altogether 33 species of epilithic bryophytes and 7 species of epiphyllous bryophytes found in this exploration areas (see Appendices).

During the Expedition, an extraordinary bryophyte species was found, *Himantocladium scrobiculatum*, which can live in many forest habitats such as on the ground, rocks, trees and even in the water. Another unique bryophyte from the forest was *Frullania* spp., almost always found in association with orchids. *Frullania* is a genus with unusual leaf structure, with sac-shaped lobes on the ventral part of the leaves, which function as a water trap. This specific adaptation might be the reason for the preference of orchids to grow in association with *Frullania* spp., though this assumption needs further study.

Bryophyte species found in BKNP-LEWS cover a broad range of taxonomic groups, from the "simplest" bryophytes (such as *Blepharostoma* sp. and *Trichocolea* sp.) to the "advanced" ones, e.g., Bryopsida. Unfortunately, some of the specimens could be identified only to the generic level . This difficulty arose partly because most of the bryophyte samples were sterile specimens, and partially because of the very limited literature available for reference in the identification of tropical bryophytes. Literature for identification of bryoflora are still restricted to Java, Malesia, Philippines, Australia, Japan, India, British Isles and America. As a result, the author (with identification assistance from Dr. Willem Meijer) is not yet able to confirm the existence of new bryophyte species from BKNP-LEWS.

III

FAUNA

F. FRESHWATER FISHES

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1. INTRODUCTION

Bentuang-Karimun National Park is located on the southwestern part of the island of Borneo. It borders the Lanjak-Entimau Wildlife Sanctuary on the Malaysian side of Borneo to form one of the largest protected trans-frontier tropical rain forests in the world with a total area of one million hectares, one of the largest areas for biodiversity reserves in tropical humid forest.

The watersheds of the Embaloh/Tekalan in BKNP and Katibas in LEWS are today separated by the high mountain ranges of Tinteng Kalimanten at the dividing boundary between Indonesia and Malaysia. During the Pleistocene Epoch, the oceans were some 60-80 metres lower than they are today, and Borneo rivers drained into a great central Sunda River which connected the tributaries of Borneo with Java, Sumatra and Malaya. In this way, the Kapuas was also distantly joined to central Sarawak and north Borneo. This connection allowed contact of the fish fauna from western and northern Borneo, and can still be seen in the overlap (about 50%) of species between these two now completely isolated areas.

The main drainage for BKNP is the Kapuas River, the largest river in Borneo. It lies in the drainage basin of the ancient and now inundated, Great Sunda River. Its ichthyofauna is extremely rich and apparently an important evolutionary center for many fish families. The Katibas River of LEWS is a principal tributary of the Rajang river, the longest river in the Malaysian State of Sarawak. The Rajang also possesses an ancient connection with the now inundated Great Sunda river within the basin of the same name. BKNP and LEWS protected areas are divided by the mountainous boundary between Sarawak and Indonesia, and thus from the standpoint of the aquatic fauna, are fully 100% isolated from one another.

Prior to 1976, there were four major ichthyological surveys of the Kapuas resulting in the identification of some 150 species of freshwater fish species. The earliest studies in Borneo were carried out in the 1600s by Johannes Nieuhof. Further knowledge of East Indian fishes came about through the efforts of Kuhl and Van Hasselt in the 1820s. The Dutch taxonomists Heckel, Schwaner and Bleeker carried on the work on Borneo fishes in the 1840s, but the most significant work of all was done by Weber and de Beaufort, who published *The Fishes of the Indo-Australian Archipelago* in 1911.

Kottelat (1982) described a small collection of fish collected by Korthaus in Central Kalimantan, but a more thorough documentation only became available on the publication of Roberts' (1989) monograph based on his collections made in the Kapuas in 1976. Of 7000 specimens collected, Roberts identified 263 species and described many new ones. Kottelat (1991) expanded the known fish from Kalimantan Barat to 303 species. Current work on freshwater fishes in Borneo (Kalimantan) is being carried out by Maurice Kottelat, Darrell Siebert and Tyson Roberts. Both Kottelat and Roberts have concentrated on the main Kapuas drainage. Until now, work on the fishes of the BKNP has not been published.

Some published scientific work on the fish fauna of Sarawak is available, though in a rather fragmented manner, and most of it carried out in the early 1980s (although a small survey was done in 1991 by Parenti, who collected 62 species of fishes from the mid Rajang Balui). The Baram drainage was studied by Watson and Balon, while the Rajang drainage was surveyed by Lelek, and the Batang Ai by Cramphorn (see reference list at the end of this volume).

LEWS was gazetted as a totally protected area in 1983 primarily as an Orangutan reserve. The first fish inventory in the LEWS was conducted during an ITTO survey of the herpetofauna by Stuebing in 1993, from which casual sampling recorded 36 fish species.

The purpose of the IBBE study is to document the fishes of the relatively undisturbed BKNP (portions of the Embaloh River drainage), and LEWS (portions of the Katibas/Bloh drainages). Information on species richness, distribution and abundance will be useful for conservation and management of fish in the Trans-Boundary Biodiversity Conservation Area.

2. DESCRIPTION OF AQUATIC HABITATS

The surrounding landscape of the BKNP within the Embaloh drainage is composed of mixed primary and secondary forests with unusual dark, igneous bedrock substrate. The general morphology of the Embaloh River changes along its length. During the Embaloh surveys, the local weather was dry and hazy. The water quality in the streams and rivers was good because the water level in the aquatic systems was low. Towards the end of September 1997, there was localised heavy rain in the upper catchment of the Embaloh and Tekalan bringing down large volume of water each time. Run-off from any significant storm produces a raging torrent within one to several hours, though this also rapidly subsides. An unseen nocturnal storm in mid-September at BKNP caused the Embaloh to rise more than two metres in as many hours downstream at the Pakararu camp. It took nearly 12 hours for the water to subside. The Tekalan River, a tributary of the Embaloh, is more uniform in appearance than its parent river, and has water that generally appears black, reflecting the color of the substrate rocks. The water clarity of Sungai Tekalan system is consistently clearer than the Embaloh and its downstream tributaries.

3. METHODOLOGY

3.1 Fish Collections

In BKNP, the main collections were made along the Embaloh river, Tekalan river and their tributaries, while in LEWS efforts were concentrated along the Katibas and Bloh Rivers (near their confluence) and their tributaries in LEWS. Fish collections in the Embaloh area was an extension of earlier field work (22.XI.96 to 09.XII.1996) by one of us (IR) for the Museum Zoologicum Bogorense. BKNP collecting sites include upstream tributaries such as the Sg. Pait and Sg. Pajau. A total of 67 river stations were established on Sg. Tekalan, Sg. Embaloh, Sg. Pakararu and Sg. Aur. Stream stations were located on the Sg. Jaket, Sg. Ange, Sg. Gong, Sg. Dajo, Sg. Jot, Sg. Sebaya, Sg. Tungun, Sg. Pakararu, Sg. Peyang, Sg. Tawang, two un-named streams below the Derian Camp, and three other un-named streams adjacent to the Pakararu Camp I (Fig. 1). In the Katibas (LEWS), a total of 45 stream stations were surveyed in Sg. Katibas and Sg. Bloh. The stream sites consisted of Sg. Menyarin, Sg. Pasir, Sg. Engkabang, Sg. Kulit Kayu, Sg. Melinau, Sg. Bedawak, Sg. Gindi, Sg. Nyungan, Sg. Kelimau Mit, Sg. Merating, Sg. Joh Paraka, Sg. Joh Ibau and Sg. Joh mainstream.

Fish were collected at stations measuring 50 metres in length, in which all relevant habitat data (stream substrate, canopy cover, stream width, depth of the water column and notes on the local weather) was recorded, and physical parameters of each river/stream measured.

The principal method adopted for field sampling was the use of an electrofisher backpack operating on a motorcycle battery of DC 12V 10Amp input and continuous output of AC 240 V, in combination with seine, cast and scoop nets. This method was used for most sampling stations and was effective for streams of water depth less than 2.0 metres. A generator (Honda EV650) was used for the same purpose in S. Pajau, Tekalan, and small streams in Ulu Embaloh when one of the electrofisher unit could not function. The generator was also used for sampling in Sg. Nyungan in LEWS.

In the deep water side pools, a mono-filament cast net of diameter 3.5 metres and mesh size 20 mm was used to sample fish. In the Embaloh river, gill nets were laid (2", 3" and 4" mesh size), cast nets were employed as well as hook and line fishing. Electrofishing was carried out over a fixed distance of 50 metres per station while the unit effort of a cast net sample was 10 throws along the fixed distance. These methods were not used in Lanjak-Entimau.

The fish specimens collected were immersed and fixed in 10% formalin. The size range of each fish species was measured in standard and total length. Large specimens were injected, and selected specimens were dissected and their gonad maturity stages noted. All collections are deposited at the Bogor Museum, Java, Indonesia (BNKP material), or in the Sarawak Museum in Kuching, Sarawak (LEWS material). The specimens will be transferred into 70% ethanol upon accession to their respective museum collections. Fishes were identified with the use of Inger and Chin (1962), Kottelat (1984), Kottelat *et al.* (1993), Roberts (1989) and cross references with materials held in Museum Zoologicum Bogorense and the Sarawak Museum. The nomenclature of the fishes follows that of Kottelat, 1993 and Roberts, 1986.

3.2 Water Quality

Water quality was measured with a YSI Dissolved Oxygen Meter for DO and temperature whereas the pH was measured with a portable pH meter. The velocity of the water flow was measured by timing with a stopwatch a floating wood for a distance of 2 m. All measurements were taken between approximately 0800-1000 hrs.

3.3 Data Analysis

The data collected and analysed will provide baseline information concerning the distribution and relative abundance of fish species known in the protected areas. Such data would be useful in future comparative ecological work. The fish distribution data were further analysed for species diversity, richness and eveness of the stations.

Fish species diversity indices, eveness and richness were calculated for the stations. Species diversity was calculated for a few representative stations with the use of Shannon-Weaver.

$H' = \Sigma P_i \log P_i$ where $P_i = n_i/N$. n_i is the number of individuals of Species i and N = total number of individuals in the collection of S species.

The variable H' is a measure of species diversity which is dimensionless, independent of sample size, and express the relative importance of each species[1].

Species Evenness (J) = $H/(H_{max})$
where $H_{max} = \ln S$ and
S = no of species in the collection.

The value of J ranges from 0 to 1. A value of 1 indicates a perfectly even distribution of individuals among species. A value approaching 0 indicates a concentration of individuals in one or more species.

The species richness of a station is described by Margalef's D (1968).

$D = (S-1)/(\log N)$,
where S is the number of species and
N is the number of individuals.

4. OBSERVATIONS

4.1 Water Quality

As a general comparison, the dissolved oxygen level was highest in the upper Tekalan River, and generally higher in the Embaloh and all its tributaries. The DO of the Katibas is comparable to that of the Embaloh, while the value for the Sungai Bloh is noticeably lower, presumably because of an increased organic load emanating from disturbed (logged) habitats along its north bank.

A total of 67 sampling stations were constructed in the Embaloh drainage system and 45 stations in the Katibas-Bloh system. A summary of the parameters measured in the main river systems is given in Table 1.

Table 1 : A summary of the water quality parameters of the three main areas of study in the BKNP

River / Parameters	Tekalan River	Embaloh River (Pakararu camp) Downstream	Embaloh River (Aur base camp) Upstream
No. of Stations	12	10	9
Stream bank height	22.1	7.1	11
Dissolved Oxygen (mg/l)	8.1 ± 0.87	8.46 ± 0.07	9.05 ± 0.4
pH	7.55 ± 0.11	7.73 ± 0.21	7.58 ± 0.12
Temperature (°C)	23.8 ± 0.49	24.9 ± 0.16	24.2 ± 0.26
Water Clarity	Transparent / Clear	Turbid / Silty	Clear
Velocity (m/s)	0.51 ± 0.28	0.48 ± 0.18	0.41 ± 0.18

[1]Pielou (1966)

A summary of the water parameters measured in the Katibas-Bloh stations of LEWS are given in Table 2.

Table 2 : A summary of the water quality parameters on the two main areas of study within the LEWS

River / Water Parameters	Sungai Ulu Katibas	Sungai Bloh
Sampling Stations	24	21
Dissolved Oxygen (mg/L)	8.06 ± 0.67	7.5 ± 0.14
Temperature (°C)	24.7 ± 0.4	24.3 ± 0.33
pH	7.27 ± 0.17	7.28 ± 0.12
Water Velocity (m/s)	0.48 ± 0.31	0.78 ± 0.36

The temperature of the water in the Embaloh area of BKNP is approximately the same as that measured in the rivers in LEWS. The dense shade of trees arching over forest streams lowers the average temperatures and moderates diurnal variation. At higher elevations, the waters are generally cooler. This can be clearly seen in the average temperature in Tekalan river and its tributaries, at 23.8 ° C ± 0.49 as compared to the Embaloh system and its tributaries around the Pakararu camp, at 24.9 ° C ± 0.16. The water temperature and pH of both rivers in LEWS were somewhat similar within the ranges of 24.3 ± 0.4 and 7.28 ± 0.17 respectively. As for the water velocity, the rivers of Sungai Bloh is swifter than in Sungai Katibas, 0.78 m/s vs 0.48 respectively.

The pH of waters in Embaloh-Tekalan rivers is slightly higher than that of the Katibas-Bloh system, perhaps caused by higher levels of organic acids in the latter. The pH of forest streams is influenced by the character of surrounding rocks and soils. There are also diurnal and seasonal changes, variation caused by rainfall cycles and respiration of aquatic organisms (affecting the bicarbonate buffering system of freshwaters).

In Katibas-Bloh of LEWS, secondary forest and vegetation is slowly invading the borders of the Sanctuary. In some areas, especially in Sungai Bloh, where the south bank of the river is still being logged, the silt load of the Bloh has increased. At the time of the sampling in LEWS, localised rainfall in the catchment of the Katibas swells the river occasionally bringing down large quantities of silt and leaf litter. However, the silt flow normally lasted for 24 hours and the river reverts to its original state quickly.

During the present sampling period, the ensurai trees (*Dipterocarpus oblongifolius*) that line the banks of the rivers were flowering heavily. From the stomach contents analysis of *Lobocheilus*, *Tor* and *Barbodes* spp., we found significant quantities of ensurai flowers. The engkabang oil trees (*Shorea macrophylla*) had heavy flowering during the haze in September and October, but there were few fruits formed after the haze. The flowers of engkabang trees along the river bank are also eaten by many cyprinids in the river.

4.2 Species Richness and Diversity

The total species now known from the BKNP-LEWS Biodiversity Conservation Area stands at 125 species from 12 families (Appendix 5). A total of 21 additional species were identified only to the level of genus. For BKNP, 91 species of fishes from 41 genera 12 families occur in the Embaloh drainage system. At least 13 of these species could only be identified to the level of genus. A total of 3186 specimens were collected over about 18 working days from the Embaloh drainage system.

In LEWS, a total of 61 species belonging to 29 genera of 9 families were recorded during the expedition. Of the figure, 50 were confirmed to the species level whereas 11 could be identified only to the level of genus. A total of 2123 specimens were collected during the two weeks of sampling.

Table 3 : Diversity and species richness at selected sites in BKNP-LEWS

Camp River	Diversity (H')	Evenness (J)	Species Richness (D)
I Sg. Jaket, Embaloh	1.146	0.382	10.840
II Sg. Tekalan	1.110	0.354	11.845
Transit S. Pajau	0.886	0.296	8.315
III Sg. Pait	0.884	0.425	4.164
(A) Menyarin	0.954	0.361	6.620
(A) Ulu Katibas	0.755	0.286	6.432
(B) Sg. Joh	0.918	0.307	9.091
(B) Sg. Merating	1.083	0.382	9.193

Fish species evenness decreased as one moved up the river from Pakararu to the transit camp. The fish species evenness in Sg. Pait was higher than in other stations probably because the stream habitats there were very homogeneous. There were fewer species at Pait, but there were more individuals evenly distributed among the species there. Similarly, most of the fish were of smaller size compared to their downstream counterparts, which live in deeper side pools. Evidently, the larger flowering *ensurai* trees were absent along the upper Pait River. The *ensurai* flowers were the main diet of many cyprinids in the stream.

Fish species diversity was generally lower in the Katibas, LEWS compared with that of the Tekalan/Embaloh in BKNP. As the stations in LEWS are not distributed over a range of elevations, no dramatic differences in diversity are apparent. The fact that Sg. Merating (station 38) which flows from an area of shifting cultivation in the buffer zone of the protected area had the highest species diversity is surprising. This disturbed river had the highest evenness and species values. Sungai Joh which flows from an undisturbed primary forest had a lower species diversity and richness even though the sampling effort and method were constant.

4.3 Endemic, Rare and New Species

A checklist of fish species found in BKNP-LEWS is presented in Appendix 5. Those that are endemic to Borneo are denoted with an asterisk, while potentially new species are denoted by (*).

Species that require further laboratory identification are *Luciosoma* sp. 1, *Lobocheilus* sp., *Neogastromyzon* sp. and *Glaniopsis* sp. *Luciosoma* sp. 1 resembles *Luciosoma spilopleura* except that the oval body spots along the lateral body surface are not distinct while the upper lobe of the caudal fin has a black stripe. The presence of *Glaniopsis* sp. in Sg. Pait and Bukit Condong during the present sampling also widens the known range of the species which was previously recorded only from North Borneo. A new species of *Gastromyzon embalohensis* (named after the Embaloh river) has already been described by Ike Rachmatika.

A number of rare and taxonomically difficult species were encountered in the collection of fish in BKNP. A few specimens of *Nemacheilus* sp. from stations 35 and 36, a black *Botia* sp. from stations 51(P6) and *Glaniopsis* sp. from Bukit Condong hill stream will require further comparisons with known species. Other closely related species such as *Lobocheilus* cf. *bo* and *L.* cf. *kajanensis* require further study as well. The hill streams of stations 18 and 19 at Pait Camp did not yield any fish although there were *Macrobrachium* and atyid prawns present. These hill streams were at elevations of about 50 to 100 metres above the Pait river and had steep waterfalls where fish could not ascend.

A number of potentially new species were collected in LEWS. The Katibas walking catfish, *Clarias* sp. which looks like *C. teysmanni*, differs in its head structure and body colourations. Similarly, *Hemibagrus* cf. *nemurus* differs from *H. nemurus* in its body measurements. At least three *Gastromyzon* species (1, 3 and 4) are likely to be new to science but would require further comparative studies with type materials in the Bogor museum. *Gastromyzon* sp. 4 is a species that has bright red dorsal, anal, pectoral, pelvic and caudal fins. Its body is dark brown in colour. One specimen of black *Leiocassis* sp. that was found in the Sg. Kelimau Mit requires further identification. There are two *Glaniopsis* species collected from the Katibas that require further study. *Glaniopsis* sp. 2 had only specimen collected from station 40 (Sg. Merating). There is also much variation in the dorsal colouration of the *Homaloptera nebulosa.* The dorsal surface spots are distinct blotches like *H. stephensoni* but its pectoral stripes colouration are rather *nebulos*a like. The *Lobocheilus* sp. 1 closely resembled *Schismatorhynchos heterorhynchos* but this has not previously been recorded from Sarawak although it was labeled as such by Parenti 1991 in her Baleh collection. This particular fish has a secondary rostrum and groove, tuberculate snout but differs from the *S. heterorhynchos* collected in BKNP. Several other species such as *Puntius* cf. *binotatus*, *Protomyzon* sp. and *Luciosoma* sp. require further taxonomic analysis for species confirmation.

4.4 Distribution and Abundance

In BKNP, cyprinids made up 51.8% of the fish species present and were thus the dominant family. The loach families were 28.3%, the remaining 8 families comprised 19.9%. By comparison, in LEWS the Cyprinids made up 56.6 % of the species collected, and were clearly the dominant group, while the loaches were 26.6%, and the remaining families a further 16.8%.

Based on the current surveys, 66 species were exclusively found in BKNP, while 24 were exclusively found in LEWS. About 45% of the BKNP species were also found in LEWS, whereas a slightly larger percentage of the species seen in LEWS were also found across the border. The most striking faunal differences were seen in the large number of loaches (Cobitidae) seen in BKNP, most of which were absent from the Sarawak drainages. Species of the genera *Gastromyzon* and *Puntius* were more numerous in LEWS than in BKNP.

Species endemic to Kalimantan (the Kapuas system) included *Gyrinocheilus pustulosus* and *Schismatorhynchus heterorhynchus*. Many species of freshwater fish that could have economic potential as ornamental aquarium fish were *Acanthopsis* sp., *Botia* sp., *Puntius* sp., *Rasbora* sp., *Gastromyzon* sp. and *Epalzeorhynchus* sp. Several expensive food fish of economic importance such as *Tor* sp., were observed in significant numbers from the field sampling. In the November 1996 surveys, *Leptobarbus hoeveni* was found in the Embaloh but this was absent during the1997 sampling.

Among the small species that are common in both protected areas are *Gastromyzon embalohensis*, *Garra borneensis*, *Nemacheilus saravacensis*, *Neogastromyzon nieuwenhuisii*, *Parhomaloptera microstoma* and *Protomyzon* *griswoldi* which prefer clear swift stream habitats. These small fishes have either modified oral suckers or ventral fins that can attach on to smooth rock surfaces. Other small swimmers are the minnows *Rasbora argyrotaenia* and *R. volzii.*

Pending further statistical analysis of the available data, fish species diversity were only calculated for a few stations in BKNP and LEWS where the fishing efforts were comparable (Table 3). The most diverse fishing stations in BKNP and LEWS were Sg. Jaket (H'=1.146) at the Embaloh and Sg. Merating (H'=1.083) at Bloh. In BKNP, fish species diversity and richness decreases as we ascend from Camp I at Pakararu to Camp III at Pait.

A general comparison of the surveyed areas showed differences in fish abundance from clear versus silty rivers. Most of the catfish families and several cyprinids were found predominantly in silty to muddy streams whereas the loach-like families (Ballitorids) inhabited only clear water streams. Nevertheless, swift currents are also important factors, since in LEWS, for example, the fish samples showed dominance by the Ballitoridae in collections made in the swifter though muddy waters of the Sungai Bloh and its tributaries. The latter family possesses special adaptations for life in fast flowing water.

Many cyprinid fishes of larger size tended to inhabit the main river while smaller sized fishes occupy the tributaries or forest streams. Thus these smaller tributaries or forests streams apparently function as habitat for immature stages. This is not true for all cyprinids, specifically *Macrochyrichtys maculatus*, *Luciosoma* sp. and the *Oxygaster anomalura*. The spawning ground/nurseries of the latter species were not located during the sampling period, suggesting that they possibly spend their entire life cycle in the main river system. Cyprinids with this type of morphology, generally thrive in areas of clear, clean and swift water, and forage only within the main river system.

For catfishes the only species found exclusively in the main Embaloh River was the carnivorous *Bagrius yorrelli.* More species of catfishes were seen to inhabit both the tributaries and main river, *e.g. Mystus nemurus, Mystus planiceps*, *Glyptothorax platypogon* and the *Leiocassis micropogon.* A surprising find on the Embaloh river system was the puffer fish, *Tetraodon leiurus,* found near Derian camp on the Tekalan River. This is rather far upstream for this species. Its presence may have been linked to the long drought, since even though this fish is well adapted to living in an all-freshwater system, it is rarely encountered in clear, rocky streams or rivers such as the Tekalan. In LEWS, the puffer, *Chonerhinus nefastus,* was found far up one of the tributaries of Sungai Joh. A group of this same species was seen along a sand bank along the main river of Sungai Bloh on a night trip down river.

Loaches inhabit all clear and clean water regions of all tributaries of the Embaloh and Tekalan River systems with swift currents and a rocky bottom substrate. They are predominantly epilithic film grazers with specialized suckers on their body adapted to these conditions.

Comparison between human induced habitat disturbance vs. undisturbed streams was made in the Sg. Merating, surrounded by a recently cleared shifting agriculture plot and rivers outside the boundary of the Wildlife Sanctuary. A surprising find was a higher level of species richness, whereby 22 species were collected from this river, the highest total for any stream in the area.

4.5 Reproductive Ecology

Most of the fishes caught towards the end of the sampling programme had gravid gonads with ovaries in stage V. It is obvious that the change in water level, water speed and decrease in temperature may stimulate or initialise the breeding cycle of fishes such as the *Gyrinocheilus pustulosus*, *Schismatorhynchus heterorhynchus*, *Botia* sp., *Bagarius yarrelli*, *Hampala bimaculata*, *Rasbora* sp., *Tor* sp. (semah) and *Barbodes schwanenfeldii*. In BKNP (September, 1997), fish species with gonads in the mature stage were *Rasbora bankenensis*, *Crossochilus oblongus*, *Crossochilus cobitis*, *Nemachilus* cf. *sarawacensis*, *Homaloptera stephensonii*, *Leiocassis micropogon* and *Barbodes collingwoodi*. The uncommon loach, *Vaillantella maassi* was found in breeding condition amongst the leaf litter of the stream bank at Sg. Dajo, Embaloh. In LEWS (November, 1997), fish with mature gonads included *Nemachilus* sp. 2, *Botia hymenophysa*, *Botia macracantha*, *Botia reversa*, *Garra borneensis*, *Lobocheilus* sp., *Rasbora lateriastriata* and *Osteocheilus pleurotaenia*.

4.6 Economic Aspects

The *semah*, a popular food fish, is the smaller species of *Tor tambra* while the large *Tor tambroides* is known as *empurau*. (*Tor soro* and *T. douronensis* are now considered as synonyms of *T. tambra*.). The larger *Tor* at the Tekalan and Embaloh can easily attain a size of 7 kg. The local price of semah/empurau and tengadak at Putusibau is Rp 3000 to Rp 7000 per kilogram as compared to the RM 30.00 to RM 150.00 per kilogram in Sarawak. The relative abundance of some of these economically valuable fish is given in Table 4.

Table 4 : Relative abundance of some economically significant fish species from BKNP-LEWS based on catch per unit effort

Species	BKNP	LEWS
Tor tambra	1.20	4.48
Tor tambroides	1.25	2.80
Barbodes collingwoodi	5.14	5.35

The differences between the two areas are most pronounced for *Tor tambra*. Differences in abundance may be attributable to seasonal factors or habitat differences, or possibly even to exploitation of the resource, though there is no information on this.

Most notable of the Katibas system is the obvious rareness of *Barbodes schwanenfeldii* or *tengadak* fish. This fish is the most expensive food fish collected by the locals from this river system. There are two types of *tengadak* recognized by the locals. The cheaper variety had reddish caudal fringes while the expensive type had whitish edgings. The juvenile of *Tor* are found in most of the small streams sampled. The most common food fish collected for domestic consumption by the locals are *pelekat*, *kepiat*, *adong* and *kulong*.

A total of 29 species from BKNP-LEWS were identified as commonly occurring in both protected areas. All of these common species occurred in large numbers and most of them are of commercial importance. Their significance lies in the high market value that they command if they are sold fresh to the consumers. The consumption of these fishes are also common in the longhouses outside BKNP and LEWS.

From gill net and hook and line fishing, it appears that the food fishes in BKNP are larger in size when compared with that of LEWS. This is true for species like *Tor*, *Hemibagrus*, *Cyclocheilichthys*, *Hampala*, *Lobocheilus*, *Osteocheilus* and *Puntius*. The largest *Tor tambroides* caught in BKNP could reach up to 5 kg in wet weight while those in LEWS did not reach one kilogram. The catfish (*Bagrius yarrelli*) which is only found in BKNP and not LEWS could weigh up to 7.0 kg each.

Many species such as *Botia*, *Gastromyzon*, *Nemacheilus*, *Acanthopsis choirorhynchus*, *Epalzeorhynchus kallopterus*, *Mastacembelus* and *Channa* have good potential to be developed for the home aquarium. Undoubtedly, the areas studied represented important habitats for the protection of *Semah* (*Tor*) and *Tengadak* (*Barbodes schwnenfeldii*) where their young are often encountered.

5. SUMMARY AND CONCLUSIONS

Specimens are currently stored in major collection centres in Indonesia and Malaysia, where further work remains to be done. Basic biological information on many species is still lacking. Many aspects such as taxonomic relationships, endemicity, reproductive behavior, feeding adaptation, food ecology and migration remain to be elucidated. Stream habitat and water quality of the sites studied in BKNP and LEWS are still in their pristine state. A combined 125 species is now known from the Tekalan/Embaloh of BKNP, Indonesia and Katibas, LEWS, Malaysia. Fish species diversity decreases as stream elevation increases. Small forest streams which had high waterfalls of over 4.0 metres are generally devoid of fish although prawns are present. The protected areas sampled are important for the conservation of commercial fish species as the adults breed and their young develop in these streams. These species subsequently move downstream to feed as they attain larger size.

G. HERPETOFAUNA

Robert B. Stuebing, Djoko Iskandar and Shahbudin Hj. Sabky

1. INTRODUCTION

The remarkable species richness of Borneo's fauna is appropriately reflected in a highly diverse herpetofaunal community. The first complete listing of the Borneo herpetofauna was published by Dr. Nellie de Rooij of Leiden Museum in 1917. Amazingly, this book is still in use, and referred to often as it is still the only full account, though somewhat outdated. There are presently about 445 species of caecilians, frogs, crocodilians, turtles, lizards and snakes known from Borneo. Recent publications have confirmed high levels of endemism in the amphibians and reptiles, with about one third of the snakes and more than three quarters of the Bornean frog fauna found nowhere else. Almost all montane frog species in Borneo are also endemic. Lizards are just as diverse, and many also endemic (especially the Scincidae), though documentation of recent discoveries is rather recent.

New species are encountered almost every year, and as recently as 1997, two new riverine frog species were described from a sample of just a few dozen specimens collected from southern Kalimantan. In 1993-94, four new herpetofaunal species (two frogs, a lizard and a snake) were discovered during less than 25 days of collecting effort at two sites in LEWS. There are certainly many more new species to be found. However, despite increased knowledge of the number and relative abundance of Borneo's herpetofauna during this past decade, the ecology of many groups remains poorly known.

Herpetofaunal surveys were conducted in the ulu Embaloh/ Bukit Condong area of BKNP from 5 October to 23 October, 1997. A long drought and numerous fires in southern and western Kalimantan resulted in a persistent haze throughout the survey area that eventually forced the postponement of Expedition surveys in Sarawak since the drought had temporarily made river travel both hazardous and difficult. Fieldwork eventually resumed in November for two weeks (12-26) in the ulu Katibas area of LEWS. Locations, dates and habitat details of Expedition herpetofaunal survey sites are given in Section I of this volume.

2. METHODOLOGY

Herpetofaunal teams were led by two scientists in BKNP[1] and one scientist in LEWS. Sampling was augmented by several staff of the National Parks and Wildlife Office (Sarawak Forest Department), and by local longhouse people. Specimens were collected along stream, river and forest transects at night, and some tadpoles were collected by the IBBE fish group. Field data on all specimens included stream size, substrate, distance from water and height above the ground.

Tadpole specimens used aquatic station data where applicable, including stream size, substrate, current speed, % canopy and water quality parameters (temperature, dissolved oxygen, pH and turbidity). Nomenclature follows Dubois[2].

Frog specimens were anaesthetised and relaxed in a saturated suspension of chlorobutanol, while reptiles were euthanised by injection with a nembutal solution. All were then weighed, tagged with a serial field number, set and preserved in 10% formalin (= 4% formaldehyde) solution. They will be transferred to 75% ethanol upon accession into national collections of the respective countries.

3. OBSERVATIONS: SPECIES RICHNESS, ABUNDANCE AND DISTRIBUTION

A list of the herpetofaunal species collected during the Expedition is given in Appendix VII. In BKNP, a total of 202 herpetofaunal specimens were collected, comprising 32 species of amphibians and 15 reptiles, while in LEWS, there were 147 herpetofaunal specimens collected, comprising 23 species of amphibians and 11 reptiles. The grand total collected during the Expedition was 341 specimens from 65 species (41 amphibians and 24 reptiles), or approximately 15% of the known herpetofauna of Borneo. The largest number of individual specimens (93) was obtained from the vicinity of the Ng Menyarin camp in LEWS, while the largest number of species from a single site (23) was also obtained from Ng Menyarin.

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[1] Sampling effort in Betung-Kerihun was hampered, unfortunately, by the ill-health of one the principal scientists, and the delayed arrival of another.

[2] Dubois, R. 1992

Based on Expedition results combined with earlier BKNP data (DI) for LEWS (RBS), a checklist has been compiled for the Betung-Kerihun/Lanjak-Entimau Biodiversity Conservation Area, and is given in Appendix 7. Thus far, 153 species are known from the combined Reserve, slightly more than one-third of the herpetofauna known from Borneo. There were 52 endemic species, about one-third of the total. Several species from the genera *Philautus*, *Rhacophorus*, and *Pseudorabdion* are believed to be potentially new to science, but await comparison with existing museum material in order to verify their status.

Of the 51 species encountered exclusively in BKNP, seven are commonly associated with human-modified habitats (commensal species such as *Polypedates leucomystax*, *Rana erythraea*, *Hemidactylus frenatus*) while another four are coastal or peat swamp species (such as *Rana signata* and *Rana glandulosa).* Of 41 species encountered exclusively in LEWS, none were commensals, but several are forest edge species (e.g., *Rhacophorus pardalis, Polypedates macrotis, Mabuya rudis*). The most significant overlap in species occurred in herpetofauna associated with small rivers/large streams, approximately 2-10 metres wide, where *Limnonectes leporinus*, *R. ibanorum*, *R. hosii* and *Bufo juxtasper* were extremely common in both BKNP and LEWS. The torrent frogs, *Meristogenys poecilis* and *M. phaeomerus* were found in small numbers in BKNP, but are much more abundant in LEWS.

4. SUMMARY AND CONCLUSIONS

Faunal assemblages were generally different when sites in BKNP and LEWS are compared, with low similarity recorded between lowland, riverine assemblages in both places. Although such comparisons must be only tentative, considering admitted differences in times and conditions for sampling in BKNP and LEWS, they are nevertheless a constructive exercise.

Generally speaking, the streams and rivers of ulu Katibas possess contrasting topography compared to those in BKNP. The volcanic origin of much of the ulu Embaloh area gives a considerably different character compared with the sedimentary rock strata of most of the LEWS region. LEWS rivers have broader, flatter (as opposed to V-shaped) beds, and tend to have more deposits of gravel and alluvium, especially in the Katibas-Bloh area. The BKNP ulu Embaloh rivers and streams, despite their lower altitude and seemingly gentler gradient, have relatively narrow channels prone to abrupt episodes of extremely swift and violent current; large areas of exposed bedrock imply that their water courses are regularly scoured by such currents.

Based on Expedition results, amphibian species richness was slightly lower in LEWS compared to that of BKNP, though this is not evident when larger scale collections (Appendix 7) are considered. A relatively large proportion of herpetofaunal species, about two-thirds of the total collected during the Expedition, were specific to a single site. This phenomenon probably can, for the most part, be attributed to insufficient sampling, particularly for snakes, which require long-term intensive effort to obtain in significant numbers. Despite the low sampling intensity however, presence or absence of some species in existing BKNP-LEWS collections may reflect actual ecological differences between the two reserves, specifically for low lying (100 m a.s.l.) areas.

For example, several frogs known to be forest edge pool breeders, such *as Chaperina fusca* and *Polypedates macrotis*, are common in LEWS, but have yet to be reported from BKNP. This may indicate that the steep gradients and their (skeletal) soils of BKNP are not conducive to formation of the microhabitats used by these species. A relatively larger number of commensal species of frogs and snakes (associated with man-made habitats), is known from BKNP. These probably originate from the partially disturbed, or inhabited areas at the periphery of the Park.

Breeding activity of anurans was observed in only one stream, the Sg. Begua, where more than forty individual frogs were collected within less than one hour. The most active and abundant species was *Meristogenys poecilis*, which was almost totally absent from the other Katibas/Bloh area streams. All these other streams were rather quiet by comparison. The extended dry spell from June through October may have caused depression of breeding in many frogs, especially those relying on torrents, elevated water levels, side pools or rain pools in the forest.

Stream assemblages for frog species in LEWS were similar to those observed in 1994, except for finding the river toad, *Bufo asper*, relatively more abundant in LEWS when compared with earlier surveys. Surveys of streams outside LEWS (the north bank of the Sg. Bloh) showed only minor differences in diversity and abundance compared with those within LEWS, with the exception of the Sg. Begua.

Relatively few turtles, lizards and snakes were found, though these always require more time and effort to survey. Apart from the potentially new species, no rare ones were found during the Expedition, though at least two (*Pseudocalotes saravacensis*, *Cylindrophis engkariensis*) are unique to this area of Borneo.

5. FUTURE RECOMMENDATIONS

It should be stressed that for herpetofauna, intensive, long-term collecting is crucial to obtain a proper understanding of species richness, distribution and abundance. Current knowledge is extremely basic that continued inventories are needed, specifically in the areas of the forest floor (leaf litter) fauna, and the canopy species. Subsequently, population dynamics and community ecology studies can be initiated for a better understanding of the role these animals play in the energy and nutrient dynamics of both terrestrial (forest) and aquatic habitats. Obviously, management of the herpetofauna of Betung-Kerihun and Lanjak-Entimau is at a very early stage, indeed.

Targets for future research should include long-term monitoring of several selected sites, identification of indicator species for the pristine undisturbed habitats of the Conservation Area and ecological studies of the role of amphibia in the food web and nutrient cycling within the tropical forest ecosystem.

H. BIRDS

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1. INTRODUCTION

The island of Borneo lies almost at the centre of the Old World tropics, and for centuries has been renowned for its rich biological diversity. More than 1,000 species of land vertebrates have been recorded, of which more than 60% are birds. High diversity and the relatively large number of bird species endemism have arisen through a long history of climatic and geological changes.

The current political divisions of Kalimantan/Borneo, though not drawn geologically or ecologically, still reflect some of the ancient barriers which have separated the portions of the Bornean fauna for several million years. Nevertheless, since birds are among the most highly mobile of animals, their distributions usually include all coastal, lowland or montane habitats of a geographical area.

The avifauna of Borneo is primarily Sundaic in character, possessing many species in common with Sumatra, Malaya and Java while most avifaunal elements are Asian in origin. Ornithological work has been conducted in various parts of the island for at least 150 years. Large specimen collections and many field observations were made primarily by British explorers, naturalists such as Alfred Russell Wallace, Charles Whitehead, and F.N. Chasen. B.E. Smythies, a forester in Sarawak, wrote the first comprehensive guide to the Bornean avifauna[1], which has been reviewed and updated. Other sources are listed in the reference list of this volume. There are now 599 bird species recorded from Borneo, of which 37 are endemic, and approximately 358 resident. Another 241 species are either migrants or vagrants. The number of species considered rare or endangered currently totals 14, though the actual status of many birds is still incompletely known. Some, such as Nieuwenhuis's Bulbul (*Pycnonotus nieuwenhuisii*) and the Bornean Peacock Pheasant (*Polyplectron schleiermacheri*) may already be extinct. Although the majority of the lowland avifauna in Borneo has been relatively well documented, species inhabiting areas deep in the interior near the central mountainous "spine" have still not been adequately surveyed.

[1] Symthies, B.E., 1960. Birds of Borneo

The IBBE bird surveys were conducted in the ulu Embaloh/ Bukit Condong area of the BKNP from 5 September to 25 September, 1997, and from 14-26 November, 1997 in ulu Katibas of the LEWS. Locations and dates of Expedition survey sites are given in Section I of this volume. Habitats of netting sites are given in Table 1.

2. METHODOLOGY

The ornithology team consisted of four scientists, two assistants and two labourers in BKNP, and three scientists, one field assistant and two labourers in LEWS. Fieldwork consisted of walking 2-4 km long transects through primary and secondary lowland, hill and submontane forests to sight birds with 10x50 binoculars, and netting operations (mostly in lowland areas) to ring species for long-term studies. River and forest transects ranged from 100 - 1,200 m a.s.l. Habitat details are given in Section I of this volume and in Table 2 (below). For netting, 10-20 four-paneled mist nets (36 mm mesh) 12 m in length, were set at five lowland (< 100 m a.s.l.) sites and one submontane site (900-1,200 m a.s.l.). Netting details are given in Table 2. At all netting sites an attempt was made to cover as many microhabitats as possible, so that approximately equal proportions of the nets were placed in streams or low, wet areas, within drier forest understorey and along small ridges. Nets were opened between 0515-0545 in BKNP and 0615-0645 in LEWS (a one hour time difference exists). Birds caught were identified, weighed, measured (wing, bill, tarsus and tail) and their moult and reproductive condition (age, plumage and brood patch) noted[2]. All nets were closed between 1645-1715 in BKNP and 1745-1845 in LEWS, or whenever rain occurred. Details of the date, time and location of capture were recorded, and prior to release the birds were ringed with appropriately sized, serially numbered Sarawak Forest Dept. aluminium bird rings.

Table 1 : Habitats for six netting sites in BKNP-LEWS

	Pakararu	Sg Aur	Derian	Bkt.Condong	Ng Menyarin	Ng Joh
Habitat	AF*	AF	LDF	HDF	AF	AF
	LDF	LDF	HDF	SMF	LDF	LDF
	HDF					

* AF = alluvial forest; LDF = lowland dipterocarp forest;
HDF = hill dipterocarp forest;
SMF = submontane forest

[2] Some were photographed prior to release

Table 2 : Sampling effort for bird netting at six sites in BKNP-LEWS

	Sites Pakararu	Sg Aur	Derian	Bkt. Condong	Ng. Menyarin	Ng. Joh	Total
Total net-hrs	812	564	509	337	905	866	3993
Total species	26	33	34	20	29	36	65
Total indiv	82	68	68	39	81	117	455
Sp/net-hr	0.03	0.06	0.07	0.06	0.03	0.04	0.05 avg
Indiv/net-hr	0.1	0.12	0.13	0.12	0.09	0.14	0.12 avg

Community comparisons of pairs of sites were based exclusively on netting results. Although there are obvious limitations imposed by netting only in the forest understorey, a comparison of bird feeding guilds was made. Valuable ecological information can still be obtained, based on observed differences in community composition.

3. OBSERVATIONS

3.1 Species Richness

During the September BKNP surveys, 165 species from 36 Families were recorded, while during November in LEWS, a total of 142 species from 39 families were noted. Thus based on both previous[3] and current work, a total of 291 bird species have been recorded from the BKNP-LEWS Conservation Area (Appendix 7). Families not found in BKNP were the Falconidae, Sittidae, Hirundinidae, Indicatoridae and Meropidae, while families not found in LEWS were the Zosteropidae and Phalaropidae.

The BKNP-LEWS species total covers approximately 50% of the known avifauna of Borneo, and more than 80% of the resident bird fauna of the island, and more than 75% of the island's lowland forest fauna. Nearly 70% of the endemic species known from Borneo have now been recorded from the BKNP-LEWS. A total of 20 endemic species were recorded altogether, 16 in BKNP and 12 in LEWS (Table 3.). There were 17 migrant species recorded, with a wide variety of species which nest in the northern hemisphere (Table 4).

[3] Grubh's ITTO inventory in 1994 and the WWF inventory of Kavanagh in 1982

Table 3 : Endemic birds found in BKNP and LEWS

No.	Species	BKNP	LEWS
1.	*Harpactes whiteheadi*	+	
2.	*Megalaima eximia*	+	+
3.	*Megalaima pulcherrima*	+	+
4.	*Megalaima monticola*	+	
5.	*Calyptomena hosei*		+
6.	*Calyptomena whiteheadi*	+	
7.	*Napothera atrigularis*		+
8.	*Yuhina everetti*	+	+
9.	*Cyornis superbus*	+	+
10.	*Arachnothera everetti*	+	
11.	*Dicaeum monticolum*	+	
12.	*Prionochilus xanthopygius*	+	+
13.	*Oculocincta squamifrons*	+	
14.	*Chlorocharis emiliae*	+	
15.	*Lonchura fuscans*		+
16.	*Pitta baudii*	+	+
17.	*Pityriasis gymnocephala*		+
18.	*Ptilocichla leucogrammica*	+	+
19.	*Lophura bulweri*	+	+
20.	*Malacocincla perspicillata*	+	

Note: endemics follow MacKinnon and Phillipps (1995)

Table 4 : Migrant birds found in BKNP and LEWS

No.	Species	BKNP	LEWS
1.	*Accipiter nisus*	+	
2.	*Cuculus canorus*	+	
3.	*Egretta garzeta*	+	+
4.	*Ficedula mugimaki*	+	+
5.	*Halcyon coromanda*	+	
6.	*Halcyon pileata*	+	+
7.	*Hirundo rustica*		+
8.	*Locustela certhiola*	+	
9.	*Locustela lanceolata*	+	
10.	*Motacilla cinerea*	+	+
11.	*Motacilla flava*	+	
12.	*Muscicapa sibirica*	+	
13.	*Oenanthe oenanthe*	+	
14.	*Phalaropus lobatus*	+	
15.	*Phylloscopus borealis*		+
16.	*Pitta nympha*	+	
17.	*Tringa hypoleucos*	+	+

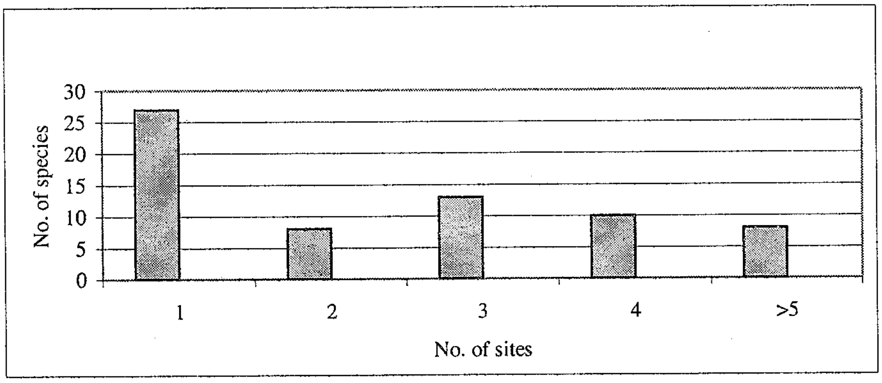
Mist netting at seven sites yielded a total of 67 species from 16 families. Totals from each site are given in Appendix 7. The highest species total (32) was netted at Nanga Joh in LEWS. Based on species obtained per net-hour, the most species-rich site was Derian Camp in ulu Tekalan, though rates from Sg. Aur and Bukit Condong were similar. The lowest rates were from Pakararu, (BKNP) and Ng Menyarin (LEWS). The highest capture rate for individual birds was seen in Ng Joh on Sg Bloh (LEWS) and the lowest in Ng. Menyarin (LEWS).

3.2 Distribution and Abundance

All eight species of Bornean hornbills were seen, as well as a majority of the babblers (Timaliidae) and flycatchers (Muscicapidae) of Borneo. Surveys in BKNP produced more submontane species, as well as species associated with "disturbed" or "man-made" habitats. The most astonishing record was of a Eurasian Tree Sparrow, *Passer montanus*, seen in Derian Camp. In LEWS, no submontane habitats were located within the study area. The record of Whitehead's Broadbill (*Calyptomena whiteheadi*) from BKNP near Bukit Condong may be the first sighting of this rare bird from Kalimantan. The Snakebird, *Anhinga melanogaster*, rather rare in Lanjak-Entimau, is common along the Embaloh River near the boundary of BKNP, where at least six individuals were seen on 04.09.97. From overall netting results, the most abundant group was the babblers (approx. 30% of all species).

Species overlap recorded between BKNP and LEWS was 194 (about 66%): 47 were seen exclusively in BKNP and 51 recorded exclusively from LEWS. The most widely distributed and abundant were the Timaliidae (Babblers), Pycnonotidae (Bulbuls) and Muscicapidae (Old World Flycatchers). The IBBE Primate team reported the Great Argus (*Argusianus argus*) to be abundant in both sides of the boundary, but it was heard about 50% more frequently in LEWS.

Figure 1. Species distribution as reflected in netting results



More than 40% of all birds netted were seen only at a single site (Figure 1), while about 15% were recorded from five or more sites.

Several groups such as broadbills and pittas displayed localised patterns of abundance. Only one bird, the Little Spiderhunter (*Arachnothera longirostra*) was common to all six netting sites. It was also the most commonly caught species, with a total of 59 individuals recorded, 23 from BKNP and 36 from LEWS.

More than a quarter of all species netted were represented by a single individual, and only four species were represented by ten or more individuals. The species and individual capture rates (per net-hour) of the mist-nets decreased to nearly zero after approximately 800 hours (or seven days), so this may be the optimum duration at a site for purposes of efficiency. It is unlikely that the capture rate would again increase significantly after 800 hours, though species would be continuously added for a long period at a low rate. Species per net-hr averaged about 0.05/net-hr, or approximately 0.5-0.6/net/day, while individual captures averaged approximately 1.1/net/day for all sites (Table 1).

Similarity comparisons[4] based on netting effort (Table 5) indicated, not surprisingly, that the highest degree of similarity (61%) occurred between Ng. Menyarin and Ng. Joh , both within about 8 km of each other in LEWS. Nevertheless, similarity values were also high between Ng. Joh and Derian (55%) Ng. Menyarin and Derian (53%) and Ng. Joh/Ng. Menyarin and Pakararu (52%). Similarity values between lowland sites within BKNP were comparatively lower, *e.g.*, between 29-37%. Comparisons of lowland BKNP-LEWS sites with Bukit Condong gave low values, ranging from 7-17%, showing the distinct character of the Condong avifauna.

Table 5 : Percent (%) similarity between netting sites in BKNP-LEWS

	Pakararu	Sg. Aur	Derian	Bukit Condong	Ng. Menyarin
Pakararu					
Sg. Aur	46				
Derian	37	29			
Bukit Condong	16	17	07		
Ng. Menyarin	52	38	53	13	
Ng. Joh	52	43	55	16	61

[4] Community comparisons of pairs of sites, exclusively from netting results, was based on percent similarity (Anon., 1984), as calculated by the equation:

$p_{ia} - p_{ib} = \Sigma_{min} P_{i\ a,b}$

where P_i = proportion of species in each of the sites a,b

In terms of community structure, approximately 70% of birds netted at three sites were insectivores, with frugivores at approximately 26% (Table 6). BKNP has a comparatively larger percentage of bark-gleaning insectivores, sallying substrate gleaning insectivores and foliage-gleaning insectivores. LEWS shows a higher relative proportion of terrestrial insectivores, sallying insectivores, nectarivores and arboreal frugivores.

3.3 Recaptures and Ring Recoveries

Twenty-one bird species were recaptured at least once. The most frequently recaptured bird was the Little Spiderhunter, *Arachnothera longirostra,* recaptured a total of 17 times (14 or approx. 25% of all individuals). One of these recaptures (21 November, 1997) was of a bird ringed on 12 July, 1994 at Ng Joh by Robert Grubh and L.K. Sim during the first Lanjak-Entimau bird ringing surveys. Other species frequently recaptured were the Yellow-Bellied Bulbul (*Alophoixus phaeocephalus*) [8x], the Short-Tailed Babbler (*Malacocincla malaccense*) [7x], the Scaly-Crowned Babbler (*Malacopteron cinereum*) [6x] and the Black-Throated Babbler (*Stachyris nigricollis*) [5x]. Two individuals of *Stachyris nigricollis*, ringed as adults on 12 July, 1994 at Ng Joh by Robert Grubh and L.K. Sim were recaptured on 21 and 23 November, 1997 respectively in excellent condition. One Green Broadbill (*Calyptomena viridis*) ringed as a subadult on 12 July, 1994 was recaptured as an adult on 23 November, 1997.

Table 6 : A comparison of avian guild representation based on netting results from BKNP-LEWS

	GUILD[5]											
	I*	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
BKNP												
Number	0	9	3	10	5	9	8	6	0	0	0	3
Percent	0	17	6	19	9	11	5	11	0	0	0	6
LEWS												
Number	0	8	0	5	2	6	6	6	1	0	0	2
Percent	0	22	0	14	6	17	17	17	3	0	0	6

[5] from Lambert (1992), and Mitra and Sheldon (1993)
* = raptors (hawks and owls)

3.4 Population Aspects

For netted birds, there was an overall sex ratio of 57 males : 26 females (approx. 2.2:1), with 73 individuals indeterminate. The difficulty of ascertaining sex in rainforest birds, many of which are monomorphic, makes calculation of a sex ratio rather difficult, and thus inaccurate. Field laparotomies would have to be done to deal with the large percentage of individuals whose sex or reproductive condition cannot be easily determined based on external appearance.

A total of 25 individuals from BKNP-LEWS birds were confirmed juveniles or immatures while there were 74 individuals whose plumage was either scored as immature or as a subadult. For abundant species (>10 individuals netted), the Scaly-Crowned Babbler (*Malacopteron cinereum*) possessed the highest number of these "immatures", approximately 57% of the individuals netted. The Little Spiderhunter (*Arachnothera longirostra*) had 39% "immatures", while the Rufous-Crowned Babbler (*Malacopteron magnum*) and the Short-Tailed Babbler (*Malacocincla malaccense*) had only about 7% immatures.

The pristine quality of the habitat is reflected in the relatively high proportion of certain sensitive groups such as trogons and flycatchers. The large number of netted species represented by a single individual supports the view that BKNP-LEWS possesses a high level of avian diversity.

The IBBE values for species abundance (individuals obtained per net per day), are five times that reported for Pasoh Forest Reserve in Peninsular Malaysia, but almost identical to the rates observed in the disturbed remnant forest of Bangi, Selangor. The differences may be the result of more extended time spent netting at a single site in Pasoh, which would lower net productivity substantially.

It has been suggested that secondary forests generally possess higher proportions of arboreal frugivores although many of these are apparently missing from isolated or degraded forest fragments. The presence of disturbed habitats adjacent to LEWS may be the reason for its relatively larger percentages of nectarivores and arboreal frugivores. The Little Spiderhunter (*Arachnothera longirostra*), which thrives in habitats disturbed by logging, is almost twice as common in LEWS compared to BKNP, where logged areas are quite distant, most disturbance in the form of shifting agriculture occurred more than a decade ago, and the areas have regenerated considerably since. Little spiderhunters are numerous in Peninsular Malaysian forests adjacent to logged areas.

Interestingly, the Scaly-Crowned Babbler (*Malacopteron cinereum*) was netted 20 times in BKNP, and only once in LEWS in November though it was one of the most common species formerly netted in LEWS in 1993-94. Furthermore, several species which were expected to be present or even common, were not seen in Bukit Condong of BKNP. Among these were the Crested Serpent Eagle (*Spilornis cheela*), Common Green Magpie (*Cissa chinensis*), Bornean Treepie (*Dendrocitta occipitalis*) and Chestnut-Capped Laughing Thrush (*Garrulax mitratus*). Both the Spangled Drongo (*Dicrurus hottentottus*) and the Rufous-Tailed Flycatcher (*Cyornis ruficauda*), usually present above 800 m a.s.l. were also not seen on Bukit Condong. The effects of drought and associated haze in late September reduced visibility to less than 20 metres at Bukit Condong site, and could have been a major reason that these species were missed.

Recapture results are not easy to interpret, but can reflect anything from net shyness to the small territories of the species concerned, or even the proximity of the net lines to a nesting or feeding site. Some babblers (*Malacopteron cinereum, M. magnum*) and perhaps even bulbuls (*Alophoixus phaeocephalus*) seem to live in small family groups, since many individuals of these species are often recaptured in a single netline.

Four recaptures consisted of three species netted and ringed in 1994, supporting the notion that some forest birds are resident on territories for long time. In Ulu Klang, Peninsular Malaysia, one of the team member (RBS) observed the recapture of a small understorey babbler (*Trichastoma* sp.), that had been ringed 3 years previously.

Concerning population structure for most species, too few individuals were caught to investigate this subject. However, an interesting situation was seen in the small babbler, *Malacopteron cinereum*. Besides a pair of obviously mature adults in each site, there were several others that were scored as "late immature" stage, and routinely netted and recaptured in small groups of two or three in the same area as the other birds. Their behaviour hints at social ties beyond a single mated pair, since this species (and several species of *Stachyris* babblers) seem to defend their territory in groups. The adult-sized, immature birds may in fact be nest "helpers" of a mature adult pair, as has been documented in Florida Scrub Jays in North America, and common in Australian groups such as corvids. It will be interesting to acquire further data on some of these babblers.

4. CONCLUSIONS AND FUTURE RECOMMENDATIONS

Despite the limited scope of the ITTO Expedition, field surveys have clearly demonstrated an enormous richness and diversity of bird species. A large percentage of the Bornean forest community is present, as well as a large component of the island's resident breeding species. A majority of the endemics and many species regarded as rare or endangered, are present, and some even relatively abundant.

In a conservation area as extensive and important as BKNP-LEWS, monitoring of species richness must be an ongoing activity, not only to ensure that vulnerable or threatened species (pheasants, hornbills, etc.) are holding their own, but to continue to add to the known inventory, a process which will take a long time.

Species distributions are patchy, a less appreciated feature of wet tropical forests, and consistently shows up in the large number of species found at only one site, and by the low percent similarity values (<50%) between many sites at the same altitude. Similarities between lowland versus submontane sites are even lower still (<30%). This accentuates the need for the preservation of large tracts of forest to ensure both the preservation of overall species diversity and sufficient breeding populations of birds for long-term survival.

Thus, it will be important, also, to monitor changes in species assemblages and their associated forest communities (*e.g.,* riverine, lowland/hill, submontane/ montane forest) over space and time. Bird ringing should be continued in sites where a sample of the birds has already been marked so that information on movements and longevity can be obtained. In places such as Derian, Pait and Katibas/Bloh, changes will undoubtedly occur in bird communities as the regenerating forest reaches a more mature stage. In the absence of monitoring, a single re-inventory might give an erroneous picture of changes in species composition, as if certain species were "suddenly" going extinct, which in fact might be a gradual decline related to successional or even sampling phenomena.

For taxonomic research, current DNA techniques will be extremely useful in delineating species boundaries as well as unravelling certain intriguing problems such as whether groups of Nesting Babblers (*Malacopteron, Stachyris* spp.) are indeed closely related, and why they behave as they do.

Some habitat management in the form of limited slash and burn agriculture in peripheral areas may be desirable to preserve a habitat mosaic that can support additional bird species. Many birds are drawn to regenerating habitats because of the abundant food resources, or as in barbets, by the availability of tall, dead trees located in relatively open areas and therefore suitable for nesting. Since diversity is actually augmented, such human activities should not be considered inimical to conservation efforts, but as an integrated part of such efforts as long as the disturbance is restricted to the buffer zones on the borders of the Conservation Area.

With regard to current exploitation, there is some concern that the Straw-Headed Bulbul (*Pycnonotus zeylanicus*) is being collected from the Embaloh area, and possibly from ulu Katibas as well. This species has become immensely popular as a cage bird during the past decade or so, and there are reports of it being aggressively sought after for sale to bird fanciers. It was not heard or seen in BKNP-LEWS during the Expedition, so that there is cause for concern.

There are reports that local people over-hunt hornbills (particularly *Buceros* spp.) for tail feathers used in traditional ceremonies. Because tail feathers can be used for many years, and because the hornbill species in question are still abundant in BKNP-LEWS, there is apparently no over-hunting at present. Nevertheless the situation should be monitored.

Finally, the BKNP-LEWS Conservation Area has been demonstrated to be an important winter range for many species of temperate zone migrants. Protection of such ranges is crucial to temperate zone breeders, and management programmes must, among other things, emphasise the broader implications of the area for avian conservation.

Furthermore, the Bornean avifauna has apparently not been limited or isolated by natural barriers (such as the Kapuas Hulu, Iran, Apo Duat Ranges) within Borneo, as have certain other faunal elements. A relatively large number of endemic species occur throughout forests in several altitudinal zones in BKNP (Indonesia) and LEWS (Malaysia). The existence of these extensive and complex distributions of bird species underlines the necessity for a cooperative management policy to ensure the conservation of bird species on both sides of the international border.

I. PRIMATES

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1. INTRODUCTION

The Betung-Kerihun and Lanjak-Entimau Biodiversity Conservation Area covers an area of approximately 1,000,000 hectares in western Borneo. Please refer to Section I of this volume for comments on its geological history and some other aspects of its historical biodiversity.

More than thirty-five years ago, one of the world's most illustrious field zoologists, George Schaller, visited the remote Lanjak-Entimau area of southwest Sarawak. There he found a large and undisturbed population of Borneo's "man of the forest", the Orangutan. Based on his experiences in the area, Schaller wrote a formal recommendation that the site should be set aside as an important refuge to guarantee the survival of the Orangutan in Borneo.

In the 1970s, the National Parks and Wildlife Section of the Sarawak Forest Department made plans to secure the area for wildlife conservation, particularly for the conservation and protection of Orangutan and hornbills. A major expedition was undertaken in 1981 with the assistance of the World Wildlife Fund (now World Wide Fund for Nature), during which surveys of Orangutan locations and densities were carried out. A boundary survey was also performed providing the basis for the gazettement of LEWS in mid-1983.

There were, however, no funds to further survey the primates in the Sanctuary, until 1991, when a report by the International Tropical Timber Organization (ITTO) Mission led by the Earl of Cranbrook strongly recommended the development of LEWS as a Totally Protected Area. The report emphasised that efforts be made to ensure the long-term survival of Lanjak-Entimau's rich flora and fauna, with special emphasis on the endangered Orangutan.

Thus, the ITTO-sponsored primate studies were carried out in Lanjak-Entimau from 1993-94 by the ITTO Primatologists Richard Tenaza and Raleigh Blouch, during which six primate species including the Orangutan *(Pongo pygmaeus)*, Orangutan Bornean Gibbon (*Hylobates muelleri*), White-Fronted Langur (*Presbytis frontata*), Maroon Langur *(Presbytis rubicunda)*, Pig-Tailed Macaque (*Macaca nemestrina*) and Long-Tailed Macaque *(Macaca fascicularis)* were surveyed. It was found that there were substantial populations of all these species, including the Orangutan, which were estimated to be more than 1,000 individuals. Gibbons were found to be more abundant that in any other site in Borneo.

Surveys of the abundance of fruit trees showed that the LEWS orangutans were concentrated in the southern portions of the Sanctuary, and connected both with groups in Batang Ai National Park in the south, as well as eastwards across the international boundary into BKNP.

The objectives of the IBBE 97 were to update surveys of all primates at field sites in both BKNP and LEWS so that distributions across the transnational boundary could be assessed. Furthermore, ecological information on all primate species encountered was to be entered into a permanent database. Integrated with this work, young scientists and assistants were given an important opportunity for training in field techniques for use in future monitoring and management programmes.

2. METHODOLOGY

A modified line transect method was used to estimate approximate numbers and locations of the primates in both the Betung-Kerihun and Lanjak-Entimau Reserves. Researchers proceeded along the transect at 50-metre intervals, where they would split up and explore a perpendicular line approximately 200 metres on each side. This process was repeated at intervals along the entire transect. Survey locations are given in Section I of this report, while lengths of survey lines are given in Table 1. In BKNP, a total of 12 days were spent on surveys, while in LEWS, 8.5 days.

Table 1 : Transect lengths for BKNP-LEWS primate surveys

Location	Length (km)
BKNP	
Pakararu camp	2
Derian	2 x 4
Bukit Condong	2
Sg. Jaket, Pait Camp	2
Sg. Benalik	2

LEWS		
Sg. Menyarin camp		2
(Bukit Menyarin)		4
(Bukit Guning)		3
(Emperan Ridan)		2
Sg. Joh camp		3
(Bukit Sengayoh)		4
	Total	34

In BKNP, surveys were conducted along existing trails, marked at 50-metre intervals, one leading out from each camp. In LEWS, two line transects were cut at each site about one month before the surveys began, mostly along the crests of ridges and spurs, since following a straight line would have been extremely difficult in the local terrain. Transect lengths were between 2-4 km, and marked at 25 m intervals with numbered flagging and an aluminum Forest Department plate marker. Except for the high altitude transect at Bukit Condong and Emperan Ridan, most other trails went through primary or old secondary lowland forests.

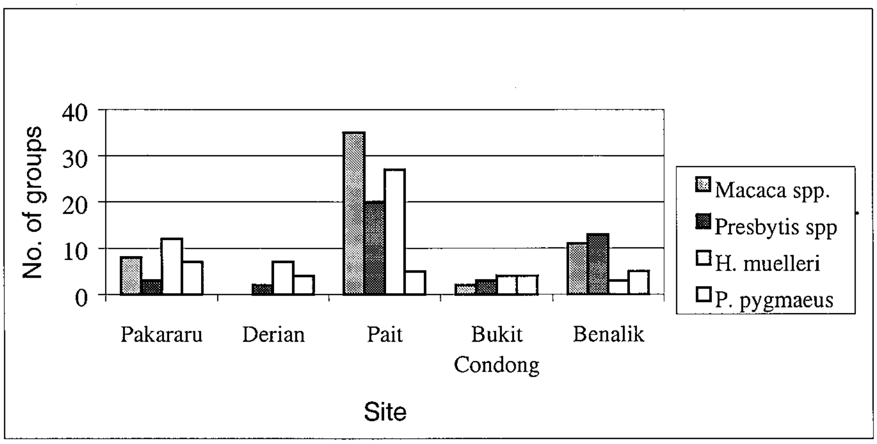
Surveys began from 0730-0930 in the morning with a team of two to three observers walking slowly (1-2 km hr) and quietly, and pausing at each station. Surveys generally took from six to seven hours, but were not done on rainy days. Each transect was walked (to and fro), for a minimum of 68 km of surveys. Approximately 4 km of riverine surveys were done in both BKNP and LEWS, which consisted of drifting without power down the Sg. Embaloh, Sg. Katibas and Sg. Bloh from about 0700-1000 hrs and 1500-1800 hrs. The number of individuals was counted whenever possible, based on sightings, calls or foliage movement. Total groups and total individuals of an area were counted at each survey site. A continuous thick haze persisted during the dry season, in the first phase of the Expedition during September, 1997, and is likely to have reduced the effectiveness of surveys by reducing visibility and perhaps even suppressing the activity of some of the primate species. Gibbons and other monkeys were, in fact, only occasionally heard in September, though they called frequently in Lanjak-Entimau in November, when the haze had already cleared.

3. OBSERVATIONS

Six primate species were recorded during the surveys, for a total of 251 groups; 172 in BKNP and 79 in LEWS. The most common species in both BKNP and in LEWS was the Bornean Gibbon (Fig. 1). The six species were also seen in a small "enclave" or fragment still outside the boundaries of BKNP in ulu Embaloh. The richest site in terms of number of individuals was Pait in BKNP, where more than 86 groups of the six species detected.

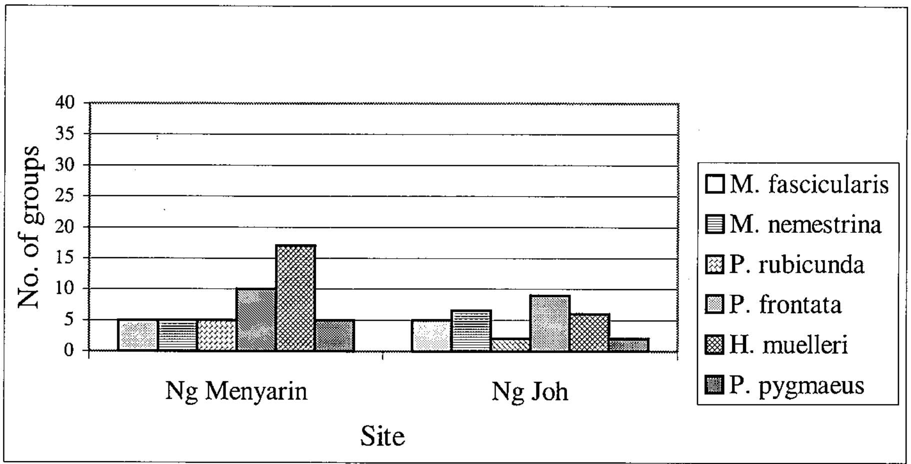
In selection of habitats, the Orangutan (*Pongo pygmaeus*) seemed confined to primary forest in BKNP-LEWS, and though there were some signs of the use of riverine habitat in BKNP, the species was not seen along rivers in LEWS (see Table 2). Their presence was determined only indirectly through sightings of fresh nests, which were constructed for sleeping. They also left signs of having fed on wild durian (*Durio* sp.) and rattan shoots. Gibbons (*Hylobates muelleri*) were widespread and abundant in both of the protected areas. They were more likely to be found along ridges and hilltops in primary habitats, but less common in secondary forest or along rivers. Maroon Langurs (*Presbytis rubicunda*) on the other hand, were more commonly detected in riverine forest. The White-Fronted Langurs (*Presbytis frontata)* seemed to range more widely, and was found both near the rivers and on hill slopes. Both species of langurs were abundant in secondary forests, as were the two macaque species. Long-Tailed Macaques (*Macaca fascicularis*) were generalists found in almost all habitats, but most commonly in secondary forests, including the periphery of a shifting agriculture plot in LEWS.[1]

Figure 1(a). No. of groups of primates detected in BKNP



[1] In BKNP, because of poor visibility due to hazy conditions, records of *Macaca* species were combined

Figure 1(b). No. of groups of primates detected in LEWS



Orangutans are usually solitary, and none were actually seen. Gibbon groups generally consisted of a pair of adults and a juvenile or infant, though in LEWS at least two groups consisted of juveniles or subadults. Langurs and macaques were mostly seen in groups, although single individuals were sighted on one or two occasions.

Table 2 : Distribution of primate groups according to habitat type in BKNP-LEWS

Habitat	*M. fasc.*	*M. nem.*	*P. rub.*	*P. fron.*	*H. muell.*	*P. pyg.*
Primary forest						
Ridge	*	*	+	+	+	+
Slope	--	*	+	+	+	--
Secondary forest						
Ridge	++	++	+	+	+	*
Slope	++	++	++	+	--	--
Ecotone	+	+	+	+	+	+
Riverine forest	++	++	++	++	*	*

++ = abundant, + = present, -- = absent, * = presence of old track, sign

4. SUMMARY AND CONCLUSIONS

Interestingly, Blouch's 1994 suggestion that the Lanjak-Entimau orangutan populations extend across into BKNP was borne out by the surveys. Densities in the ulu Embaloh / Bukit Condong area of BKNP were comparable to that in LEWS. Blouch also reported that orangutan were fewer in the northern and central parts of LEWS, though from our surveys we estimate that there are between 7-14 individuals in the Katibas-Bloh area, perhaps slightly more abundant than previously thought.

The abundance of the Bornean Gibbon and White-Fronted Langur was quite astonishing. Blouch remarked on the high densities of gibbons in LEWS in his earlier report, and this assertion was confirmed by the expedition scientists. The great numbers of these primates in BKNP-LEWS seems to reflect the mostly pristine condition of its forest.

The macaques also seem to have a smaller body size compared with those in locations elsewhere in Indonesia, and this will be a fertile topic for future research. This trend towards smaller body size has been observed in monkeys of the same genus in Japan, where their populations have been stable for many hundreds, if not thousands of years.

In Indonesia, four of the six primate species found in BKNP-LEWS are protected, which includes the two species of langur and two apes, but excludes the two species of macaques. Malaysian law protects all six. In protected area of BKNP-LEWS, all except for the orangutan are abundant. Blouch is of the opinion that the estimated 1,000 individuals of the orangutan population of LEWS is a viable population. The addition of animals from the BKNP side certainly augments and improves this situation. A survey by van Schaik and Sugardjito in 1990 estimated that approximately 2,000 orangutans live in BKNP, concentrated in the western portions contiguous with LEWS. Thus, this BKNP-LEWS orangutan population is now known to extend from just east of Danau Sentarum into Batang Ai National Park and Lanjak-Entimau, then south-westwards into the Bukit Condong region of Betung-Kerihun. International cooperation between the governments of Indonesia and Malaysia is crucial for the management and continued protection of this, the largest and most geographically extensive populations of the species in Borneo.

Stringent protection measures will be necessary for the protection of this species as well as for the gibbon and langur, since illegal hunting is still practiced by the local as well as outside communities, and indiscriminate shooting of these primates still persists.

For conservation purposes, the territorial integrity of BKNP-LEWS must be maintained, and that it would be beneficial if isolated "enclaves" or fragments of habitat near the park which have orangutans be incorporated into the Park as soon as possible. Consolidation of such areas will contribute positively to the survival of the existing primate populations of this valuable biodiversity conservation area.

IV

LOCAL COMMUNITIES

J. GENETIC RESOURCES

S. Dayanandan and Kamaljit S. Bawa

1. INTRODUCTION

The two contiguous nature reserves in Borneo, Lanjak Entimau Wildlife Sanctuary (LEWS) in Malaysia and Betung Kerihun National Park (BKNP) in Indonesia, cover almost one million hectares, and represent one of the largest protected tropical rainforests in the far east. Conservation and protection of these forests are extremely important because of the high levels of biodiversity. Moreover, these forests contain valuable forest resources such as timber, non-timber forest products and medicinal plants. Many local communities depend on these resources, making the forest critical to their social and economic well being. Because of the contiguous location of these two reserves, it is extremely important to have complementary management plans for successful conservation. These plans include, among other programmes, creation of gene banks and seed sources for economically important timber and non-timber forest products.

Phase I of the LEWS project supported by the ITTO revealed that several species of wild plants are being used by local communities as medicinal products, wild fruits or vegetables. Areas were also designated as gene banks or seed sources of valuable timber species. Phase II of the above project was initiated in 1997 to continue the scientific programmes as well as to integrate local communities into Sanctuary management. A similar project has been jointly implemented by ITTO, WWF Indonesia and the Ministry of Forestry Department of Indonesia to develop a comprehensive conservation plan for BKNP.

2. OBSERVATIONS

Several species of fruit trees have emerged as important genetic resources for local communities which are amenable for further genetic improvement (Table 1). These species are important for local economy, as they are sometimes cultivated in home gardens and have a high potential to grow in plantations. Examples are *Canarium odontophyllum* (locally known as *dabai*), *Piper* spp. (black pepper and related species) and the trees of the family Dipterocarpaceae were selected for further genetic studies.

2.1 Canarium odontophyllum "Dabai"

Canarium odontophyllum, or *dabai*, is a species with separate male and female trees growing to 20-30m in height, occurring in natural forests as well as in home gardens in Sarawak. Olive-like fruits of *dabai* are rich in protein, sold in local markets throughout Sarawak, and have the potential to develop into a commercial crop.

Male and female trees are indistinguishable at young stages, and usually reach reproductive maturation in six to eight years. Excess male trees are removed from home gardens after they become reproductively mature. Development of genetic markers for early sex identification, preferably at the seedling stage, would be useful in early selection of female trees to maximise the fruit crop in home gardens and plantations. These markers could be used to screen sex of seedlings in nurseries of community forestry programmes prior to distributing to local communities for cultivation in home gardens or in establishing large-scale plantations.

Leaf samples of male and female dabai trees were collected to develop polymerase chain reaction (PCR) based molecular markers for early identification of the sex of the plant.

2.2 Piper spp.

Black pepper (berries of *Piper nigrum*) is one of the most widely consumed spices throughout the world, and plays a key role in the economy of the Asian region. *Piper nigrum* grows as a climber in plantations throughout the Asian tropics. It is thought to have been domesticated from natural forests in the western Ghats of India. Several species of *Piper* are found in the natural forests of Borneo, and many are potentially useful for domestication and breeding to develop improved varieties. Moreover, black pepper plantations in Sarawak are under a serious threat of a fungal root disease that is extremely difficult to control by fungicides. One of the potential ways to combat the disease is by transferring genes from disease resistant varieties or closely related wild species to domesticated plants through breeding or genetic engineering.

Studying the phylogenetic relationships of wild pepper species in relation to cultivated varieties would yield baseline information on the genetic relatedness of wild and cultivated *Piper* spp. Leaf material of six wild pepper species were collected to conduct molecular phylogenetic studies of *Piper* spp.

2.3 Dipterocarpaceae

The tropical tree family Dipterocarpaceae comprises over 500 species. Over half are found in the forests of Borneo, dominating the rainforests of the region. Dipterocarps are not only a valuable source of timber, contributing over 25% of the world's timber requirements, but are also a source of non-timber products such as resin and edible fruits (e.g. *engkabang* or illipe nuts) important for the local economy. Because of their high economic value, most of the dipterocarp species are threatened by over-exploitation.

Detailed inventories of the flora, including dipterocarps, are being prepared by the floristic and ecology study teams of the expedition group. Dipterocarp species are common in Borneo, but a detailed survey is necessary to identify any local endemics restricted to the Lanjak-Entimau. Upon completion of the final report of the expedition, the floristic survey data, particularly of dipterocarps will be reviewed and suitable species for further genetic study will then be identified.

3. TECHNICAL TRAINING ASPECTS AND FUTURE RECOMMENDATIONS

In order to implement a successful conservation programme, it is imperative to develop human resources, particularly to train local scientists to document biological diversity. Furthermore, training local scientists from both Indonesia and Sarawak in molecular systematics would be extremely valuable in implementing the conservation plans of Lanjak Entimau and Betung Kerihun nature reserves. Furthermore, genetic studies on forest genetic resources need to be conducted for the long term sustainability, particularly for exploited species.

3.1 Identification of Genetic Resources

There are a number of economically useful species in the region. Although several species have been selected for genetic analysis, a comprehensive list should be developed for further genetic work. Inclusion in the list should be based on economic and ecological significance. Detailed information on distribution of these species should be developed.

3.2 Reproductive Biology

The reproductive biology of species that are being harvested should be documented in detail. Such studies should include phenology, pollination biology, sexual systems, seed and fruit dispersal and seed germination. Studies on reproductive biology should facilitate domestication and genetic improvement, and would be useful for management of natural populations.

3.3 Survey of Genetic Diversity

Genetic diversity in plant populations follows a hierarchical distribution, and the genetic structure is maintained by interaction of mating systems, gene flow, selection and genetic drift. Several molecular genetic markers such as Randomly Amplified Polymorphic DNA (RAPD) and microsatellites could be effectively used to study the genetic structure and processes underlying the maintenance of genetic diversity. This will enable assessment of the impact of current harvesting methods on sustainability of genetic resources and formulation alternative methods of harvesting.

3.4 Impact of Harvesting on Genetic Diversity

Species that are being intensively harvested should be targeted for genetic analysis. Specifically, the impact of harvest on genetic diversity should be examined. This would entail first, the identification of species and populations that are being harvested, and then comparative studies of genetic variation in harvested and non-harvested populations.

3.5 Genetic Improvement and Propagation of Exploited Species

Identification of any morphological or molecular markers for any character of interest would facilitate domestication of a given species into home gardens or plantations. These desired characters could be identification of male or female plant, fruit quality, wood quality, resistance for a given disease or tolerance for a given environmental condition. Recent development of molecular techniques such as RAPD, or Sequence Characterised Amplification Reactions (SCARS) would be useful in identifying such characters at very early stage, such as seedling stage, and useful in selecting plants for domestication.

Identifying any varieties or genotypes of economical importance, and micro-propagation of such varieties could contribute to the improvement of the local economy. For instance, several varieties of wild mangoes (*Mangifera* spp.) with high quality fruits have been identified (Chai 1997)[1], which could be domesticated and introduced to local as well international markets.

[1] Chai, 1997

Table 1 : Selected species of fruit trees of the Bornean forest amenable for genetic improvement and important to the economy of local communities

Species	Common name
Dimocarpus spp.	Isau
Canarium sp.	Dabai
Durio spp.	Durian
Mangifera spp.	Mango
Artocarpus spp.	Terap
Nephelium spp.	Rambutan
Garcinia spp.	Mangosteen
Musa spp.	Banana
Baccaurea spp.	Rambai

K. ETHNOBOTANY

Joseph Pounis Guntavid, L.C.J. Julaihi and Supardiyono

I. INTRODUCTION

Borneo, one of the most important centres of plant diversity in the world is conservatively estimated to harbour 10,000-12,000 species of flowering plants including great numbers of endemics. The earliest evidence of human beings in Borneo dates back about 39,000 years. The early peoples of Borneo were hunter-gatherers and only recently have settled down as shifting cultivators, although some form of primitive agriculture or selective management of wild plants is believed to have existed for at least 5,600 years. However, hunting and gathering of jungle produce continue to be an indispensable part of life for indigenous peoples, and through many generations they have accumulated extensive knowledge on the usage of plants. The function of forest for the society is, of course, not only ecological, but also economic and cultural, and this traditional knowledge is inherently linked to use and management of natural resources. Because of this link between indigenous culture and local plants, purely taxonomic assessments are enhanced by investigations of associated human experiences, perceptions and beliefs.

A considerable volume of data on ethnobotany has been gathered, some of it focused on edible species but most concentrated in medicinal uses. During the past 20 years, exploitation of the interior has been rapid especially in the form of logging activities and land conversion to plantations, leading to serious consequences for the environment and for many of the indigenous people. Regional threats include the use of pesticides and poisons, habitat destruction and loss of genetic resources. Unfortunately, environmental degradation coupled with rapid development has seriously eroded traditional ethnobotanical knowledge. Thus, there is an urgent need to record this knowledge for preservation of the cultural understanding of indigenous peoples, and to ensure sustainable development of areas holding ethnobotanical resources.

Publication of ethnobotanical data can enlighten policy makers and the general public about the importance and values of forests, in particular, for management of national parks and wildlife sanctuaries. Furthermore, a two way communication between ethnobotanists and local people can benefit the latter in making full use of the nearby forests and improving their economical status by introducing new uses of plants, cultivation of suitable crops and medicinal plants.

The objective of the ethnobotany team was to understand the relationship between local people and their forest resources. As many uses as possible of forest or other plants by the local communities were documented.

2. LOCATIONS AND ETHNIC GROUPS

Under the ethnobotany project, two different cultural sub-groups of the twelve local ethnic Dayak communities were interviewed in Kalimantan between 4 September and 25 September 1997. These were the Iban of Kampung Sadap (17 households) and Kg. Kelayam (20 households) and the Tamambaloh of Kg. Pinjawan (25 households). All three communities were in the upper Embaloh, Kapuas Hulu District (West Kalimantan) adjacent to the BKNP.

In the Batang Ai area, south of LEWS, from 13 November to 27 November 1997, four Iban settlements of the Batang Ai area were interviewed, including Rumah Dayung, Rumah Ipang, Rumah Radin and Rumah Endan, all of Lubok Antu District, Sri Aman Division, Sarawak. These interviews however provided information and contributed only incidental data to the study. The primary focus was the Embaloh area.

3. METHODOLOGY

Ethnobotanical interviews were conducted with local informants selected through formal contacts made in the respective villages. Informants consisted of knowledgeable elders of the communities ranging from the *balian* (renowned traditional healers) to smallholder farmers. Most interviews with these informants were conducted in the dry rice fields or *umai* (as this was during the main tilling seasons of the Iban and Tamambaloh) or at their homes with other members of the family present, mostly during evening and night sessions.

During these interviews, plant collections were either shown or local names were mentioned to each informant. For each plant that was known to the informant, the information was recorded in local Iban and Tamambaloh languages, including the uses, local knowledge and perceptions of the plants in terms of their habitat occurrence, folklore related to each plant, and other related information.

After the interview sessions, an open discussion was held. This informal session provided time to socialize with the family members and to gather additional information. The total time spent with each informant or family per session ranged between one to three hours.

During the course of community survey, 23 key figures of Iban and Tamambaloh were interviewed. Nine women and eleven men including three Iban boys aged 9 to 10 years old were actively interviewed. Apart from the three Iban boys, those interviewed ranged from 30 to 70+ years of age. A description of each informant, including age, origin and residency is given in Appendix 8A.

4. OBSERVATIONS

During the expedition in BKNP, 439 plants from 75 families, 199 genera and 323 species of 107 varieties, were collected; 365 specimens were obtained, of which 229 had been cultivated, and the rest were wild plants from the forest (Appendix 8B). In Sarawak, from the Batang Ai area, 162 ethnobotanical specimens from 54 families and 144 species were collected. These plants were categorised as plants of traditional importance, which included medicinal plants, food plants, ritual, ceremonial and taboo plants, building materials, and other miscellaneous use plants (Appendix 8C). Medicinal plants cover all species that are employed during treatment in traditional herbal healings by the herbal practitioners. Food plants constituted edible fruits, shoots or leaves including flavours, seasonings and condiments. Building materials are any plant materials that are used in construction, house building, boat making and trees that are recognized for their value as timber. Ritual, ceremonial and taboo plants cover plants that are used in pagan practices. Miscellaneous uses include other uses such as in dyes, rope, basketry, household and agricultural implements and other handicrafts.

4.1 Traditional medicinal plants

With the active and vigorous introduction of western health treatment, modern medicine is slowly taking the place of traditional herbal medicine. The Iban and Tamambaloh are willing to accept this new trend. However, across Iban and Tamambaloh society, there are elders and youngsters who still practise what has been handed down to them for generations. Herbal medicine although seldom utilised, is employed especially by women to treat the basic ailments of their children and after child delivery. However, with the improved accessibility of government rural clinics in the villages, most complaints are now dealt with by medical doctors and their assistants. Even periodic contraceptives are provided by this agency. The use of traditional cures however seems not to conflict with the use of modern medicine; in many cases one complements the other.

Traditional herbal medicines are only used in emergency cases awaiting treatment from the local rural clinics. Where traditional herbal medicine is still personally and actively practised, many of the ingredients, methods of preparation and administration are kept secret for fear of misuse, competition and rivalry. The herbal preparations are usually passed down secretly by word of mouth and compensated with small payments of traditional paraphernalia such as salts or other small gifts.

The efficacy of *Jamu* or traditional medicine made by *manang* is believed to be equivalent to western herbal medicine. Generally, traditional societies such as the Dayak believe the efficacy and the restorative power of a plant depends on the mystical quality of the plant. Dayak tribes such as the Iban and Tamambaloh believe that curing a disease also requires a ceremony like *belian* or *bumok* with a *manang* or shaman. They believe that someone is sick because his spirit or soul is disturbed, or taken away by *roh halus* (invisible spirits).

According to the Iban and Tamambaloh, traditional indigenous knowledge of herbal medicine is revealed either through physical or metaphysical means. Initially, it is revealed through dreams and also said to be revealed by spirits of the forests. The doctrine of signature of the natural forest also contributes to the enhancement of the utilisation of traditional herbal medicine. Copying and following the way orangutans behave in treating their families against ailments is also one way the Iban and Tamambaloh received their traditional herbal medicinal knowledge. Through the ages, practicing through trial and error, the Iban and Tamambaloh were able to substantiate and sustain their traditional practices of herbal medicine.

During the harvesting of plant materials for use in traditional medicine, several rules and regulations must be observed. Spirits and other unseen forces of the jungle are consulted prior to collection. Taboos and other do's and don'ts also must be fully observed. Timing the collection at the right moment is vital. All the proper actions and deeds are believed to contribute to a good, sound and effective remedy.

From the survey, a total of 27 families, 36 genera and 41 species of medicinal plants were collected and their functions noted (Appendix 8C). Normal and common ailments are treated with traditional herbal medicine. These common ailments range from simple fevers, boils, skin diseases, cuts and wounds, diarrhoea to chronic dysentery and maternal ailing after giving birth. For fevers the *kabu* (*Ceiba pentandra*), *akar takup dedaup* (*Bauhinia acuminata*) or *mempelas* (*Tetracera korthalsii*) are employed. Cuts and wounds are treated with the *jambu monyet* (*Bellucia pentamera*). *Rumput merah* (*Phyllanthus urinaria)* or the well-known *biabas* (*Psidium guajava*) are used to remedy diarrhoea and dysentery. After giving birth, mothers use the *mambong* (*Blumea balsamifera*) to regain energy. For aphrodisiac properties, the *sasapah* (*Eurycoma longifolia*) is used; *Costus glabra* is used in Sadap and Pinjawan. For *Tinea capititis* or skin diseases, the *serugan* (*Cassia alata*) is said to be an instant cure. For suckling children with stomach ailments, the *mudur* (*Caryota mitis*) is decocted and consumed by mothers. To expel and eradicate stubborn stomach thread worms and other helminthics, the aromatic rhizomes of the *jerangau* (*Acorus calamus*) is consumed after decoction. Two species of plants are used by all three communities. These are *Acorus calamus* for treating fever and *Fibrauea tinctoria* for treating jaundice. *Blumea balsamifera* is used in Sadap and Kelayam.

4.2 Food plants

a) Food plant varieties

Plants described under this category include fruits, flowers, vegetative parts of plants such as leaves, shoots and stems, rhizomes, tubers and seeds which are either eaten raw, cooked, fermented or prepared in some ways. A total of 46 families, 95 genera of 144 species (118 varieties) are used in some ways as food. Many species of fruits are eaten. The three communities gather wild fruits from nearby forests apart from planting them around their houses. Leaves are normally eaten as vegetables. Leaves of *Manihot esculentum* are consumed almost everyday.

Wild fruits and vegetables are well-known to the Iban and the Tamambaloh. Depending on the season, the wild vegetables commonly gathered and prepared for meals are the *pantu'* (*Eugeissona utilis)*, which is mixed with meat flavoured with *bungkang* (*Eugenia cephalanthum)* or young flowers of the *asam kecala* (*Etlingera elatior).* During the tilling and dry rice planting seasons the indispensable *kangkung* (*Ipomoea aquatica)*, and easily available *Empasak* (*Manihot esculentum)*, are collected and prepared for simple convenient food.

During the fruiting seasons, desserts and traditional cocktails are easily prepared from the vast and easily available wild *durian burawang (Durio zibethinus)*, *timadak* (*Artocarpus integer)*, *limpauh* (*Baccaurea lanceolata)*, or *sioh* (*Nephelium ramboutan-ake*). These fruit plants are readily available as they are domesticated in home gardens which surround the longhouses.

These produce are consumed and shared among all the longhouse occupants. However, excess production may sometimes be sold or bartered during rare excursions to the nearby stalls. However, the *unti* (*Musa accuminatum* x *balbisiana*) and the *melingo* (*Gnetum gnemon*) are the most commonly available through out the year. Other common food plants are the rattans. Almost all rattan shoots are edible and palatable. Other food plants are listed in Appendix 8D.

Consumed plants are either cultivated or collected from nearby forests. Women normally collect plants for daily meals. Men only collect food plants while on hunting trips or searching for particular species with good flavour. About 38% of plants consumed are cultivated in Sadap, 59% in Pinjawan and 41% in Kelayam. This shows that the people in Sadap still depend for variety of food sources very much on the nearby forests which are still relatively undisturbed and not too distant.

About 12 species of plants are consumed by all three communities, accounting for only about 7% of the total identified species since most of the species consumed by people of Sadap are collected from undisturbed forests. The forests around Pinjawan and Kelayam are disturbed forests or scrubs. The plants used in common by all three communities are shown in Table 1.

Plants used as carbohydrate sources are padi (*Oryza sativa*), *pulut* (*Oryza glutinosa*), *ubi raung* (*Dioscorea alata*), *ubi besar/ubi bekaran* (*Dioscorea hispida*), *umbi* (*Amorphophalus variabilis*), *keladi* (*Alocasia* sp. and *Colocasia* sp.), *jagung* (*Zea mays*), *engkuliset* (*Coix lachryma-jobi*), *pisang* (*Musa accuminata x balbisiana*), and *sagu* (*Metroxylon sagu*).

Almost all the common plants used are cultivated except *Arenga pinnata,* used to produce an alcoholic drink from the fruit stalks. After processing, plants such as pulut (*Oryza glutinosa*) can be used for producing a beverage.

Table 1 : Some common food plants used in Upper Embaloh, West Kalimantan

Scientific name	Local name		
	Sadap	**Pinjawan**	**Kelayam**
Amaranthus gangeticus	Bayam	Bayam	Bayam
Ananas comosus	Nanas	Nanas	Nanas
Anona muricata	Durian belanda	Rian belada	Rian belada
Arenga pinnata	Ijuk	Nauh	Ijuk
Artocarpus heterophyllus	Nangka	Nangkah	Nangkah
Artocarpus integer	Cempedak	Timadak	Cempedak
Baccaurea motleyana	Rambai	Rambaian	Rambai
Cucumis sativa	Rampou	Antimun	Rampan
Manihot esculentum	Empasak	Ubie	Ubie
Nephelium ramboutan-ake	Sibau	Sion	Sibau
Stenochlaena palustris	Miding	Taakas	Midin
Zingiber officinale	Liak	Laiya	Liak

Fermentation produces *brem.* The extract of stems and midrib of *ijuk* (*Arenga pinnata*) mixed with the bark of *raruk* (*Shorea ochracea*) produce *saguek* or *tuak,* an alcoholic drink. In addition, this plant can also be used to prepare palm sugar. The extract of stem and midrib of *Arenga* is boiled with sikop/sialan (*Garcinia mangostana*) leaves in a giant frying pan.

Different local names are used by the three communities for most plants although many of the local names are similar. More distinct differences in local names are seen between Pinjawan and the other two communities as they are of different ethnic origins, Tamambaloh and Iban, respectively.

Plants used as vitamins and mineral sources are *bayam* (*Amaranthus gangeticus*), *kelindang* (*Blechnum orientale*), *rampon* (*Cucumis sativus*), *ganouk* (*Lagenaria siceraria*), *petai* (*Parkia speciosa*), *retak rogan* (*Psophocarpus tetragonolobus*). Edible fruits include *mawang* (*Mangifera pajang*), *mangga* (*Mangifera indica*), *rian belanda* (*Annona muricata*), *sikop/sialan* (*Garcinia mangostana*), *rian* (*Durio zibethinus*).

b) Varieties of rice

Rice is the most important crop for most of Borneo's subsistence communities. There are many varieties of rice cultivated in the three communities studied. Non-glutinous rice is the staple food eaten at all meals. Glutinous rice (*pulut*) is cultivated on a much smaller scale for cakes, snacks and rice wine.

The cultivation of rice is linked closely with spirits, ancestors and gods. Local people have rituals and ceremonies while preparing the padi field, burning, commencing of planting (*nugal*) in the field, sowing of the variety of rice called *pakai pon* and *sanking* (passed down from the older generations) and harvesting. Riponce is called *Pakai* in Sadap and Kelayam and called *Ase* in Pinjawan.

The varieties of rice or *padi* planted are shown in Tables 2 and 3. There are 24 varieties of rice planted in Sadap, 21 in Pinjawan and 29 in Kelayam.

Table 2 : Non-glutinous rice

No.	Sadap	Pinjawan	Kelayam
1	*Pakai nibong*	*Ase PB*	*Pakai sibou*
2	*Pakai antu*	*Ase tutung adon*	*Pakai bintuk*
3	*Pakai lensat*	*Ase libong*	*Pakai ijun*
4	*Pakai panjang tangkai*	*Ase wong*	*Pakai nibong*
5	*Pakai senum*	*Ase rabe*	*Pakai delup*
6	*Pakai jawi*	*Ase bugis*	*Pakai kepit*
7	*Pakai punan*	*Ase payak tasik*	*Pakai saking*
8	*Pakai pundanek*	*Ase bontik*	*Pakai serau*
9	*Pakai simin*	*Ase baruh*	*Pakai berbuku*
10	*Pakai PB*	*Ase siok*	*Pakai empawa*
11	*Pakai burok*	*Ase nasi kuning*	*Pakai siam*
12	*Pakai paya tasik*	*Ase anak baingih*	*Pakai rabik*
13	*Pakai paya tembakau*	*Ase lampa*	*Pakai antu*
14	*Pakai paya rabi*	*Ase banjar*	*Pakai sayap*
15	*Pakai sinik*	*Ase lima*	*Pakai kutu*
16	*Pakai palim*		*Pakai melanau*
17	*Pakai remin*		*Pakai paya wi*
18	*Pakai sanging*		*Pakai paya undai*

Table 3 : Glutinous rice

1	*Pulut mit*	*Pulut jaranang*	*Pulut kajang*
2	*Pulut kutu*	*Pulut lawang*	*Pulut lulong*
3	*Pulut melanau*	*Pulut banang*	*Pulut kulusi*
4	*Pulut wi*	*Pulut tuwei*	*Pulut udun*
5	*Pulut sembai*	*Pulut tasik*	*Pulut sawah*
6	*Pulut ranggai*	*Pulut melanau*	*Pulut selipik*
7			*Pulut lankang*
8			*Pulut runtuk*
9			*Pulut bugau*
10			*Pulut rusa*
11			*Pulut paku*

The cultivation system and terminology used by the two groups (Iban and Tamambaloh) differed somewhat. The Iban either in Kalimantan (Sadap, Kelayam) or in Sarawak recognize several stages of cultivation, as explained below.

(i) Iban rice cultivation

In an area currently under rice cultivation, and for preservation of local varieties of rice, the Iban tribe recognizes *pakai pon* as the main variety and *pakai sanging* as an auxiliary variety. It is apparently compulsory to grow both kinds at every planting. Other varieties are grown only when time or opportunity arise. If a family has no more *pakai pon* or *pakai sanging*, they can request seed from other families.

The Iban demonstrate a keen understanding of the fallow process. *Temudak* is a field that has been left fallow for one year. It is indicated by rice straw, *empasak* (*Manihot esculentum*), and *enteburuk* (*Saccharum* cf. *cinarum*). Farming a *temudak* area is called *ladang kerukuh*. The *dijab* is a field that has been left fallow for about two years. It is usually colonized by *Pandanus* sp., *Trema orientalis*, *Melastoma melabathricum*, *Macaranga gigantea*, *Commersonia bertuna*, *Themeda gigantea*, *Homalanthus* sp., and others. A *damun* is a field that has been left for about ten years. In this area can be found plants such as *Pternandra azurea*, *Bellucia pentamera*, *Schizostachyum* sp., *Commersonia bertuna*, *Camnosperma squamatum*, *Ficus* spp., *Psychotria aurantiaca*, etc. The *pengerang* is a field in the last stages before becoming forest, usually after more than twenty years. The Iban assess the stages of the field based on the size of trees which grow on it, rather than the number of years it has been left fallow. If they wish to farm the land at this *pengerang* stage, they cut the trees and burn the plot. If burning is ineffective due to wet weather, they abandon the area, and return the following year to burn for the second time. Such a farming practice is called *berladang bodok*. In this type of area the dominant plants are *Durio zibethinus, Euodia aurantiaca*, *Lithocarpus* sp., *Artocarpus* sp., *Ficus* spp., *Koompassia exelsa*, *Shorea* spp., etc.

(ii) Tamambaloh rice cultivation

The rice farming system of the Tamambaloh, especially those who live at Pinjawan, is different from the farm system of the Iban, although they are close neighbours, within about 5 km of each other. This tribe has three kinds of farms, including, *ladang bukit* (hill farm), *ladang paya* (swamp farm) and *ladang tepi* (riverside farm). This tribe does not recognize *padi pon* and *padi sanging*. However, they appreciate their ancestors for preserving *ase tutuk*, and continue to grow the same variety by obtaining seeds from their parents or other members of the family. This society often rotates the use of a field, in a system known as *manasap*. A *bale umang* is a field that has been fallow for about 1-2 years (also *pemudak*). *Bale umang* has been fallow for 3-5 years. *Tanah tu'an/pengerang* has been fallow for more than 10 years and the diameter of the trees is similar to that of a person's thigh.

4.3 Ritual, ceremonial or taboo plants

The traditional religions practised by tribal people in Borneo have all developed within the same setting, the tropical rain forest. Life in the rain forest ecosystem as a shifting cultivator is unpredictable. Spirits, ancestors and gods are believed to control everything of importance that is otherwise inexplicable.

Numerous rituals, ceremonies, prescriptions and prohibitions have been developed to ensure harmony with these supernatural powers. Although most people in the three communities studied are Christians, they still hold traditional beliefs. During the expedition, plants of 22 families, 31 genera and 38 species (of 24 varieties) were identified which are used in traditional ceremonies and social activities (Appendix 8E).

The majority of plants utilised were lower cryptogams and phanerogams. They were believed to posses spirits of their own that were given by God to bring good or bad luck. The *bunga padi* (*Celosia argentea*) for example, was given by God Almighty to look after the rice planted by both the Iban and Tamambaloh communities. The *sabang* (*Cordyline terminalis*) is used during the *slametan* ceremony to fullfil and strengthen the *berdarap* ritual where a pig is slaughtered and the characteristics of its liver used to divine the future well-being of the Iban community and its visitors.

To symbolize acceptance by the Iban and Tamambaloh during ceremonial receptions, the *rejang* (*Platycerium coronarium*), *tepus payun (Hornstedtia scyphifera)*, *selapadi* (*Lycopodium campanulatum*), *kemuntieng (Melastoma malabathrichum)*, *ingak* (*Cocos nucifera)* and *lembak* (*Curculigo latifolia)* are symbolically used side by side in decorations at the entrance of the village. Ritual paraphernalia which include seven leaves each of the *sireh* (*Piper betle*), *gambir kelait* (*Uncaria gambier*), *sigup* (*Tobaccum herbaceum*), and *kenyit* (*Curcuma domesticum*) are served during the traditional reception ceremony. These seven items each depicts and symbolize the seven spirits of the world. During the ancient traditional *Nganjung Kaladan* ceremony, the pulut rice (*Oryza glutinosa)* cake specially wrapped in the *gernih* (*Licuala petiolulata)*, pop-rice and *saguek* (*Arenga saccharifera)* wine are served. *Jerangau* (*Acorus calamus)*, is planted beside the long houses to expiate evil spirits. During ritualistic healing, the *bunga panggil* (*Clerodendrum paniculatum*), is employed to call the healer spirit, while the *uwi buntar* (*Flagellaria indica)*, is strategically tied to chase away evil spirits. During the *nugal padi pon* (ancient original dry rice) initiation ceremony a special ritual enchantment is performed to please the spirit of the sacred red *entemu* (*Curcuma mangga*), before it is planted in the middle of the *umai* (dry rice field). Other plants used in social activities are widespread ones such as *sirih* (*Piper betle*) and *pinang* (*Areca catechu*). For major social and ritual occasions the Iban use *burung kenyalang* (rhinoceros hornbill) as their main symbol. For this ceremony they make a large sculpture of the bird from *kayu pelai* wood (*Alstonia scholaris*).

Among several taboos or *pantang* mentioned were that *tapang* trees (*Koompassia excelsa*) are not to be cut down (these are protected because they harbour the nests of honey bees), and that the *buan* plant (*Dillenia suffruticosa*) cannot be brought into a longhouse.

4.4 Building materials

For building materials, a total of 28 species of plants are used in Sadap, 30 species in Pinjawan and 26 species in Kelayam. Building materials here refer to parts of plants used to build a house, hut, shelter, bridge, boat or similar kind of structure. All three communities obtain building materials from the forests. These include timber, canes, leaves and bark. Most farm and village houses are still constructed with materials from the forest. The people have no special preference in selecting materials for house construction with the exception of *Eusideroxylon zwageri* for posts. Bark of *Prunus arborea* and meranti (*Shorea* spp.) are commonly used for walls especially in farmhouses.

The majority of plants utilized as building materials include a wide range of trees consisting of light to heavy hardwood growing commonly at the edge of villages and in riverine habitats along the periphery of BKNP. Lists of the plants used as building materials are shown in Appendix 8F. Other non-tree plants used for building purposes which are common and abundant throughout the riverine forests are bamboo species, namely *Bambusa striata.*

Hardwood timbers utilized in house building cover a wide range of primary and old secondary forest species. The Dipterocarpaceae *tekam* (*Shorea* sp.), *resak* (*Vatica* sp. and *Coteylelobium* sp.), including the long-lasting *belian* or *kaolian* (*Eusideroxylon zwageri*) are preferred. Traditional house roofs and thatchings are made from hardwood shingles and leaves. Palms and ginger fronds are still commonly used as thatching especially for rice storage *sulap* or huts.

Like other Dayak tribes, the main transportation of Iban and Tamambaloh is by river. All the above species have wood of excellent quality as boat-building material. An average sized boat (*circa* 7-8 m long) costs around Rs 400,000.00, although capital was scarce in the study areas. Timbers preferred for boat building by the Iban and Tamambaloh are the *perawan lilin* (*Shorea leprosula*), and the *kaladan* or *kelansau* (*Dryobalanops beccarii*). Other hard woods used for boats are *Shorea asahi*, *Shorea laevis*, *Shorea laevifolia* and *Upuna borneensis*. To strengthen the joints of the boat's accessories, rattans and belian wood pivots and nails are used. Natural *Aphis engkululut* resins are used to caulk joints and cracks.

4.5 Miscellaneous plant uses

a) Ropes and basketry

Other uses of plants include basketry, fibre, food wrapping, dye, poison, weapons, flavouring, firewood and others as shown in Appendix 8G.

Like other Dayak groups, the Iban and Tamambaloh are skilled in rope making. They usually use species of *rotan* (*Calamus* spp.), bamboo (*Bambusa* sp., *Gigantochloa* sp.) *pandan / perupuk* (*Pandanus* sp.), and *tekalong* (*Artocarpus elasticus*), etc. During the expedition, 6 families of 11 genera and 17 species of plants used as plaited and rope materials were collected. All the materials are abundant in the forest. This represents only a fraction of the rattan species of the forest, which number in the hundreds.

Plants used in basketry and handicrafts are *Calamus iners, C. nematospadix, Donax canua* and *Pandanus* sp. in Sadap. *Artocarpus utilis* and *Calamus scipionum* are used in Pinjawan and *Donax caniformis* in Kelayam. Bark of *Artocarpus elasticus* and *Prunus arborea* is used for making *padi* containers. *Morinda citrifolia*, *Psychotria aurantiaca*, *Daemonorops micrantha* and *Nephelium cuspidatum* are used as dyes in making traditional clothing.

b) Fishing and Hunting

Fishing, done mainly in the early hours of the day, is an important part time activity of both the Iban and the Tamambaloh. Selective fishing is practised where only certain sizes and weights of fish are caught. Fish are caught through a variety of methods, namely with trammel nets *pukat*, cast nets *jala*, container basket-like traps *bubu* made from *wi semambu* (*Calamus scipionum*) and bamboo (*Schizostachyum* spp.), spears *budjak* and *rawai* hook and line. Fish caught are tied together with strings made from rattan or *wi* (Iban) or *uwi* (Tamambaloh) or with liane fibres. Sometimes the Iban and Tamambaloh use *tubai* or *akar panua* (*Derris elliptica*) or the *beregantung* (*Fordia splendidissima*) to stun fish. However, stunned fish have to be caught promptly as they recover after only a few minutes. To catch small fish *saluang (Rasbora* spp.) the Tamambaloh use a basket-like trap or *saruak* made from rattans or bamboo plaited with *limpasoh (Gleichenia linearis)* cords. Nets are plaited and shaped into trammel nets and cast nets by using the net plaiting apparatus *ripang* and *ucuan* made from the *belian* or *kaolian* wood (*Eusideroxylon zwageri)* or *tapang* wood (*Koompassia excelsa*), smoothed with *mempelas* (*Tetracera korthalsii*) leaves.

Rattans and bamboos are the principal materials for making basket-like traps called *bubu* or saruak. They are cultivated in smallholder rubber gardens *kebun* or *hutan rawah* (secondary swamp forests) and rice fields *umai.*

Besides fish, animals are traditionally hunted with blowpipes made from the *belian* or *kaolian* wood (*Eusideroxylon zwageri)*, and darts from the *apeng* (*Arenga porphycarpa)*, or *pantu* (*Eugeissona utilis).* Dart tips are poisoned with the sap of the *upas* (*Antiaris toxicaria)* tree. However, during the course of this study, guns were already widely used but blowpipes were not seen. Animal carcasses are strapped into *panji* or knapsack used by the Iban to carry agricultural products or *lanji'* (Tamambaloh) made from the liane fibre, *akar kemedu* (*Spatholobus oblongifolius)* and rattan *wi semambu* (*Calamus scipionum*).

c) Implements

During the dry rice-harvesting season, various agricultural implements are prepared from rattan. The main rattans used are the *wi semambu* (*Calamus scipionum*), *wi batu* (*Calamus iners*), *wi rengut* (*Calamus nematospadix*) and *wi saka* (*Calamus caesius*). Among common agricultural and household implements are the *panji* (Iban) or *lanji'* (Tamambaloh), *panggau* (Iban) or *bibilah* (Tamambaloh) for threshing and winnowing rice, and the *tapan*, *sintung*, *lesung* or wood mortar.

d) Clothing and dyes

Traditionally, tree bark such as the *takalong* (*Artocarpus elasticus* and *Artocarpus utilis*) are finely beaten and processed for making traditional costumes, *sapit tambaryong* (common attire) and *sapit buri* (costumes decorated with fine seashells). With the introduction of the *tayah* (*Gossypium herbaceum)* or cotton from foreign traders, cotton balls are spindled into threads and ingeniously plaited into the traditional clothes of the Iban, the *kain kumbu*. The threads are coloured red with the leaves of *engkerbai* (*Psychotria aurantiaca)*, and the *wi duduk (Daemonorops didymorphylla)* or yellow from the *mengkudu* (*Morinda citrifolia)* roots and black from the *rengat* (unidentified species).

e) Fuelwood

Since the earliest times, wood has been the main source of fuel among both the Iban and Tamambaloh. Wood fires are used daily for cooking and during cultural festivals such as the Iban's *gawai padi*, the Tamambaloh's *pamoleh balio, bedurok* and *situlis* co-operative labour systems activities. However, not all tree species are suitable for fuelwood. Although certain plants may be readily flammable, taboo plants such as the *buan*, (*Dillenia suffruticosa*) are not brought into the long houses because this action might bring bad luck or even illness. The *agang* (Iban), *kapar* (Tamambaloh) or wood debris washed down by river floods are preferred. These fuel woods are said to burn more readily and efficiently than collected firewood. Cutting down trees is the last resort to get fuel wood. Fallen branches of the rubber tree or *karet* (*Hevea braziliensis*) make excellent fuel wood. Other commonly collected fuel woods are the *berangan mayau* (*Castanopsis costata*), the *markiang* (*Dimocarpus longan*), *empedu* (*Elaeocarpus griffithii*) and the *jaykar babi* (*Baccaurea membranacea*).

5. SUMMARY AND CONCLUSIONS

The ethnobotany team sought to describe and assess the complexity of interactions between local people and their environment especially with respect to the forest resources. The ultimate goal was to come up with solutions to lessen human dependence on the forests of Betung-Kerihun National Park and Lanjak-Entimau Wildlife Sanctuary. Obviously, any management programme for the Trans-boundary Biodiversity Conservation

Area must target the needs of the local people as well as the attainment of conservation objectives.

If sound environmental strategies are applied to the management of the National Parks, natural products and other non-forest resources will contribute to the subsistence economy of the Iban and the Tamambaloh. Some of these goods will be harvested for personal gains in trade, cash and other services. Perhaps the *bedurok* and the *situlis* co-operative labour systems incorporated with the *nganjung kaladan* principles can be modified and inserted into the protected area management system. Traditional methods of harvesting in the Embaloh River and the forests nearby had a relatively low environmental impact on the overall forest and river ecosystems, largely due to the low population, abundant forest resources and land available for cultivation.

It is interesting to note that much of the indigenous knowledge of the population in the studied areas remains intact and venerated. The depth of knowledge among the younger generation, even small children, bears this out. During the course of survey, the few children who were interviewed could identify over 95 % of the plants growing around the long houses and in secondary forests. Such knowledge can be positively employed and utilised for biomedical prospecting and research as well as ecotourism.

L. ANTHROPOLOGY

Mering Ngo

1. INTRODUCTION

There is increasing recognition that the participation of local people is important for the sustainability of a national park. Although the idea of local participation is receiving increased support, it has yet to be received as a critical component in protected or conservation area planning. This is understandable because planning with a broad-based inter-disciplinary team and, more important, the political commitment from government and the private sector are required. Actions and alternatives must be identified and, in turn, be promoted to fit local needs, interests, and capabilities within the shared goal of conservation.

This brief report highlights a socio-cultural assessment of local communities adjacent to BKNP, West Kalimantan. The assessment was undertaken in collaboration with the ITTO Borneo Biodiversity Expedition 1997, and involved experts from Indonesia and Malaysia. Description and analysis of the major findings is presented under six headings, *e.g.*, (1) ethnic profiles and their historical background; (2) social organization and structure; (3) modes of livelihood; (4) land tenure; (5) folk stories about the park area; and, (6) discussion of key issues for park development.

2. ASSESSMENT SITES AND METHODOLOGY

This assessment was carried out in six *dusun* or hamlets of the Iban, and one *dusun* of the Tamambaloh in three subdistricts, namely Embaloh Hulu, Batang Lupar, and Badau of Kapuas Hulu Regency. An in-depth assessment was conducted in four hamlets of the Iban and Tamambaloh, namely, Sadap, Madang, Kelayam, and Pinjawan.

Several methods were used in this assessment. A genealogical approach was used to gather data and information on the historical background of each group, including old settlements and forested areas, and historical ties among Iban groups in West Kalimantan, Indonesia, and Sarawak, East Malaysia. In-depth interviews were used to collect data and information on kinship, social groupings within and beyond the village and political interplay with implications for decision-making about resource use. Data and information regarding land tenure, relevant folk stories, and perceptions of BKNP were also recorded. Most of the interviews and discussions were conducted in the local language.

The participative observation technique was used to observe leadership and social dynamics, both within the hamlet and beyond hamlet boundaries. The use of authority was observed through cultural interpretation during daily activities, decision-making processes and ceremonies. A sociogram analysis was used to describe local-level politics and its implication on resource use. Unfortunately, the village sketch mapping technique, a powerful tool for encouraging user group discussion over resource use, could not been used because of time constraints.

3. OBSERVATIONS

3.1 Ethnic profiles and historical background

The ethnic composition of the Iban and Tamambaloh hamlets was studied. The Iban are one of the most researched indigenous groups of Sarawak, though less so in West Kalimantan. In Sarawak, for example, a general account of Iban movements from the time of their entrance into the Batang Lupar or Batang Ai drainage until the coming of the Brookes has been published, as has their movements since the establishment of the Brooke Raj[1]. References to social structure, settlement of specific rivers, cultural values, social and political participation can be found in the bibliography at the end of this volume.

Oral histories and genealogies of the Iban showed that the Kapuas basin of West Kalimantan, or more specifically, the Ketungau tributary, was the homeland of these groups before they entered the territory of modern Sarawak. The history of early Iban migrations from the Kapuas into Sarawak began in the middle of the sixteenth century from the Kapuas drainage into the Batang Lupar drainage, with the first group settling on the Undup River. From the Undup, the pioneers migrated to north, east, and west, occupying all the major rivers in what is now Sarawak's Second Division, and some downriver areas of the First Division. By the early 1800s large-scale movements of the Iban were underway in the basin of the Rajang River, an area now divided into the Third, Sixth, and Seventh Divisions of Sarawak.

[1] Sandin , 1967a, 1967b; Pringle, 1970

These migrants crossed mostly from the headwaters of the northern tributaries of the Batang Lupar and Saribas rivers into the southern tributaries of the Rajang. From the upper Batang Ai, they then crossed the border into what is now West Kalimantan, Indonesia, following the Labiyan (officially known as Leboyan) and Batang Kanyau or Embaloh rivers during the rule of the Brookes (1841 - 1941).

Genealogical experts (*tukang tusut*) in Sadap, Kelayam, and Madang described where they used to live in Lemanak, Kampung Menawa, Wong Panjai, and Rumah Sukong, upper Batang Ai areas. For example, Nyempal Anak Embah, a former *temenggung* or *adat* chief could recall vividly the stories of his ancestors, and specifically how and by what route each person had settled in his present home. He could describe ten persons as his ancestors in at least ten different sites or settlements that they used to occupy since leaving the Lemanak area of Sarawak. Those old settlements were called *tembawai.*

The history for some kin groups goes back further, specifically to those descended from the first settler of a particular forested area (*purih panteh*). For instance, Telibai Anak Tagung in Sadap is the twentieth descendant of Bungkong Menalu and Ribut Nyepu of upper Batang Ai. She is also a descendant of the famous Ambau Anak Raden Tanjung, the leader of Iban settlers of Batang Ai, just north of the modern town of Lubok Antu. Therefore, the legend of Lubok Antu relates to Ambau. It has been reported that Ambau and his followers settled at Pangkalan Tabau and headed the first Iban migration into the Engkari River.

Historical reconstruction of these Iban groups shows that there were many inter-related factors which determined the Iban's movements. First, intense warfare was a major reason for the earliest exodus from the upper Batang Ai. This warfare existed, either among local Iban groups, or between independent Iban of upper Batang Ai and the Iban from the lower Batang Ai who were forced upriver by Brooke's punitive expeditions beginning at the middle of the nineteenth century. Secondly, migrations were undertaken due to lack of desirable farming land, lack of fish and wild game, or crop failures. Thus, the Iban of Sadap and Kelayam have been at their present sites only for three to four generations. Thirdly, during confrontation (1963-1970), the Indonesian Armed Forces moved previously existing villages for security reasons. The Iban of Madang, for example, were moved by the army in 1967. About seven Iban households from the area moved to Sengkabang, upriver from the town of modern Simanggang (Sri Aman). Most of the villagers are now residing in newly-settled areas.

In Pinjawan, the Tamambaloh or Maloh in Iban, is a more established settlement of the Embaloh River, or Batang Kanyau (Iban name). According to oral tradition (*baranangis*, or the chanting of a saga), and the history of old settlements (*balean sao*), the Tamambaloh used to live in the Bunut River branch of the Kapuas River about twenty generations ago, but from this area migrated to the Embaloh and Apalin rivers looking for new fertile areas. Some people led by *Baki* Baulut or Grandfather Baulut then moved to Labiyan River because they considered the river as an abundant provider of food. Thus, they relate a legend of this movement to the "river of abundance" locally expressed as *labiyan*.

To some extent Iban migrations have gradually displaced peripheral Tamambaloh communities southwards, and forced them to concentrate in the middle courses of the northern Kapuas tributaries, including the present Tamambaloh village of Pinjawan. However, Iban relations with the Tamambaloh and other groups were apparently not characterized by hostility. In fact, contacts between the Iban and Tamambaloh exhibited a range of relations from aggression and raiding to alliances, inter-marriage, cultural exchanges, trade and economic co-operation.

During their earliest movements out of the Batang Ai, the Iban conquered or evicted peripheral Tamambaloh settlements such as Tatangai, Malit, Supape', and Banyu in upper Embaloh or upper Sadap. Initially, the Iban had avoided these longhouses, but as they moved into virgin forest near Tamambaloh settlements, raids increased. The Tamambaloh felt it unsafe to farm in the area, and so those settlements were abandoned by the mid-nineteenth century. Some inhabitants moved further downriver to the village of Pulau Manak which includes the Balimbis and Pinjawan hamlets.

The alliance between Iban and Tamambaloh was made through inter-marriage between the leading Iban families and Tamambaloh aristocrats, and thus reduced hostilities. A joint attack was undertaken during the war between the Tamambaloh and the Malay ruler of Sintang, wherein Iban warriors from Kelayam were led by Guntur alias Demang Anak Nyelang, the son of Nyelang from Rumah Sukuong in upper Batang Ai. Since then Guntur or *Raja Berani*, an honourific title for the brave and wealthy, and his people have been permitted by the Tamambaloh to occupy the modern Kelayam areas.

As the Dutch extended their control in the regions in the late nineteenth and early twentieth centuries, a peaceful relationship was eventually established. The Dutch also gave legal recognition to Iban claims to land they had settled, and drew boundaries between Iban and Tamambaloh territories. Iban absorption of Tamambaloh has been affected by Iban moving into Tamambaloh hamlets. The Tamambaloh have therefore become fluent in Iban. The Tamambaloh have also adopted many Iban words, used some Iban basket and mat designs, and held various Iban beliefs associated with illness and traditional medicine. On the other hand, Iban learned to produce silver products that, at one time, were made only by the Tamambaloh. The tracing of migration and the history of Iban-Tamambaloh contact is directly relevant to modes of livelihood and land tenure.

3.2 Social organization

a) Settlement

The settlement patterns of the Iban and Tamambaloh differ markedly. Most Iban groups, for example, still live in longhouses (*rumah panjai*). The Tamambaloh such as the Pinjawan hamlet, no longer live in longhouses (*sao langke*). Iban groups can generally be identified with the particular longhouses of each river system, *bilek* or family unit of a longhouse.

Longhouses of the Iban consisted of a section of open platform (*tanju*), verandah or public area (*ruai*), a private family compartment (*bilek*), and kitchen (*dapur*). The longhouse in Kelayam, however, still retains the loft (*sadau*). The traditional Tamambaloh settlement consists of individual, unconnected dwellings.

b) Kinship

The Iban term for kin is *kaban*. However, in its widest connotation, this term refers not only to an individual's relatives but also to all of his (or her) friends and acquaintances. Thus, *kaban* can be translated as friend. Nevertheless, in many contexts it carries the general implication of "to whom I am probably related." Thus, within the broad category of kith and kin, three distinctions can be made, namely cognatic or close kin (*kaban mandal*), affinal or distant kin (*kaban tampil*), and lastly, other people (*orang bukai*). *Kaban mandal* includes first to third cousins; *kaban tampil* includes the fourth cousin to the fifth cousin.

The terminology for kin in Tamambaloh is *separanak*. This term also refers to both cognatic and affinal kin. *Saparanak* was used in a narrow sense to refer to siblings and cousins. The use of *saparanak* overrides genealogical and certain collateral distinctions. Beyond close relatives (*separanak inso'*) were distant relatives (*separanak bajau*) which were said to comprise the sixth and the seventh cousins. Beyond these were "friends" (*kawan*) or "non-friends" (*tau bokan*).

The smallest important social units for the Iban and Tamambaloh are *bilek*-family and *kaiyan*. For the Iban, the *bilek*-family conducts many social and economic functions for its members. First, an individual is born into the *bilek*-family, and subsequently obtains an orientation with which to deal with the outside world. Transmissions of values are then undertaken through this family unit. Generally, these values are both competition (*bepaket*) and co-operation (*gerempung penemu*), and are imparted to children between the ages of 11 and 15 years old. As an economic unit, the *bilek*-family also acts as a property-owning unit, helping to foster co-operation as well competitive values among members of different *bilek*-families. In farming, for example, co-operation between several families is known as *bedurok* (i.e., labour exchanges), and this can be carried out at any point in the farming cycle, that is, burning (*nunu*), dibbling (*nugal*) or harvesting (*ngetau*). In hunting, competition is the norm, and now as in the past, this activity is viewed as a symbol of maleness.

The *kaiyan*-family in Tamambaloh society, as a property unit acts differently from the *bilek*-family in Iban because the Tamambaloh is a more stratified society. Thus, the *kaiyan*-family does not act as a single entity in land distribution or inheritance. Properties, therefore, are distributed and managed in consultation with the aristocrats and nobles.

c) Leadership and social structure

The Iban are commonly described as a classless and egalitarian society. They do not have a social stratification of named ranks and classes, though the long-settled Iban groups (such as the Iban in the Saribas, Sarawak) are not actually classless. Nevertheless, in traditional Iban society, the knowledge or expertise of many different leaders is considered appropriate to different tasks, such as the opening of new land, headhunting, and so forth. Thus, there are various leaders (*tuai*) such as the head of an apartment (*tuai bilek*), long house headmen (*tuai rumah*), the leader of customary law (*tuai adat*), bird elders (*tuai burong*). In Kalimantan, many of these positions gradually disappeared following the Dutch intervention early in this century; and have become weakened since the 1970's due to the government's "village regrouping programmes". Now there are only a few positions that have survived the effects of modernization, such as, the *tuai rumah* and (although in decline) the *temenggung*.

In contrast, the Tamambaloh in Pinjawan, were formerly organized according to a strict system of social rank that classified members according to several strata. These strata are the ruling group (*samagat tutu*) which occupied one apartment per long house, nobles (*samagat*), and the rich (*pabiring*) and poor (*banua*), the latter representing the majority of the population. In the past, there were also slaves (*pangkam*), who comprised the lowest strata. Slaves have now been absorbed into the *pabiring* or *banua* strata, mostly by inter-marriage. This system of social stratification has been weakened due to the conversion of the Tamambaloh to Catholicism, and through associated Western education beginning around 1914. In addition, the nation-state ideology (*Pancasila*) since 1945 and the "village regrouping programme" of 1979 have been instrumental in the abolition of the hierarchical system. Nevertheless remnants of the old division of society are manifest during the harvest festival (*pamole beo'*), and, to some extent, colour local-level politics and the decision-making process regarding customary law.

The present traditional leadership institutions of the Iban and Tamambaloh are now primarily an informal sub-unit of the government administration, supported and influenced by the latter. The "village regrouping programme," (Act No. 5/1979), for example, requires that a village must consist of a minimum of 2,500 people. If there are less than that total, small villages must be grouped together in order to fullfil the requirement. Even if two or more groups in villages do not come from the same ethnic background, they are still administered as one village. This uniformity has jeopardised the local leadership and associated political structure and thus reduced the effectiveness of the local leader in governing his people. Thus, villagers tend to offer less respect to persons holding only traditional positions. This administrative ambivalence influences the political dynamics within and among the hamlets.

d) Modes of Livelihood

The Iban and Tamambaloh of visited villages are shifting cultivators. The Iban of this study prefer dry land in forested hills for shifting cultivation, primarily because of a reluctance to weed farm fields. This preference is related to two considerations, first, that weeding normally requires intensive labor, and second that it conflicts with the idea of maleness in Iban society (weeding is generally done by women). There are, however, some new trends resulting from the adoption of weed-killer and the fact that now many Iban families borrow farm land (e.g., wet land, or *tana paya*) from the Tamambaloh, and help the Tamambaloh in farming activities to produce extra rice supplies. This is particularly significant among people who have close relations through marriage or friends. For example, the Tamambaloh in Pinjawan tend to recruit Iban people, as it provides an opportunity to ease the burden of certain activities such as weeding or harvesting.

To earn cash, the Iban frequently work away from the village, a practice traditionally known as *bejalai.* They commonly travel to Sibu, Kapit, Limbang, East Malaysia, or to Bandar Seri Begawan, Brunei Darussalam, staying for months or even years. For other income, they sell fresh meat or fish in Lubok Antu, and also tap *Para* rubber on a small scale to sell at Nanga Embaloh.

In contrast, the Tamambaloh are skillful in both dry and wet land cultivation (*tana paya*) or on flooded land near riverbanks (*tana dasapui danum*). Cash income is mostly earned by tapping rubber trees, selling vegetables and fresh meat or fish and, recently, by constructing food stalls or small shops along northern outbound roads.

e) Land Tenure

To understand the principles and differences in land tenure among Iban and Tamambaloh, we must keep in mind the historical background of the study sites described above. In terms of rights of settlement, for example, the Iban of Kelayam and Madang are the most insecure community. The Sadap Iban are more secure following "the Banujung Treaty" achieved in September 1939 which imparted rights of residence (TOR). Lastly, since they have long been resident in the Embaloh River area, the Tamambaloh have even more secure land tenure.

Traditionally, in Iban communities each longhouse claims rights to a certain territory or *menoa*, a tract of land to which household member have access. In any previously uncut forest within that territory, all such resident members have equal rights to first felling. The shape and extent of a *menoa* that includes primary forest can be decided in many ways. Once a tract of forest is felled, for example, rights of access to that land are limited to the household (*bilek*) whose members first felled it. The right to farm that land is then held by the *bilek*-family if it remains in the area. That right is inherited by all who are or become members of the household by marriage or are recruited through adoption. Upon partition of the *bilek*, both parties retain the right to use all land used before the split. However, upon marrying out, all rights to land owned by the household are lost by the person leaving, including rights to use tracts that he or she may have felled previously.

For the Iban in Kelayam, these principles cannot be fully enforced because the modern hamlet and its surrounding forest lands were given by the Tamambaloh. As explained above, a joint attack by the Tamambaloh and Iban against the Malay sultanate of Sintang, about four generations ago, was the reason the Tamambaloh gave a large tract of lands to the Iban in Kelayam. Meanwhile, for Iban in Madang, there is land insecurity because this hamlet was settled only in 1967. The Iban of Madang were moved by the army to inhabit a present site for security reasons during the communist insurgency. Land tenure of the Iban of Sadap, however, became more secure following the Banujung Treaty mentioned above, which obtained the consent from both Iban and Tamambaloh leaders, and was attended by J.A.C. Schotte and Raden Pati, the Dutch representatives in Nanga Embaloh.

In the Tamambaloh community, a household may hold rights as a group in farm land, including rights to animals, fruit trees, and rubber gardens obtained during the lifetime of the group's adult members, either through inheritance or their own efforts. However, its members might also share with closely related members of other households (i.e., *kapulungan*), rights to land and fruit trees. On the other hand, the yields of food and other goods obtained by household members through application of their rights in *kapulungan* are shared by the household as a unit. Certain kinds of property are owned by individuals (*hak kuasu diriam*). If a child married outside its household, some of these properties would be forfeited. On the death of an individual his (or her) personal goods might be divided between children or become general household or *kapulangan* property.

Men or women who remain in the parent's household permanently became the custodians of the undivided estate (*toa kapulangan*). Even if the estate were looked after by a child who stayed in his (or her) place of birth, other items of property would be divided among all the children. The custodian receives the biggest share. Parcels of forested lands inherited from a given ancestor are collectively *toan kapulungan.*

The aristocrats (*samagat tutu*) usually possess and control a larger portion of land than commoners (*pabiring* and *banua*). The main reason for substantial *samagat* land ownership was that formerly aristocrats controlled the labor resources necessary to open virgin forest, and they could accumulate other property through trade and raiding. Because of *samagat* inter-village marriage, most of the *samagat* households scattered throughout Tamambaloh country have shared rights in the same land. Aristocrats in Pinjawan, therefore, retain much of the best land, particularly that near rivers. As they could not work all of this themselves, some land was rented to other people for farming or to small shops along main roads. In other cases, government efforts to develop village roads or small-scale irrigation have been hampered by those property rights. Thus, an understanding of the relationship between descent and rank, and their relationship to the structure of *toan kapulungan* is important to understand in local development.

Among the local concepts relevant for a community-based conservation programme is the idea of "reserved forest" for future usage. In Iban and Tamambaloh terminology, this reserved forest is commonly called *kampong galau* and *toan palalo*, respectively. The forest resources are usually used for house and boat construction, medicinal plants and other daily or future needs. Essentially, this forested area is used collectively under a common property regime that is managed by consensus, including access and rules regarding why, when, and how this reserved forest is to be used. If any outsider or insider violates these rules of conduct, he or she can be fined.

3.3 Folk stories

This study encountered folk tales relevant to park awareness campaigns, for example the legend of Bukit Betung (the hill of Betung). The Iban believe that this hill was once occupied by a queen of the *mayas* or orangutan (*Pongo pygmaeus*). Once upon a time, there was a man by the name of Sukuong Pandung who was hunting in the vicinity of Bukit Betung. Because he was hunting alone, he became lost in the forest. Then he slept the night at a place called Lubok Engkararu. On the following day, he went to drink from the small river. There he met a huge orangutan. It is believed that they could talk to each other. Some days after they met, they got married, and a year later they produced a child, whom they named Buangga. In later years as an adult, Buangga became an exceptional hunter, especially of the Bornean rhinoceros. As the story goes, this unique family vanished because Buangga disappeared in the forest while hunting, and soon afterwards Sukuong Pandung and his wife also died. This folk story could be useful for use in a participative management campaign to promote a sense of local community identity with the Park.

3.4 Park development issues

Previous studies of migration of the Iban and Tamambaloh and other historical events and settlements are numerous. Basic anthropological descriptions of social structure, livelihoods and principles of land tenure are also generally well-documented. However, some gradual changes over natural resource decision making, have yet to be sufficiently examined. Particularly important are recent shifts in traditional institutional and power structures since 1979, new roads and market pressures, and insecurity of land tenure.

As noted above, leadership in Iban and Tamambaloh communities is weakening. Since personal access to a higher government official is important, traditional positions are now less respected by villagers. In addition, the "village regrouping program" has also reduced the political domain of traditional leadership. For example, the *temenggung* position, which was previously elected to govern resource use, has now become a symbol of the past. A case study of this issue in other communities is important to elucidate the socio-cultural potential for strengthening traditional institutions to support park development.

Resource utilisation at the community level is also influenced by the existence of roads and markets. Improved road access near to BKNP can have both positive and negative impacts. Improving roads can raise standards of living by permitting cash cropping, and reduce reliance on park resources. It can also encourage alternative land uses and non-agricultural activities, improve access for tourists and thus increase tourism revenue for local communities. On the negative side, roads can also make the park area more accessible to poachers, and lead to increased intensification of land use within park boundaries. The latter can increase the rate of conversion of a natural habitat to human-dominated land uses. Hunting and fishing are two major activities that could have serious impacts on park integrity. A case study of wildlife management that includes hunting and fishing and related decisions in local communities would contribute to appropriate park management.

Security of land tenure affects the willingness of local people to invest in improved land use systems that avoid land degradation. Villagers in Kelayam and Madang are less enthusiastic about planting cash crops such as rubber because of insecure land tenure. Nevertheless, for the time being, *de facto* tenure may be more important than *de jure* recognition, *e.g.* having one's land rights respected by one's neighbours or the park agency may be more important than complete and legal title. Thus, a community resource mapping exercise would help to reduce latent conflicts between local people and park authorities in relation to land development. Community resource mapping is also important to the design of buffer zones, traditional use zones and for park zonation in general. A new institutional mechanism is obviously needed to clarify stakeholders' rights, roles, and responsibilities in managing park resources.

As stated in the introduction, collaborative management is strongly recommended for promotion within and outside BKNP. Stakeholders must agree on sharing management functions, rights, and responsibilities for a territory or set of resources under protected status. The major stakeholders include the formal park authority and various associations of local residents and resource users (male and female), but can also involve non-governmental organizations, local administrations, traditional authorities, research institutions as well as the private sector.

Local perceptions regarding the park are also important for promoting collaborative management. For example, many local people asked about the purpose of the park and the recently conducted biological diversity survey in the park area. Beyond basic research activities, a series of village or group discussions on biological diversity would be fruitful for promoting park conservation. Many local people are also confused about the official name of the park (Bentuang Karimun) since they are unaware of the location of Mt. Bentuang. It would be prudent to consider modifying the official name of the park to the locally more familiar *Betung Kerihun National Park.* Highlighting relevant folk stories should be a component of a park awareness campaign.

4. RECOMMENDATIONS

Iban behaviour, including their shifting cultivation practices have been attributed to a "warrior's" view of natural resources or "plunder to be taken" and to a "superior indifference toward agricultural proficiency"[2]. Thus the Iban have been called less "shifting cultivators than "*mangeur de bois*". These images have emerged and been reinforced over the years. Iban methods of shifting hill-rice cultivation are primarily relevant to pioneer areas and not

[2] Geertz, 1963; Bronson, 1972

all such shifting cultivation has been exhaustive or damaging. Iban shifting cultivation in long-settled areas such as Saribas or Lemanak rivers (Second Division) is different but sustainable. More research on this topic should be undertaken in the Embaloh area in future.

Unfortunately, and because of the complexities of geographical distribution, a proposal for recognition of "reserved forest" (*kampung galao* and *toan palalo*) could not be fully worked out in the expedition time available. A participatory resource mapping of those reserved forest areas should be conducted to promote integrated conservation and development.

M. SOCIOECONOMY

Syamsuni Arman

1. INTRODUCTION AND METHODOLOGY

The purpose of the socioeconomic study was to understand some of the socioeconomic conditions of the areas surrounding the protected areas for more effective conservation, as well as for socioeconomic development in general. The peripheral zones of the two reserves were treated separately.

2. SURVEY SITES

For BKNP, field activities were confined to three *Kecamatan* or Sub-districts in Kapuas Hulu Regency namely Embaloh Hulu, Batang Lupar, and Badau. In addition, a brief visit was made to Nanga Kantu, Empanang Sub-District. Field work took place between 04 and 27 September.

In Embaloh Hulu the team visited the Sub-district Office, Sadap, Madang, Kelayam, and Pinjawan villages; Sadap was selected because of its location as the last upstream human settlement along the Embaloh River. This village could be used as a check point to control human activities around and within BKNP. It was also the final preparation point before entering BKNP.

Madang became important after the completion of the northbound main road in early August 1997. Two local family shops had already started selling food and drinks, becoming regular visiting places for public buses travelling between Putussibau - Benua Martinus - Lanjak - Badau and, across the border, Lubuk Antu. Fish caught from upper Embaloh and possibly from waterways within the BKNP are stored in Madang and then transported across the border to Lubuk Antu and beyond.

For the areas around LEWS the guide was William George Jebron, manager of the Batang Ai National Park (BANP) Headquarters. He provided a detailed itinerary of the research programme within and peripheral to the Batang Ai National Park. Several longhouses have already moved out from the BANP, namely: (1) Rh. Bunjai/Kw. Ng. Mujan to Subandi/Lundu; (2) Rh. Jakung/Kw. Ng. Mujan to Pasir/Lundu; and (3) Rh. Rimung/Kw. Tapang Jarau to Entambah. Outside the boundary there are a number of other longhouses. From Kw. Wong Irup (Batang Ai Hydroelectric Dam) going upstream on the Batang Ai river, these longhouses are: Rh. Gara/Kw. Pan; Rh. Sunuk/Kw. Teliting; Rh. Geruna/Kw. Piat; Rh. Ipang ak Ningkan/Kw. Rudai; Rh. Pilang/Kw. Mapi Pasir; Rh. Abung/Kw. Mapi; Rh. Mujan/Kw. Kerangan Mong; Rh. Lumpeng/Kw. Bengap; Rh. Ambun/Kw. Musing; Rh. Tutung/Kw. Telaus; Rh. Dayung/Kw. Tapang Pungga; Rh. Ipang/Kw. Ng. Delok; Rh. Usik/Kw. Dingin; and Rh. Jaruk/Kw. Engkaras.

The fieldwork was conducted along the Batang Ai river and its tributaries. The schedule of visits was confined to two river courses: Batang Ai to Ng. Lubang Baya Ranger Station, and Ng. Delok to Rh. Ngumbang Kw. Ng. Sumpa. Site visits were made from 12 to 27 November.

3. OBSERVATIONS

3.1 BKNP

At Relayam, there are two longhouses consisting of 20 *bilek* (apartments) and 6 *bilek*, respectively. The Iban community showed how the interplay of rice farming, rubber tapping, timber cutting, and working as wage labourers had kept the longhouses going.

Pinajwan was the next village the team visited during the survey. This community of Embaloh people had lived in longhouses in the past, but since the last five decades had begun to move into individual family houses. The transition could be seen in older houses in which three or five families built adjoining rooms to make a mini-longhouse. Later dwellings were built as individual family houses.

a) Batang Lupar

The first stop along the northbound main road was Ukit-Ukit village, in the Sub-district of Batang Lupar. Ukit-ukit was populated by Tamambaloh people. In this village we did not find any longhouses, but about one hour's walk away at Bakul village there was a rare example of two Embaloh longhouses sharing living space with an Iban longhouse. The Tamambaloh practised wet farming in *tanah ujung* (land along the river temporarily flooded during the wet season).

Another Iban longhouse is located at Sg. Sidik consisting of 14 *bilek* and four individual families. This community showed strong adherence to the Iban tradition of protecting the *kampung galau* (forest preserved for future generations) although they had been approached several times by timber cutters. Timber cutting only occurs when they need timber to build their houses.

Sg. Sidik could be developed into a tourist attraction since it has a hilly and forested environment. It also has a small but year-round flowing waterfall held sacred by the community. Beside the waterfall there is the legendary Lubok Batu Ancau 'and, it is believed, to be the footsteps and spear of Bunga'nuing, a demi-god of the Iban community.

After Sg. Sidik, Lanjak (Batang Lupar Sub-district) was visited. Lanjak is a seasonal town. During the rainy season the Sentarum and Luar Lakes fill with water but during the long dry season like that of 1997, the Luar Lake is completely dry. The bottom of the lake had hardened so that one could even ride a motorcycle or drive a jeep across it.

During the rainy season thousands of fishermen from Lanjak, Jangkong, Selimaban, and Semitau converge on the lake to catch fish. The methods used by the fishermen, however, could threaten some fish species. The fishermen recognize the seasonal behaviour of the fish population. In the beginning of dry season the fish migrate into secondary rivers that drain the Lake towards the Kapuas river in the South. At the beginning of the wet season, the fish move back into the lake. The fishermen wait with their various traps, nets and poison for the fish to pass through the mouth of the river.

During the dry season hundreds of fishermen lay down their fishing tools and pursue other income-earning strategies until the next fishing season. Many of the younger fishermen look for wage labor in other areas, including work across the border in Sarawak. Many fishermen also remain in town, either unemployed or doing part-time work.

b) Nanga Badau

Nanga Badau has developed into a vigorous frontier town since the completion of the northbound main road early in August 1997. The role of this town as a warehouse location for goods coming from Lubok Antu opened great opportunities for local business.

According to the Immigration Office, in August this year about 130 Indonesians were repatriated by Sarawak authorities. These labourers had entered Sarawak through several entry points in Kalimantan in search of work but without the proper work permits.

Seriang, an Iban settlement characterized by three long houses and several individual houses, indicated reliance on forest resources. Apart from planting dry rice and tapping rubber, the villagers also cut timber at nearby locations. Although it was somewhat questionable legality, timber extraction improved the household economy.

At the village of Sg. Timbaga, located beyond and westward of Badau, there is a single Iban long house of 22 *bilek*. This village was not dissimilar to other Iban settlements visited by the socioeconomic team. Dry rice and rubber tapping predominate and their relationship with Badau and Lubok Antu is close.

3.2 LEWS - BANP

The objective of this phase of the study was to describe the socio-economic condition of the people within the LEWS area in an attempt to recommend improved park management, especially in respect of conserving and preserving the natural environment while promoting the socioeconomic well-being.

Field work was not carried out in the LEWS where human settlement is illegal but in the adjacent Batang Ai National Park, south of LEWS in Lubok Antu District, Sri Aman Division.

The District of Lubok Antu covers an area of 2,338.4 km^2 and a population of 22,270 people (based on 1991 data). The population is classified into 19,796 Bumiputera[1] and 2,474 non-Bumiputera. The Bumiputera population is divided into 18,870 Iban, 794 Malay, 25 Melanau, 85 Bidayuh, and 22 other ethnic groups; and the non-Bumiputera population consists of 2,408 Chinese and 66 of other races. The average density of the population is 9.52 people per square kilometre.

The Iban constitute more than 85% of the total local population or more than 95% of the Bumiputera population. The majority of the Iban still live in longhouses, although next to the longhouses a few families build detached dwellings. This district lists no less than 189 longhouses each with its *Tuai Rumah* and respected *Jawatankuasa Kemajuan dan Keselamatan Kampung* (Village Development and Security Committee).

The preponderance of the Iban is an important factor in formulating a management plan and strategies of development for the LEWS and the

[1] Indigeneous groups

BANP. There are at least two important reasons why ethnic characteristics should be taken into account: firstly, Iban culture and their economic strategies have modified the natural environment and resources for decades; secondly, the conservation of flora and fauna in those two areas requires some degree of restricted access and protection.

a) Batang Ai National Park (BANP)

The Batang Ai National Park was gazetted in 1991. It covers an area of 24,040 ha. Protected animals include hornbills, gibbons, and the threatened Bornean orangutan. Besides flora and fauna, this park also serves as the water catchment area for the artificial lake powering the Batang Ai Hydroelectric Generator. Realizing its potential as a tourist attraction, the Hilton Hotel built the Batang Ai Longhouse Resort on the lakeside.

BANP has two offices in the field, the BANP Headquarters in Ng. Delok, and the Ranger Station at Nanga Lubang Baya. The BANP serves multiple functions : (1) Conservation of unique flora and fauna; (2) Secure water catchment for the Batang Ai Hydroelectric dam; (3) Socioeconomic development of the communities living inside and around the park and increase in tourist potential; (4) Conservation and preservation of traditional Iban values and (5) Research into Iban ethnobotany.

There have been several phases in park development:

- ❑ Introducing preservation and conservation concepts to the communities.
- ❑ Inviting *tuai rumah* to visit other parks.
- ❑ Inviting the community to participate in management planning.
- ❑ Presenting the park proposal to the communities and the government.
- ❑ Site surveys to determine the boundary of the park.

The involvement of the longhouse dwellers in the early part of those activities has proven to be a key factor that released tensions often typical of resettlement efforts. Under Section 7(2) of the National Park Ordinance seven longhouses were gazetted into the Park, namely: Rh. Rimong ak Alek in Tapang Jarau Entabah; Rh. Mujab ak Tibuk in Ng. Beretik (later becomes Rh. Radin ak Meragan); Rh. Nira ak Cheong in Ng. Tibuk later becomes Rh. Endan ak Luyuh); Rh. Kana ak Median in Sg. Jengin; Rh. Chaneing ak Resa in Pala Taong; Rh. Along ak Dana in Ng. Sumpa (later becomes Rh. Ngumbang ak Janguk); Rh. Kasi ak Sanggong in Jambu.

An interesting feature of the management plan is that local communities are allowed to voluntarily propose their inclusion in the park. Members of gazetted longhouse are allowed to work as labourers for the park and receive other privileges. However, they are also subject to some restrictions which also apply to the general public.

The population of the gazetted longhouses have the privilege to fish in the following rivers and their tributaries: Ulu Batang Ai, Beretik, Babiyong Mit, Tekalong and Jengin.

The population also have the privilege to extract forest products, such as resin, rattan, rubber products from *jelutung*, *rian* and *murau* trees, *pandan* leaves and leaves of other plants for weaving, edible plant parts such as fruits, leaves, buds, and roots. The population can also collect wood and sticks for firewood and for building material for longhouses and boats. They are permitted to hunt wild animals for food, but the meat is not to be sold or traded in any way.

The Ordinance also stipulates a licensing scheme for various extractive activities such as carrying arms and hunting animals. Supervision has been the most difficult part of Park management. It was easy to control the activities of those who live near the BANP Headquarters and Ng Lubang Baya Ranger Station, but much more difficult to watch for people coming from outside the boundary. Park personnel mentioned that it was difficult to control the movement of speedboats in the river, especially tourist transport.

b) Batang Ai Longhouse Resort (BALR)

The BALR contributes in several ways toward development of Batang Ai. It was built at a strategic point where guests could enjoy the beautiful view of the 33 square miles of the lake and the hydroelectric dam at Wong Irup. When the Sarawak Electric Supply Company (SESCO) closed the dam the original river depth increased by 60 m, about 26 longhouses were required to move out and resettle at the Batang Ai Resettlement Scheme in Lubok Antu.

BALR has staged various programmes to promote tourist visits to Batang Ai. The most striking contribution to the economy was the involvement of members of the longhouse in transporting tourists from the resort jetty into the Park. No less than 1000 tourists visited the area in 1996 with the assistance of one Borneo Adventure tour guide, Yonathan ak Jarau.

The other significant contribution to the local economy was employment offered by BALR. According to the Resident Manager of the resort more than

90% of labourers were recruited from the local population. Local recruits receive around RM240/mo plus bonus if many tourists stay at the resort.

The purchase of food, souvenirs, and various personal items by tourists also provide employment opportunities and cash income. It is clearly important that the resort and local community work hand-in-hand to preserve important characteristics, such as the natural environment and its social and cultural assets.

c) Batang Ai Resettlement Scheme (BARS)

The resettlement scheme was established to provide for members of the 26 longhouses removed from the area inundated by the Batang Ai Reservoir. The longhouses in the scheme were built by the Housing Development Commission. Their development was entrusted to the Sarawak Land Consolidation and Rehabilitation Authority (SALCRA), a state level agency for developing Native Customary Rights (NCR) land in Sarawak. The longhouses had about 25 m clearance around each building, with land for cultivation 15 to 30 minutes walking distance from the longhouse.

Two of those settlements were visited, Skim Beretik TR Ayum ak Mujab (constructed in 1983) and Skim Mepi TR Pilang. The Beretik Scheme consisted of 13 bilek or apartments and the Mepi Scheme consisted of 19 apartments. Each family signed a loan of RM30,000 payable in instalments of RM98/month but no payment has yet been collected to date. Important aspects of this development scheme are noted below:

(i) Cultivation schemes

According to information gathered from members of the longhouses each family who moved to the new resettlement received 11 acres of land designated for the following purposes: Pepper and vegetable gardens - 1 acre, Rubber (600 trees) - 5 acres, oil palm (170 trees) - 3 acres, and Rice field - 2 acres.

The land for home gardens, rubber, and oil palm plantations had already been awarded to members of the resettlement scheme. It was not clear why the land for the rice fields had been withheld. The cultivation of rubber and palm trees in the resettlement scheme was managed through SALCRA. According to the informants rubber was sold to SALCRA at the price of RM0.50/kg in block form. The participants of the BARS received 5 acres of land for oil palm where 170 trees per acre could be grown. They also received RM8/day for maintenance work done in their gardens. The types of work that these people were offered included : (1) land clearing; (2) tree trimming, (3) fertiliser application, and (4) insecticide spraying. The owner also received RM3/ton for hauling the palm fruits into the truck.

(ii) Benefits (Employee's provident fund)

Families participating in the resettlement scheme were registered in an Employee's Provident Fund (EPF). For every Malaysian Ringgit (RM) that the family put into the fund, SALCRA deposits RM2. The fund was then redistributed to the families at the end of the year, reaching as much as RM9,000.

d) Longhouses

During the study, seven longhouses were visited, where in-depth interviews were conducted with several key informants in Rh. Dayung, Rh. Ipang, Rh. Radin, Rh. Endan, Rh. Ngumbang, Rh. Kasi, and Rh. Chatlging. Highlights of those interviews are presented in Appendix 9.

e) Farming Occupations

This section describes farming activities of the longhouse community. Although the description focuses on a particular longhouse Rh. Ipang, the general agricultural features are essentially similar in all longhouses visited during this study.

(i) Hill-Rice Farming

The Iban prefer to plant rice on steep hill slopes. Examples of these steep rice fields occur all along the upper Batang Ai river. The rice planting sequences included *nebas* (slashing), *nebang* (felling), *nunu* (burning), *nugal* (stick planting), *mantun* (weeding), and *ngetau* (harvesting).

Farmers worked continuously in the rice fields from the second half of June until the end of November, when they have a break for two to three months before harvest, which comes in the second part of February. Besides this break there is another idle period of about three months during the months of March, April, and May. These idle periods were used for conducting other activities such as house repair or visits to relatives at the new resettlement scheme.

In the past, people cut down trees using axes, but now they use more technologically advanced chainsaws; similarly, *parangs* once used for weeding have been replaced by application of herbicides. The methods work twice as fast, while incurring costs to buy the equipment, chemicals, oil, and gas. The use of herbicides on hill slopes especially on river bank could be detrimental to fish population.

An average family owns between two to five acres of rice field capable of producing between 40 to 50 gunny sacks of padi or unhusked rice, each one weighing between 40 to 50 kg. So in each planting season they produce between 1,600 to 2,500 kg of *padi.* When *padi* is processed into rice the amount would decrease by half. If the amount of 800 to 1250 kg of rice was sold under the current price of MR1.40 per kg, each farming family would collect between MR1,200 to MR1,875. Aside from the cash potential, rice farming also has psychological importance for this community. Having abundant stocks of rice in the *tibang* (container made of tree bark) a family feels confident about food security.

(ii) Pepper

Pepper is a crop that requires intensive maintenance and high input. First of all, as a climber each clump needs a *belian* support that costs MR4 to MR6 apiece. The area must be clean-weeded at all times, and fertiliser and insecticide must be applied regularly. So, in order to succeed, an Iban must take a large technological step away from his traditional shifting cultivation. The second problem is the marketing of the peppercorns, which requires strict quality control and careful scheduling. The price of pepper often fluctuates wildly, so that the cultivator must bring his pepper to the *Pengkalan* (where buyers usually wait for them) at the appropriate time.

Perhaps the only aspect of pepper cultivation that mimics Iban technology is site selection. Pepper almost without exception is planted on steep slopes, resembling those for hill rice cultivation. Unlike rice, however, pepper requires clean weeding. The soil surface is stripped bare and is therefore unprotected from leaching and soil erosion. To ensure stable production this method requires progressively more and more application of fertilizer.

Tuai Rumah Ipang ak Jarau was one of a few who cultivates pepper quite successfully. He owns 500 pepper clumps, each clump producing between 5 to 10 kg of pepper. At the time of this study black pepper was sold for MR17 and white pepper as high as MR24. Theoretically, if all 500 clumps produced 5 kg each, selling at MR20 per kg, this family could collect M$50,000 every season. But the old man reported that he might not be able to continue to tend the pepper grove for very long, since this crop needed continuous weeding, herbicide spraying, and fertilizer application.

(iii) Rubber

Rubber was perhaps the most common perennial crop. Each family owned an average of two acres where they had planted approximately 400 trees. On clear weather days (tapping cannot be done in the rain. Rain water washes away the flowing latex), the family collected between 10 to 20 kg (4 - 5 sheets) which are sold for MR2.40 a kilogram. So, each working day a family could earn between MR24 to MR48. When the price was low they usually stored their rubber sheets waiting for better price.

Rubber and rice have been a good crop combination for rural families. During the two periods of idle time in the rice season, the whole family taps rubber. In the past, during the weeding period, women worked in the rice field and men tapped rubber to provide cash for the family. But when herbicide was introduced into the area, weeding ceased to become tedious work that nobody liked. If done manually weeding could take months to finish, but using spray the same result could be achieved in a matter of weeks. The use of herbicide also removed women from weeding completely since working with the chemical was considered too dangerous for them.

(iv) Fish Farming

In 1994 the 14 families in Rh. Ipang collectively owned 30 *sangkar* or cages. Each family was responsible to manage two cages, and took turns daily to watch the float for damage, predators, or intruders. The remaining two cages were owned by the longhouse and used for common needs such as longhouse *gawai* or to invite guests like ourselves to dinner. Each family in the longhouse received a subsidy of MR4300 for purchasing wood, net, and fish fry to start the fish farm. Feed for the fish was provided by the Fish Mart.

Each cage was stocked with 400 red *tilapia* fish fry averaging 2-3 cm long. In six months the fish would weigh between 0.9 to 1 kg, and could be sold to the nearby Fish Mart at the price of MR4.5 a kilogram. This price was quite reasonable provided there was no damage to the cages or other problems.

Longhouse co-operation with the Fish Mart seemed to be working well. Periodically the Fish Mart sends its cold storage truck to the *pengkalan* or jetty, and from there sends a fresh water tank to collect live fish from the longhouse. The fish is transported without risk from the longhouse for the one hour journey to the jetty. The key element of success of this co-operation is the commitment of the Fish Mart to buy whatever amount of red tilapia produced under the agreement. This arrangement has alleviated some of the risks faced by the local community in its effort to take part in the wider market network.

At the beginning of the rainy season the water in Batang Ai was contaminated with silt washed down from river banks. Such contamination was detrimental to fish population in general and particularly to the fish kept in the cages. During heavy rain the water in the river rose rapidly and the current became swift and turbulent. At one time several cages were washed down the river by the swift current and more than MR1000 worth of *patin* fish was lost.

f) The modern form of *bejalai*

Iban groups in the past often travelled extensively in the area which has now become the Malaysia-Indonesia border region. Although today Iban groups are increasingly settling down in area of their choice, the spirit of Iban migration lives on in a different form.

The Iban of today like their ancestors move around for practical reasons such as looking for better employment or better access to educational facilities. Some of them travel long distances, for example to Singapore, Jakarta, etc., taking jobs in offshore oil rigs, working as crew on ocean going vessels, or simply working as wage labourers in Miri, Kuching, and Brunei. They obtain work as carpenters for MR40/mo or as general labourers for MR20/mo. Instead of bringing back jewellery confiscated from a defeated enemy, they now send home money to the longhouses or occasionally return home after 6 months or once a year during Christmas celebrations.

After being exposed to better education many young Iban do not want to return to planting rice on steep slopes or to go hunting or fishing as their parents did. Like other people, they look forward to a better future by adapting to modern life.

4. SUMMARY AND CONCLUSIONS

BKNP

In general the number of teachers in most schools is insufficient, but some schools, particularly grade schools face the worst problems.

Inadequate distribution of health personnel was evident. Since their numbers could not be increased easily, perhaps their mobility should be improved. To take advantage of the new road perhaps it is time to organize a mobile clinic in the area.

Nanga Badau will become a key gateway for socioeconomic relations with Sarawak. Therefore, this border crossing should be developed into a fully-fledged international crossing like Entikong in the Sanggau Regency.

To preserve fish populations in Lake Sentarum and Lake Luar, stricter measures must be taken to control the use of harmful fishing tools such as the *jermal* and *tuba*.

To prevent road damage, the weight of transport vehicles should be strictly controlled.

BANP - LEWS

Several institutions have been instrumental in changing the natural environment and economy of local communities in and around BANP, namely: Batang Ai National Park; (2) Sarawak Electric Supply Company (SESCO); (3) Batang Ai Longhouse Resort; and (4) Sarawak Land Consolidation and Rehabilitation Agency (SALCRA).

BANP has launched various programmes and activities in conservation and preservation of flora and fauna, including development of social and economic well-being of the local communities in and around the Park. One important feature of park management practice recognizes Native Customary Rights (NCR) of Iban living in longhouses within and around the Park.

SESCO was very much concerned with the quality of forest stands in the watershed of the Batang Ai dam. SESCO should therefore assist the local community to find alternatives to forest exploitation.

The Batang Ai Longhouse Resort has invested a great deal to build the resort. The success of its investment clearly depends on the influx of tourists. Apart from the quality of the management of the resort, the people of the longhouses are one of the key elements in attracting tourists. Therefore it is important to educate the people not only formally, but also in the various service aspects of handling the tourist visits such as cooking, sports, art, rituals and entertainment

SALCRA assumed the responsibility of helping people to move from the lake site. If all the two acre plots designated for rice farming were handed over to the farmers, traditional rice farming could be continued. Many rituals in the life of the community are in fact closely related to rice farming, so if the farmers do not farm, the rituals also could vanish. This was the reason they continue to return to the old longhouse, despite the costs of time, money, and energy to make the trip.

Many of the longhouses in the area were no longer in good condition. The occupants, especially the younger generation, have left the longhouse in search of work in distant places and return only occasionally for brief visits. Those who received better education adopt a different way of life in towns and cities instead of returning to the longhouse.

Actually, those who return after gaining experience could be valuable to the community. For example, Yonathan ak Jarau, after returning from many years working in several cities became an important figure in promoting ecotourism in Kw. Nanga Sumpa. The absence of such a figure may have been one of the reasons why the number of tourists visiting Ulu Batang Ai were significantly fewer compared to those who visited Ulu Nanga Delok.

As a final note, there are some environmental concerns. For example, the colour change of the aquatic plants from normal green into blackish in Ng. Delok river could be a sign of chemical herbicide pollution worthy of further investigation. The practice of hill slope farming on plots situated on riverbanks could also be detrimental to caged fish farming. The practice of pepper planting on steep slopes, combined with strip weeding methods ignores the danger of nutrient leaching and soil erosion. Perhaps SALCRA could devote some resources to finding alternative technologies which are both environment-friendly and profitable for farmers.

V.

PROTECTED AREA MANAGEMENT

N. The Trans-Border Conservation Domain of Betung Kerihun National Park and Lanjak Entimau Wildlife Sanctuary:

Towards Collaborative Management through Bilateral Research

Christopher P.A. Bennett and Robert B. Stuebing

1. INTRODUCTION

Over the past twenty five years, conservation development has undergone a paradigm shift from the protection of target species to the preservation of overall biological diversity (biodiversity). Biodiversity conservation encompasses genetic and ecosystem diversity as well as species diversity[1]. Although our understanding of biodiversity remains imperfect, it has become increasingly clear that areas designated for its conservation must often cover large areas to accommodate species dispersal and migration and to provide buffers against threats. Recognition of the vital role that local people can play in management of protected areas, together with growing public awareness of the need for biodiversity conservation have further expanded conservation domains. Protected areas now account for about 8% of the world's land surface[2].

While conservation domains have expanded, protected area management has had to increasingly face the challenge of different development policies in parks which are traversed by the administrative boundaries of districts and provinces as well as by international borders. In fact, the number of trans-border parks is increasing (Gilmour 1998). Betung Kerihun National Park (BKNP) in West Kalimantan, Indonesia and Lanjak Entimau Wildlife Sanctuary (LEWS) in Sarawak, Malaysia, sharing a common border and providing an uninterrupted biophysical corridor between two regions of high biodiversity, represent a new and important contribution to trans-border conservation.

Drawing on the results of the 1997 ITTO Borneo Biodiversity Expedition, this paper considers the rationale for recognition of the BKNP-LEWS Trans-border Protected Area and challenges for its successful management. Given that the LEWS management plan is completed (ITTO 1996) and that for

[1] WCMC 1992
[2] Gilmour 1998

BKNP soon will be, suggestions are made for how the conservation domain can be managed under collaborative rather than joint management. Initially this should take the form of bilateral research initiatives focussed on the scientific and institutional needs of protected area management.

2. THE BIOPHYSICAL DOMAIN OF BKNP-LEWS

More species of plants live in tropical rainforests than in all of the rest of the biomes of the world combined[3]. The biophysical domain of BKNP-LEWS promises to be a worthy representative of the tropical rainforest biome. Although the nearly one million hectares constituting the combined conservation area is topographically, floristically and faunistically similar in many respects, there are also marked differences. The area itself covers one of the lesser known regions of the island of Borneo. Highland ranges and lowland expanses accommodate a wide range of flora and fauna and their habitats. The area represents a unique biological region of the island of Borneo. Indeed, Borneo is the richest unit of the Sundaic sub-region and a main centre of distribution for many genera of the Malesian flora and the Indomalayan fauna[4]. Small-plot tree diversity is as high as that found anywhere in New Guinea or South America.

2.1 Geology

The Katibas area of LEWS is composed largely of a mixture of weathered sedimentary and metamorphic rocks ranging in age from 5 to 15 million years old, while much of the Embaloh watershed where the expedition took place is of igneous origin, and considerably younger. This leads to striking differences in the steepness of valleys, thickness of soils and amount of river sediment. Thus, the terrain of the Embaloh is generally more rugged and steep, the soils more skeletal, the stream and the river valley profiles narrower. A distinct and significant difference between the rivers of both protected areas is that BKNP possesses aquatic habitats below 100 m a.s.l, with rivers of laminar, rather than turbulent flow. This feature and numerous steep tributaries have influenced the aquatic biota. Ironically, despite the younger age of the rocks of the upper Embaloh watershed, the Kapuas River and its tributaries have probably existed relatively intact for a longer time than the rivers of Sarawak.

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[3] Raven *et al.* 1992, p.662
[4] Mac Kinnon *et al.* 1996

2.2 Flora

Floristically, dipterocarp forests define both areas with specific differences that on-going inventory work is making clear. The expedition included areas with hill dipterocarp trees of such surprising size and elevation as to recall Corner's classical description that "Dipterocarpaceae construct the most luxuriant forest on earth. The immense trunk, superbly engineered .... branches at a height of 100 feet into the large canopy of small branches, many twigs, and spreading limbs along which animals may travel, eat sleep and give birth without returning to the ground"[5].

All current evidence points to high floral diversity across the range of lowland dipterocarp, hill dipterocarp, summit ridge, sub-montane and montane forests. Species richness is high. Approximately 80% of species in all forest sample plots were represented by a single individual. Only 14% of specimens were repeat collections. The altitudinal range of palms revealed novel distribution characteristics as did that for orchids. Bryophyte diversity was found to be two to three times greater than in tropical parts of Africa and America.

BKNP-LEWS offers a rare opportunity to study forest regeneration decades after shifting cultivation was abandoned and the results of the exclusionary (LEWS) and community participative approaches (BKNP) to park management on the floral (and faunal) biodiversity of the protected areas.

2.3 Aquatic Biota

The greater age, extent and altitudinal range of the Embaloh watershed have undoubtedly contributed towards its considerably higher fish diversity and numerous endemic species. From the Expedition it has been seen that overlap in fish species is only about 50%, and that certain groups such as the Cobitidae (loaches), display a much greater species richness on the BKNP side, despite the fact that the Sarawak river drainages are geographically close by. The Sarawak rivers such as the Katibas are considerably shorter by comparison, with a more restricted range of available habitats and microhabitats.

2.4 Herpetofauna

The amphibian fauna have also been influenced by these differences, and even though there is considerable overlap, still display distinctness of community making the discovery of new species likely. A large number of

[5] Corner 1968, p. 158

Borneo's herpetofauna can be found in BKNP-LEWS, undoubtedly including a large number of undescribed species. The reptiles are still the least known, and much remains to be done in the documentation of lizard and snake species.

2.5 Primates

BKNP-LEWS should be viewed as a crucial conservation site for primates, especially for the Pongidae - the orangutan and gibbon. The majority of Borneo's endangered or threatened primates are resident and move across the BKNP-LEWS divide. It is clear that perhaps the largest and least disturbed orangutan population in Borneo is here, numbering up to several thousand animals. As for the Bornean gibbon, its abundance, particularly in LEWS, is higher than any other locality reported from the island. An abundance of fruit trees and a complex forest habitat have probably played an important role in supporting these populations.

2.6 Birds

The share of Borneo's endemic (70%) and resident (80%) bird fauna found in BKNP-LEWS is truly impressive. Biophysical complexity and disturbance have played important roles. The complexity of topography, altitude and the resulting diversity of habitats in the area is matched by few other protected tropical forests in Asia. The biological richness of these habitats, ironically have been enhanced to a certain degree by human disturbance in the form of shifting cultivation. Such disturbance, where not excessive, has produced forest in various stages of regeneration (and species composition), thereby increasing the number of available ecological niches and the local food supply for bird species. Furthermore, the results of expedition surveys indicated that the area serves as an important resting and foraging refuge for Asian migrants, enabling their survival during overwintering periods. A part of BKNP outside the expedition area is becoming well-known for deep sink-holes and caves of direct ecotourism value (see below) as well as where commercially-valuable swiftlets live[6].

2.7 Human Interactions

Ethnobotany and socioeconomic studies (as well as observations made by other expedition scientists) reaffirmed that forest plants and animals contribute to the well being of local communities in numerous ways, from

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[6] Palawa 1998

food and medicine to construction materials and implements, as well as for ritual purposes. Apart from adding to our knowledge about the intimate connection between people and tropical forests, the results of ethnobotanical research reminds us of the inextricable relationship between conservation and development.

Despite the influences of development and modernisation, over 400 kinds of forest and agricultural plants are still in use including a wide range of plants with medicinal properties. Nearly 150 species are used as food, some of these retrieved from the forest and planted near villages. The latter possess, of course, rich and easily tapped genetic resources. Apart from the forest plants, there are at least 24 varieties of rice used by local communities, another indication of the diversity of their approach to food production. The overlap in food plants used between villages is also as low as 7%, indicating an adaptive approach to local conditions. Finally, traditional knowledge of the uses of plants is still part of the Iban and Tamambaloh cultures, knowledge that to this day is passed on to children.

3. TRANS-BORDER CONSERVATION PRIORITIES

While it is true to say that conservation strategies increasingly focus on ecosystem conservation rather than selected species, it is important to recognize which species are under the greatest threat of elimination or even extinction and set appropriate management priorities accordingly within defined protected areas. The trans-border dimension of BKNP-LEWS is particularly relevant to such problems because illegal collectors and traders in commercial species can readily escape across international frontiers. Among the trans-border management challenges for species conservation are:

- ❑ Strict protection for all pongid primates, chief among them the orangutan.
- ❑ Regulation of the collection of specific forest products such as *gaharu*, orchids and other commercial plants.
- ❑ Protection of rare avifaunal endemics (e.g., Bulwer's pheasant), migrants and cultural symbols (e.g., hornbills).
- ❑ Protection of the fish fauna except for subsistence fishing in specified areas.
- ❑ Monitoring of threatened or endangered species, game species, and selected floral or fauna groups suspected to be crucial to certain aspects of forest dynamics (pollination, seed dispersal, food sources).
- ❑ Allowing traditional subsistence agriculture in clearly-defined buffer zones to maintain habitat complexity.

- Conservation of traditional institutions of the culturally-diverse communities living in an around BKNP-LEWS which favour biological conservation objectives.

4. THE TRANS-BORDER CONSERVATION DOMAIN

4.1 Biodiversity Boundaries

No protected area is an island - not even an island. Centres of biodiversity richness are the focus of many conservation efforts but biodiversity, "essentially a synonym of life on earth" (WCMC 1992), is a biophysical continuum stretching across geographical regions. Rarely are the boundaries between species as sharp as the borders between administrative districts, let alone countries. Biodiversity borders are blurred. Thus, management of the BKNP-LEWS must cover an area far greater than the approximately one million hectares gazetted for protection. People and animals are unimpeded by the mostly invisible international divide.

Expedition observations have indicated the conservation importance of areas outside BKNP-LEWS. Thus, significant orangutan populations were observed adjacent to the settlement of Tanjung Lokam located just outside the boundary of BKNP. Migrant birds from temperate zones depend upon BKNP-LEWS as an overwintering refuge. Although the famous black orchid, *Coelogyne pandurata* was rarely encountered during the expedition, it was unexpectedly abundant in the village of Sadap, south of the BKNP boundary.

A further instance of the conservation relationship with areas outside the two protected areas is watershed drainage from BKNP which is critical to the hydrological and biological integrity of the downstream wetland reserve of Danau Sentarum. The same can be said for LEWS' importance to Batang Ai National Park. BKNP-LEWS is surrounded, then, by a perimeter of ecological, social and economic features beyond the combined official borders of each protected area, wider still than conventional buffer zones. Furthermore, the shared boundary with LEWS offers protection for only part of BKNP which is also flanked by areas in Sarawak outside the protection of a wildlife sanctuary. It is for these reasons that protected area management should take into account the wider conservation domain straddling domestic and international boundaries.

4.2 Bilateral Research towards Collaborative Management

A primary objective of the expedition was to inventory flora and fauna in selected sites. Indeed, the expedition may become known for its discovery of a cornucopia of new plant and animal species. Although the scientific value of the painstaking work of collecting and identifying the multiplicity of species encountered is undeniable, the expedition would perhaps best be noted as a valuable exercise in bilateral science aimed at strengthening the concept and implementation of trans-border protected area management. Several findings and lessons have emerged from the expedition that can significantly contribute to effective management of BKNP-LEWS as well as to worldwide initiatives to promote the idea of trans-border management of protected areas.

During the expedition teams of scientists worked successfully to make an important contribution to understanding the biodiversity of BKNP-LEWS. The interaction between the Indonesian and Malaysian scientists was both productive and collegial. Cross-fertilisation of ideas and productive interchange of comment and opinion was evident, despite some differing methodologies and interpretations - the fertile ground of constructive scientific dialogue. Inter-institutional ties were also strengthened. In keeping with the baseline nature of the science, a firm foundation for future scientific collaboration was established.

It might be concluded that as productive as the bilateral research initiative may have been, political realities can make realisation of trans-border conservation problematic over the long-term time frame essential for effective management. Indications of the commitment of Indonesia and Malaysia to the trans-border concept as applied to BKNP-LEWS as well as the experience of the expedition itself suggest a different and more positive conclusion with one important qualification. The higher political profile of such trans-border conservation activities may persuade governments to provide the necessary support and remove major threats such as nearby large-scale development schemes, e.g., nearby plantation schemes, mines and major roads.

Shared conservation objectives for the combined protected areas of BKNP and LEWS does not require joint management. Achieving joint park management is difficult when diverse government and non-government stakeholders are involved. Bilateral research collaboration based upon a shared commitment of each nation to conserve BKNP and LEWS according to the separate management plans probably offers the best chance of maintaining the ecological integrity of the trans-border area. In practice, this could be realized through periodic dialogue about research of mutual importance which has implications for protected area management. This would include discussion of research agendas as well as results of completed research. In time, successful research collaboration might evolve into closer linkages between the management institutions of both protected areas.

4.3 Spatial and Temporal Dimensions of Conservation Research

The expedition has increased our knowledge about biodiversity within BKNP-LEWS with observations of new records of known species and discoveries of new species. Many instances of differences across sites have added to our understanding of the palaeohistory of the area. Spatial distribution of species and forest habitats have provided valuable insights into the design of meaningful park zonation. Thus, lowland dipterocarp, hill dipterocarp, sub-montane, montane and summit ridge forest sub-systems were recognized and studied.

Spatial distributions are obviously not static. Evidence of changes over time are crucial to developing sound conservation strategies. Thus, research observations of a more temporal nature, however, may have the most far reaching implications for the future of BKNP-LEWS. A symbolic reminder of this was perhaps the discovery in Derian, BKNP, of the town-dwelling tree sparrow. Excitement about evidence of impressive biodiversity need to be tempered by the fact of exotic flora and fauna deep in the interior of the conservation areas. High orangutan populations suggest a rich habitat or refuge from the loss of original habitats through human disturbance. Shifting cultivators penetrated both areas some thirty years ago only later to abandon them.

New encroachments of shifting cultivators may only be a matter of time; hunters and gatherers who are also shifting cultivators already reach far into BKNP and may be more prevalent in LEWS than is generally acknowledged. There may even be more avifaunal and large mammal biodiversity where there is a mosaic of shifting cultivator plots at different stages of regeneration. The economic crisis of 1997/98 has almost certainly increased local reliance on forest resources, perhaps leading to over-exploitation of exportable commodities such as birds nests and *gaharu* which have more than tripled in value in local currency terms.

Time, of course, is not always tilted against conservation. Out-migration from villages to urban centres or other areas with growing employment opportunities may reduce encroachment pressure on the forest. Industrial and commercial development in urban centres, while presenting environmental challenges of its own, can therefore be a boon to conservation by reducing direct pressure on the forest[7] and, with rising incomes, creating greater public concerns about the environment. Given time, some deforestation can be reversed. Observations of the botanists and forest ecologists indicated vigorous forest regeneration in areas long-abandoned by shifting cultivators.

4.4 Trans-border Local Communities as Assets to Conservation

Findings of the socioeconomists, ethnobotanists and anthropologists provide encouragement for the idea that the right protected area policies can create alliances with local people to support conservation and that the wrong policies, albeit well-meant, can only encourage local communities to constitute a threat to the integrity of conservation areas. It is clear that people value parts of the forest as forest, for non-timber products (e.g., tradeable such as rattan and medicinals) and small quantities of timber for local use. Most encouraging of all, Iban and Tamambaloh Dayaks have traditionally conserved natural forests in their settlement areas. These *kampung galao* (Iban) or *toan palalo* (Tamambaloh) areas have also been identified elsewhere, e.g., *tanah ulen* in East Kalimantan.

In some conservationists' eyes, local people represent one of the most serious threats to protected areas but seen from another perspective they represent the last line of defence against encroachment. Conservation budgets are limited and park ranger resources spread thinly. Who but local people can effectively alert authorities to outside threats to the parks? But in return, can secure access to specific forest resources be offered in exchange for community participation in park management, i.e., recognition of traditional access rights with responsibilities? An important point about responsibilities as well as rights is that, contrary to idyllic images of harmony between indigenous people and their natural surroundings, not all traditional practices are inherently conducive to biodiversity conservation, although some are eminently so, e.g. *kampung galao*.

Conservation management agreements with local people such as the Iban and Tamambaloh Dayak groups, especially less integrated groups such as the Punan, must be clear and complementary on either side of border lest they create confusion and a sense of being jostled between two different sets of regulations and agreements. The task is no easy one because of the differing social objectives of BKNP and LEWS, ranging from objectives to actively involve local communities to minimization of their role in protected area management, respectively. Encouragingly, adjacent village communities are

[7] Vincent & Ali 1998

likely to differ less than the political institutions under which they find themselves. Hence, there is the possibility for effective community collaboration under simple conservation guidelines acceptable to both nations, e.g., agreement to exchange information about illegal harvesting and report to respective forest rangers.

In conclusion, local people, far from being the greatest threat to BKNP-LEWS conservation, can become its greatest asset. Ironically, local people on either side of the border, with shared cultural backgrounds, may find it easier to collaborate than government officials from the civil services of two different countries. This again argues for devolution of management implementation as far as possible to the local level while maintaining over-arching policy control from the centre.

4.5 Integrating Ecological Imperatives with Economic Necessity: *Oikos*

One of the most notable successes of the expedition was its multi-disciplinary approach ranging from inventories of botanical families and forest ecology to anthropology and socioeconomics. It provided a sobering reminder of the inextricable relationship between economic forces and ecological integrity, a relationship that is conventionally regarded as an antagonistic one. Etymology confirms this[8]. Thus, the origin of the prefix eco- is rooted in the ancient Greek word *oikos* for house and the suffixes -nomics and -logy originate from words which means accounting or reckoning. One of the underlying reasons why deforestation continues inexorably is that forest managers, be they corporate or community, simply do not place their highest priority on conserving the forest as forest and the underlying reasons for this can often be found in inappropriate exploitation and conservation policies[9].

The trans-border nature of BKNP-LEWS highlights the interplay between economics and ecology, specifically the market values of the forest resource and its biodiversity endowment. Certainly, economic incentives can generate threats, e.g., illegal, commercial fishing in the upper reaches of Embaloh and Katibas rivers, over-exploitation of *gaharu* and the CITES-condemned international trade in primates such as orangutan, illegal logging as well as shifting cultivation. As mentioned above, incentives to extract internationally tradeable commodities such as primates and *gaharu* have risen dramatically over the past year (1997/98) because currency depreciations will have greatly increased domestic sale prices for exportable

[8] Bennett 1998
[9] Bennett 1996

commodities. Unemployment as a result of the economic crisis during this period is likely to have increased dependence on forest resources.

In recent years, expectations have grown that ecotourism can play a key economic role in protected area management, providing employment for local people as guides or income from handicraft sales, incentives for the preservation of traditional artifacts and dwellings as well as for traditional uses of plants. Ecotourism can also encourage tourism with an eco-friendly impact and generally increasing public awareness about the benefits of conservation. Ecotourism prospects for BKNP are modest at best and should not draw down a disproportionate amount of development funds. Interestingly and again stressing the importance of the trans-border concept, access from Sarawak is likely to remain the practical option for ecotourists for some time to come. Finally, the problem of deteriorating long houses in Batang Ai National Park, Sarawak, is a sobering reminder of the impact of economic opportunities outside protected areas, arguably good for the park, bad for ecotourism.

In recent years, recognition of the diverse values of biodiversity conservation has resulted in attempts to calculate the total economic value (TEV) of protected areas covering the full range of direct, market values to intangible, non-market values. A vast body of literature attests to this trend. It has been suggested that such studies should be undertaken of BKNP-LEWS (Gilmour 1998). Whereas estimates of market values are relatively straight forward and immediately informative, non-market approaches such as contingent valuation and travel cost methods are subject to biases and rely on widely differing assumptions as well as being high-cost to undertake well (Bennett 1998). There is the further question of what use TEVs are where protected areas have already been gazetted. Less ambitious, targeted valuations may prove more useful, e.g., the economic value of readily-traded *gaharu* and alternative, more sustainable exploitation practices.

In sum, recognition of economic realities, if supported by appropriate conservation policies through appropriate resource agreements with local communities, should ultimately favour conservation of the trans-border protected area of BKNP-LEWS.

5. LESSONS FROM PARK MANAGEMENT EXPERIENCE

Indonesia and Malaysia have a long history of conservation development. Over the past decade several protected areas have come under so-called Integrated Conservation Development Programmes (ICDP). The lessons learned from the experience of ICDP[10] and similar approaches are particularly relevant for the development of trans-border protected area initiatives. This section draws on the findings of conservation programmes and studies implemented by Indonesia in collaboration with World Bank (Wells 1997), Asian Development Bank, USAID[11] as well as those of the authors. Among four of the more awkward constraints to successful conservation management of large protected areas such as trans-border parks which typically involve more than one administrative institution are:

- **Conservation Threats**

  There is a tendency to exaggerate threats to protected areas from local communities and to underestimate those from large public and investments (e.g., road construction, logging, estate crop development).

- **Local Stakeholder Participation**

  Entrenched government misperceptions of the rudimentary capacity and questionable motives of local institutions severely constrains meaningful opportunity for active participation by local communities (see 4, below). Given the relatively small number of staff and resources allocated by conservation departments to on-site management, local participation becomes even more important. Nonetheless, resource allocation agreements or rights must include community acceptance of responsibilities to keep within agreed park impact parameters consistent with simple, clear and outcome-based guidelines (see below).

- **Management Planning**

  Management planning often places too much emphasis on concentrated infrastructure approaches and too little on low-cost, dispersed strategies which would better reflect both limited development budgets and socio-economic realities. One impressive HQ is likely to be less effective than several lower cost and more modest ranger posts around the park (which can also be used as research posts).

- **Developmental and Regulatory Framework**

  Conservation development approaches tend to be overly-prescriptive and inflexible rather than end results- or outcome-based[12] Thus, instead of focussing on conservation goals (and how they can be effectively monitored in a way readily understood by stakeholders), government

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[10] Wells 1997
[11] Merril & Saunders 1998
[12] Bennet 1997

development projects and regulations prescribe management practices along rigid guidelines established primarily at the centre and therefore rarely adaptable to local conditions (related to 2, above).

6. RECOMMENDATIONS FOR FUTURE RESEARCH INTO EFFECTIVE TRANS-BORDER MANAGEMENT

Along with the impressive array of faunal and floral data, the bilateral research of the expedition represented an important start in the collection of information which can be translated into the knowledge necessary for conservation of the trans-border area of BKNP-LEWS. Future bilateral scientific research should have a direct bearing on the theme which has underpinned ITTO's support from the start, namely, support of trans-border initiatives for protected areas. Initially, however, bilateral BKNP-LEWS initiatives should be restricted to collaborative research. The following research and development activities and topics are recommended:

6.1 Biological Research

a) Biodiversity Inventories

A similar second expedition devoted to the production of checklists of flora and fauna in the two areas is obviously necessary. This strategy is probably of greater value for the BKNP where biodiversity endowment is relatively less understood than in LEWS. Information gathered from such a follow-up expedition would greatly assist completion of the management plan, in particular, park zonation. Again, this is of less importance to LEWS which already has an operational management plan. Inventorying biodiversity is a task without end and is arguably less important to the survival of the trans-border conservation area than the migration studies described below.

b) Trans-border Migrations of Flora and Fauna

Studies of migration across the international frontier of people, primates, smaller mammals, herpetofauna as well as flora would be of inestimable value to protection of BKNP-LEWS. This would require cross-border surveys between the two protected areas and between these areas and relevant areas outside the protected area boundaries, that is to say within the conservation domain. There should also be seasonal components requiring field visits during the dry and rainy seasons. Another related migration issue (with national as well as international implications) worthy of research is that between lowland and highland regions as well as upstream and downstream, both of which should contribute to efforts to develop park zonation.

c) Biodiversity Context and Information

Conduct a literature review to place BKNP-LEWS in the context of the Bornean and global centres of biodiversity. Establish a web page for the area and an occasional electronic Newsletter to cover advances in research about the area as well as information about other trans-border areas.

6.2 Institutional Framework and Strengthening

a) Institutional Framework for Trans-border Management

Explore decision-making, information-dissemination and conflict-resolution mechanisms which would contribute to the separate management systems for BKNP and LEWS without unduly interfering in issues of national sovereignty. One of the first steps in this research would be to identify the trans-border conservation domain and the management challenges it presents. For example, Batang Ai National Park and Danau Sentarum Wildlife Sanctuaries should be included within the domain.

b) Analysis of Threats to Ecosystem Integrity

There is a pressing need to understand the relative importance of a wide range of conservation threats. Careful analysis of threats to biodiversity conservation in BKNP-LEWS are essential for the allocation of limited resources to dealing with the most important problems, some of which may require bilateral action such as cross-border smuggling of endangered or commercial species.

c) Institutional Development

The results of a) above should provide insights into developing a working group to co-ordinate the management of the conservation domain starting with a system for sharing information. An institutional development programme should be developed, including opportunities for appropriate training. The programme should clearly specify institutional scope given the different administrative backgrounds of participating agencies. It will be far better to achieve modest collaborative goals than ambitious joint management schemes which are likely to disappoint all parties and undermine conservation efforts. Although joint management *per se* is unlikely, invaluable collaboration is possible through research and working groups providing inputs for respective protected area institutions.

7. CONCLUSION

The expedition reaffirmed the promising prospects for the further development of the ITTO-sponsored trans-border research initiative for BKNP-LEWS. It also showed that bilateral research collaboration, and the mutual understanding it depends upon, help to facilitate successful national management of the respective parts of the entire conservation domain. There is every indication that the proposal for the expedition at the twentieth session of the International Tropical Timber Council's Committee on Reforestation and Forest Management at Santa Cruz de la Sierra, Bolivia, 21-29 May 1996, will be remembered as a significant step in a new and successful development direction for the ITTO to conserve tropical forest ecosystems through a programme of bilateral research which supports the management of trans-border protected areas.

VI

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VI. BIBLIOGRAPHY

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VII

APPENDICES

APPENDIX 1 : BOTANICAL COLLECTIONS

A: Numbers of specimens collected at each site in BKNP

Location	Team BA	Team BB	Johanis (palms etc.)	Adjun (orchids etc.)	M'sian Ecology Group	Tukirin	Total
Pakararu Camp	105	157	103	6	27	11	409
Derian Camp	72	94	48	2	27		243
Pait Camp	40	76	5	6	32		159
Condong Camp	50	75	39	11	14		189
Pait - Derian	13	-	14	2	-		29
Dusun Sadap	20	-	-		-		20
Totals	300	402	209	27	100	11	1049

B : Numbers of specimens collected at each site in LEWS

Location	Team BA	Team BB	Johanis (palms etc.)	Adjun (orchids etc.)	M'sian Ecology Group	Total
Camp A (Ng. Joh)	130	133	90	14	12	389
Camp B (Sg. Menyarin)	170	188	111	19	33	521
Totals	300	321	201	33	45	900

APPENDIX 2 : PALMS

Areca insignis var. *moorei* (Dransf.) Dransf. - 0591 [2]) , E*
Areca minuta Scheff. - 0599, 0656
Areca jugahpunya Dransf .- 0633 [2]), 0857 [2]) [3]), E
Areca sp. 1 - 0368, 0605, 0595
Areca sp.2 - 0585
Calamus blumei Becc. - 0549, R
Calamus caesius Bl. - 0508, R
Calamus conirostris Becc. - 0684
Calamus corrugatus Becc. - 0597 2), E, R
Calamus divaricatus Becc. 0607 2) 0608 2) E, R
Calamus erioacanthus Becc. - 0881, E, R
Calamus flabellatus Furt. - 0099, 0818
Calamus javensis Bl. - 0047, 0514, 1125
Calamus laevigatus var. *mucronatus* (Becc.) Dransf. - 0055 2) E
Calamus mattanensis Becc.- 061 1), E, R
Calamus myriacanthus Becc. - 0592, 0618, E, R
Calamus ornatus Bl. - 0577, 0578
Calamus paspalanthus Becc. - 0017, 0045, 0515, 0586
Calamus pogonacanthus Becc. - 0546, 0584, 0880
Calamus tenompokensis Furt. - 0020 [2]), 0054 [2]), 0516 [2]), 0654 [2]), 0686, 0878, 0879
Caryota sp. - 0804
Ceratolobus discolor Becc. - 0507, 0510, 0576, 0877
Daemonorops atra Dransf. - 0660, E, R
Daemonorops collarifera Becc. - 0615, 0687, 0688, 1132, 1133, E
Daemonorops didymophylla Becc. - 0803, 0805
Daemonorops formicaria Becc. - 0590 [2]), 0609 [2]), E
Daemonorops fissa Bl. - 0882, E
Daemonorops periancantha Miq. - 0659, 0811
Daemonorops sabut Becc. - 0581
Daemonorops sp. 1 - 0663
Iguanura wallichiana (Wall. ex Mart.) Hook. F. subsp. *malaccensis* (Becc.) Kiew 1), 0360 [2]), 0598 [2]), 0616 [2]), 0619 [2]), E
Korthalsia cheb Becc. - 1 1 43, E
Korthalsia echinometra Becc. - 0806
Korthalsia hispida Becc.- 0042, 0853
Korthalsia rigida BI.- 0060
Korthalsia rostrata BI.- 0041, 1116
Korthalsia rostratioides Mogea [4]) - 1147 [1]), E, R
Licuala borneensis Becc. - 0695, 0895 1)
Licuala petiolulata Becc. - 00 1 9, 0621

Licuala pygmaea Merr. - 0059
Licuala sp. 1 - 0655, 0685
Licuala sp.2 - 0689
Licuala sp.3 - 0893
Pinanga aristata (Burr.) Dransf. - 0536
Pinanga angustisecta - 0617
Pinanga bifidovariegata Mogea [4]) - 0593 [1]), E, R
Pinanga brevipes Becc. - 0538, 0542, 0816 [3])
Pinanga chaiana Dransf. - 0861
Pinanga lepidota Rendle - 0009, 0010, 0217
Pinanga mooreana Dransf - 0651, 0692, 0827, E
Pinanga patula var. borneensis Becc. - 0588
Pinanga salicifolia Bl. - 0518 [1]), 0594 [1]), 0606, 0690, 1104
Pinanga sessilifolia Fuit. - 0025, 0512, 0652, 0662, 0826
Pinanga tenella (H. Wendl.) Scheff. - 0027, 0673
Pinanga tomentella Becc. - 0602 2), 0614 1+2)
Pinanga variegata Becc. - 0035 [2]), 0071 [2]), 0524 [2]),, 0550 [2])
Pinanga sp. 1 - 0015, 0056
Pinanga sp.2 – 0681
Pinanga sp.3 – 0863
Pinanga sp.4 – 0865
Pinanga sp.5 – 0894
Pinanga sp.6 – 0896
Plectocomiopsis geminiflora (Griff.) Becc. - 0583, 1111, 1112
Plectocomiopsis mira Dransf. - 0624, R
Plectocomiopsis triquetra (Becc.) Dransf. - 0579, 1142,
Pogonotium divaricatum Dransf. - 0613 [2]) 0693, E, R
Salacca affinis var. *borneensis* (Becc.) Mogea - 0073, 0657
Salacca dransfieldiana Mogea – 0623 [2]), 0830 [3]), E, R
Salacca vermicularis Becc. - 0072, E
indeterminate 1 - 0802
indet. 2 - 0819
indet. 3 - 0828

* 1 = Photograph available, 2 = new record for West Kalimantan, 3 = new record for Sarawak, 4 = new taxon, E = endemic to Borneo, R= rare; (Collection numbers under ITTO/BA)

APPENDIX 3 : ORCHIDS

SPECIES	SITE*					
	PR	DN	PT	BC	NJ	NM
Acriopsis indica Wight		+	+			+
Adenoncos sp.	+		+			
Afrostasia sp.				+		
Agrostophyllum bicuspidatum J.J. Sm.	+	+	+		+	+
Agrostophyllum glumaceum Hk.f.		+				
Agrostophyllum longifolium Rchb.f.	+			+		
Agrostophyllum majus Hk.f.	+	+	+	+		+
Agrostophyllum sp.	+	+			+	+
Appendicula brevifolia					+	
Appendicula buxifolia Bl.		+				
Appendicula sp.	+	+	+		+	+
Arachnis sp.	+	+				
Bromheadia aporoides Rchb.f.				+		
Bromheadia scirpoidea Ridl.	+					
Bromheadia brevifolia Ridl.	+					
Bulbophyllum binnendijkii J.J. Sim		+				
Bulbophyllum disjunctum Ames & C.Schweif				+		
Bulbophyllum cf. *hamatipes*						+
Bulbophyllum lepidum J.J.S.	+					
Bulbophyllum limbatum Lidl.			+			
Bulbophyllum lobbii J.J.S.		+	+	+		
Bulbophyllum macranthum Lindl.	+					
Bulbophyllum medusae Rchb.F.	+	+	+		+	+
Bulbophyllum odoratum Lindl.		+			+	
Bulbophyllum pupurascens T. et B.			+			
Bulbophyllum salaccense Rchb.f.	+					
Bulbophyllum stella Ridl.	+		+			
Bulbophyllum uniflorum Hasslt.		+	+	+		
Bulbophyllum sp.	+	+	+	+	+	+
*Calanthe pulchra (*Bl.*)* Lindl.				+		
Ceratostylis sp.	+					+
Chelonistele amplissima (Ames & Schweinfurth) Carr				+		
Chelonistele lurida (L. Linden & Cogn.) Pfitzr.				+		
Chelonistele sp.	+					

* BKNP: PR = Pakararu (100-200m), DN = Derian (200-350m), PT= Pait (200-600m), BC = Bukit Condong (950-1200m); LEWS: NJ = Ng Joh (80-200m), NM = Ng Menyarin (100-400m)

SPECIES	**SITE***					
	PR	DN	PT	BC	NJ	NM
Claderia viridifolia Hk.f.	+					
Cleisostoma sp.		+	+	+		
Coelogyne asperata Lindl.	+	+	+		+	+
Coelogyne bruneiensis de Vogel	+					
Coelogyne carnen Hk.f.				+		
Coelogyne echinolabium de Vogel		+		+		
Coelogyne foerstermannii Rchb.f.					+	+
Coelogyne incrassata			+			
Coelogyne massangeana Rchb.f.		+				
Coelogyne rochusseni de Vr.					+	
Coelogyne sp.	+	+	+	+	+	+
Cleisostoma sp.					+	
Cymbidium sp.	+				+	+
Dendrobium acuminatissimum (Bl.) Lindl.					+	
Dendrobium carnosum (Bl.) Lindl.		+		+	+	
Dendrobium concinum Miq.	+					
Dendrobium confusum Schltr.		+				
Dendrobium leonis (Lindl.) Rchb.f.						+
Dendrobium rosellum Ridl.	+		+			
Dendrobium sp.	+	+	+	+	+	+
Dendrobium truncatum Lindl.					+	
Dendrochilum carnosum (Ridl.) Holtt.			+			
Dendrochilum pubescens			+			
Dendrochilum sp.					+	
Dendrochilum longifolium Rchb. f.				+		
Dendrochilum sp.	+	+	+	+	+	+
Dilochia wallichii Lindl.				+		
Dimorphorchis lowii (Lindl.) Rolfe.					+	
Dipodium pictum Lindl.		+	+			
Dipodium scandens J.J.Sm.				+		
Dipodium sp.					+	+
Epigeneium sp.		+			+	+
Eria discolor Lindl.					+	

* BKNP: PR = Pakararu (100-200m), DN = Derian (200-350m), PT= Pait (200-600m), BC = Bukit Condong (950-1200m); LEWS: NJ = Ng Joh (80-200m), NM = Ng Menyarin (100-400m)

SPECIES	SITE*					
	PR	DN	PT	BC	NJ	NM
Eria floribunda Lindl.	+		+			
Eria iridifolia Hk.f.		+				
Eria leiophylla Lindl.					+	
Eria monostachya Lindl.	+	+				+
Eria multiflora Lindl.	+	+		+		
Eria neglecta Ridl.	+					
Eria nutans Lindl.	+			+		
Eria panea Lindl.						+
Eria pellipes Lindl.		+		+		
Eria pulchella Lindl.					+	
Eria rigida Bl.		+				
Eria xanthoceila Ridl.		+				
Eria sp.	+	+	+	+	+	+
Flickingeria sp.	+	+		+		+
Gastrochilus sp.					+	+
Grammatophyllum speciosum Bl.					+	+
Habenaria cf. *Setifolia* Carr.					+	
Liparis compressa (Bl.) Lindl.						+
Liparis condaylobulbon Rchb.f.					+	
Liparis gibbosa Finet.					+	
Liparis grandiflora					+	
Liparis lacerata Ridl.		+				
Liparis latifolia (Bl.) Lindl.					+	
Liparis pallida (Bl.) Lindl.			+			
Liparis sp.	+	+		+	+	+
Lecanorchis sp. 1						+
Lecanorchis sp. 2						+
Macodes sp.		+				
Malaxis cf. *Micrantha* (Hk.f) O.Ktze					+	
Malaxis sp.			+			
Neuwiedia sp.	+	+	+	+		+
Nephelaphyllum sp.						+
Oberonia sp.	+	+			+	
Phaius fauciflorus Bl.				+		

* BKNP: PR = Pakararu (100-200m), DN = Derian (200-350m), PT= Pait (200-600m), BC = Bukit Condong (950-1200m); LEWS: NJ = Ng Joh (80-200m), NM = Ng Menyarin (100-400m)

SPECIES	SITE[*]					
	PR	DN	PT	BC	NJ	NM
Phalaenopsis maculata Rchb.f.			+		+	
Pholidota sp.		+				
Plocoglottis acuminata Bl.					+	
Podochillus sp.				+	+	
Pomatocalpa kuntsleri (Hk.f.) J.J.S.		+	+			
Pomatocalpa spicata Breda	+	+				
Pomatocalpa sp.					+	
Pteroceras sp.		+				
Renanthera sp.						+
Robiquetia spatulata (Bl.) J.J.S.	+					
Robiquetia sp.	+	+			+	+
Sarcochillus sp.		+				
Taeniophyllum sp.		+				
Tainia pupureifolia Carr.	+	+	+			
Thecostele alata Par. & Rchb.f.			+			
Thelasis micrantha J.J.S.		+				
Thelasis sp.	+					
Trichotosia ferox Bl.			+			+
Trichotosia sp. 2			+	+	+	+
Thrixspermum arachnites (Bl.) Rchb.f.	+	+				
Thrixspermum sp.					+	+
Vanila sp.					+	

[*] BKNP: PR = Pakararu (100-200m), DN = Derian (200-350m), PT= Pait (200-600m), BC = Bukit Condong (950-1200m); LEWS: NJ = Ng Joh (80-200m), NM = Ng Menyarin (100-400m)

APPENDIX 4 : BRYOPHYTES

A. Bryophytes of BKNP

No.	Species	Location and Collection Number Pakararu	 Derian	 Pait	 Condong
	Class : Hepaticopsida Order: Jungernaniales				
	Family : Herbertaceae (1)				
1.	*Herberia* sp.				113
	Family : Trichocolesceae (2)				
2.	*Trichocolea tomentella* N. ab. E		55	94	
3.	*Trichocolea* sp. A				111
4.	*Trichocolea* sp. B				161
5.	*Leiomitra hirticaulis* Schust.				112
	Family : Lepidoziaceae / Bazzaniaceae (3)				
6.	*Lepidosia trichoides* N. ab. E				162
7.	*Lepidosia* sp.				158
8.	*Bazzania trilobata* (L.) S.F. Gray			98	
9.	*Bazzania* sp.				139,156
	Family : Calypogeae(3) / Trigonarithaccae (4)				
10.	*Calypogoia* sp.				182
	Family: Cephaloziaccae (5)				
11.	*Masligobryum linguaeforme* V.d. sd. Lc		53		159
12.	*Mastigobryum* sp..		54		
13.	*Kantia arguto*	15			
14.	*Kantia* sp.		90		
15.	*Cephalozia fluitan*	157			
16.	*Modoilieca acutifolia* Lehn. et Ldbg,		62		
	Family: Lophoziaceae (6)				
17.	*Chiloscyphus polyanthus* (L.) Corda			79	
18.	*Nardiai obovaia*				154,160
19.	*Lophocolea* sp.				155
	Family: Radulaccae (7)				
20.	*Radula caringtoni*	13			
21.	*Radula, lindbergii*	29	63		
22.	*Radula* sp, A	8			
23.	*Radula* sp. B				117

No. Species	Location and Collection Number			
	Pakararu	Derian	Pait	Condong
Family: Scapaniaceae (S)				
24. *Scapania ferruginea* Lchn. et L.				163
Family: Epigonanthaceae (9)				
25. *Conoscyous* sp.				153
Family: Jungernaniaceae (10)				
26. *Jungermania* sp.			179	143
Family: Plagiochilaceae (11)				
27. *Plagiochila sandei* Dozy	4,31,32	60	92	168
28. *Plagiochila junghuhniana* V.d. Sd Lc,30				172
29. *Plagiochila* sp,				171
Family: Flullaniaceae (12)				
30. *Frullenia teres* V.d. Sd Ld.	21	61		
31. *Frullenia orientalis* V.d. Sd Ld.				174
32. *Frullenia* sp.			95.	
Family: Lejeuneaceae (13)				
33. *Ptychanthus intermedius* Gottshe	9			
34. *Ptychanthus* sp			83	
35. *Ptychocoleus* sp..	18			
36. *Physocolea* sp.			87,101	
37. *Thysananthus convolutus* Ldbg.				169
38. *Pygnolejeunea* sp.	38			
39. *Hygrolejeunea* sp.	37		99,109	142
40. *Leucholejeunea* sp.	5		180	
41. *Drepanolejeunea* sp. A	11,34		188	
42. *Drepanolejeunea* sp. B.			189,190	
43. *Euosmolejeunea* sp,	38			
44. *Lejeunea ovata*		51		
45. *Lejeunea* sp. A		49		142
46. *Lejeunea* sp. B		52		120
47. *Lejeunea* sp. C	50	88		
48. *Lejeunea* sp, D			89	
49. *Lejeunea* sp. E				175
Family : Schistochilaceae (14)				
50. *Schislochila sciophila* Schust.				133
51. *Schislochila stratosa* (Mont.) Evs.				134
Family: Pelliaceae (15)				
52. *Pellia epiphylla* (L.) Corda				151

No.	Species	Location and Collection Number			
		Pakararu	Derian	Pait	Condong
	Order: Metzgeriales				
	Family: Metzgeriaceae (16)				
53.	*Metzgeria fucoides* Mont. et N.			93	
	Family : Aneuraceae (17)				
54.	*Aneura multifida* (L.) S,F. Gray	12			145
55.	*Aneura indica* (M.S.) St. 7171		71		148
56.	*Aneura ambrosiodes* N. ab E.				146
57.	*Aneura palmata*		81		147
58.	*Aneura* sp.				144
59.	*Riccardiai hymenopilylloides* Schiffil,				159
60.	*Riccardia* sp,	26			
61.	*Cryptothallus mirabilis* Malmb..			178	152
	Family : Pllaviciniaceae (18)				
62.	*Pallavicinia hibernica*		78		151
63.	*Pallavicinia lyelliii*				149
64.	*Pallavicinia* sp. 70		70	104	141
	Order: Marchantiales				
	Family:. Marchantiaceae (19)				
65.	*Damortiera hirsulu* R.	16		110	
	Class : Anthocerotopsida				
	Order: Anthocerotales				
	Family : Anthocerotaceae (20)				
66.	*Antlicceros laevis* Linn.	22	69		
67.	*Dendroceros javanicus* Naib E.	20		187	
	Class: Bryopsida				
	Order: Bryales				
	Family: Fissidentaceae (21)				
68.	*Fissidens zippelianus* Dozy & Molk.	19	56,57,82		176
69.	*Fissidens nobilis* Griff.		77		
70.	*Fissidens gedehensis* Fleisch.			102	
71.	*Fissidens javanicus* Dozy & Molk.			181	
	Family: Dicranaceae (22)				
72.	*Microdus miquilianus* (Mont.) Bescher			107	
73.	*Dicranoloma blumii* (Nees) Par.				127
74.	*Dicranoloma reflexum* (C.Mull.) Ren.				125
	Family: Leucobryaceae (23)				
75.	*Leucobryum javense* (Brid.) Mitt.	1			121
76.	*Leucobryum sanctum* (Brid.) Hamp.			41	122
77.	*Leucobryum* sp.			75	

No. Species	Location and Collection Number Pakararu	Derian	Pait	Condong
78. *Arthrocormus schimperi* Doz. & Molk.			42	
79. *Exodicryon blumii* (C.M.) Fleisch.			43	
Family: Calymperaceae (24)				
80. *Calymperes porrectzim* Mitt.	3	45		
81. *Calymperes serratum* A.Br.		44		
82. *Mitthyridum fasciculatum* (Hook,.& Grev.) Robinson	6.10	72		
83. *Octoblepharum albidum* Hedw.		76		
84. *Leucophanes candidton* (Schwaegr,) Lindb.			96	
85. *Syrrhopodon confertus* Lac.	2,36			
86. *Syrrhopodon aristifolius* Mitt.	17	73	185	
87. *Syrrhopodon muelleri* (Doz. & Molk.) Lac,	74			136
88. *Syrrhopodon tristichus* Nees ex Schwaegr.				126
89. *Syrrhopodon scalariformis* Dix.				128
90. *Syrrhnpodon* sp.			97	
Family: Pottiaceae (25)				
91. *Hyophyla involuta* (Hook.) Jacq.		67		
92. *Hyophyla* sp.				186
Family: Bryaceae (26)				
93. *Bryum* sp.			105	
Family: Rhizogoniaceae (27)				
94. *Rhizogonium spiniforme* (Hedw.) Bruch,				114
95. *Rhizogonium pennatum* Hook. f. & Wils.				129
Family: :Bartramiaceae (28)				
96. *Philonotis mollis* Doz. &, Molk.	24	80	103	
Family: Hypnodendraceae (29)				
97. *Mniodendron divaricatum* (Hsch. et Pw.) Lindb.		56		
98. *Hypnodendron junghuhnii* (C.M.) Lindb.			91	108
Family: Pterobryaceae (30)				
99. *Endrotrichella elegans* (Dz. et Mb.) Fleisch.		59		
Family : Meteoriaceae (31)				
100. *Floribundaria floribunda* (Dz. et Mb.) Fleisch.			85	
101. *Barbela* sp.	14			
Family: Neckeraceae (32)				
102. *Neckeropsis bornensis* Fleisch	23			

No.	Species	Location and Collection Number			
		Pakararu	Derian	Pait	Condong
103.	*Homaliodendron microdendron* (Mont,) Fleisch.	25			
104.	*Pinnatella ambiqua* Fleisch.	28			
105.	*Calyptothecium urvilleanum* (C.M.) Broth.				84
106.	*Himantocladium loriforma* (Lac.) Fleisch.				184
	Family : Hookeriaceae (33)				
107.	*Callicostella papillata* Mitt.	33			
108.	*Callicostelia prabraktiana* C.M.			108	
109.	*Distichophyllum cuspidatum* Doz. & Molk.				164
110.	*Distichophyllum tortile* V.D.B. et Lac.				165,166
	Family: Thuidiaceae (34)				
111.	*Thuidium plumulasum* Doz. & Molk.		68	183	
	Family: Plagiotheciaceae (35)				
112.	*Cteridiadelphus plumularis* (C.M.) Fleisch,		69		
	Family: Schistomitriaceae (36)				
113.	*Schistomitrium apiculatum* Dozy & Molk.				124
	Family: Sematophyllaceae (37)				
114.	*Acanthorrhinchium papillatum* (Harv.) Fleisch.		47	177	
115.	*Acanthorrhinchium* sp.	7,35			46
116.	*Acanthocladium* sp	40			
117.	*Sematophyllum* sp.				106
118.	*Acroporium sigmatodontium* (C.M.) Bioth.				116
119 .	*Acroporium* sp. A				115
120.	*Acroporium.* sp. B				131
121.	*Acroporium* sp. C				137,138, 140
122.	*Trichostellum longisetulum* Fleisch.				173
123 .	*Trichostellum* sp. A				123
124.	*Trichostellum* sp. B				130
125.	*Trichostellum* sp. C				135
126.	*Trismegistia lancifolia* (Harv.) Broth.				170
	Family : Hypnaceae (38)				
127.	*Ectropothecium dealbatum* Jaeg.			65	
128.	*Ectropothecium penzigianum* Fleisch.			66	
129.	*Ectropothecium* sp.		27		
130.	*Vesicularia montagneii* (Bel.) Fleisch.				100
131.	*Vesicularia* sp.				86
132.	*Hypnum* sp.				132

No.	Species	Location and Collection Number			
		Pakararu	Derian	Pait	Condong
	Order: Polytrichales				
	Family : Polytrichaceae (39)				
133.	*Rhacelopus pilifer* Doz. & Molk.				167

B. Bryophytes of LEWS

No.	Species	Location & Coll. No.	
		Joh	Menyarin
	Class : Hepaticopsida		
	Order: Jungermaniales		
	Family: Pseudolepidocoleaceae (1)		
1 .	*Blepharostoma trichophyllum* (L.) Dumort.	224	
	Family: Trichocoleaceae (2)		
2.	*Trichocolea tomentella* Lindb.	212	275
3.	*Trichocolea* sp.	218	
	Family: Lepidoziaceae (3)		
4.	*Lepidozia* sp.		264
	Family:Cephaloziaceae (4)		
5.	*Mastigobryum gibbum* V.d. Sd Lc.	203	
6.	*Mastigobryum venezueleanumi* Molk. Mspt.		265
7.	*Cephalozia* sp..		236
8.	*Calypogeia* sp.		253
9.	*Madotheca acutifolia* Lehn. et Ldbg.	193	
	Family : Lophoziaceae (5)		
10.	*Chiloscyphus polyanthus* (L.) Corda		246
11..	*Lophocolea* sp.	215	248, 277
	Family: Radulaceae (6)		
12.	*Radula caringtoni* I	200, 219	259
	Family: Frullaniaceae / Jubulaceae (7)		
13.	*Frullania* sp.		234,271
14.	*Frullania reflexistipula* V.d. Sd Le.	232	
	Family: Plagiochilaceae / Epigonantaceae (8)		
15.	*Plagiochila* sp.	193	
16.	*Plagiochila propinqua* V.d. Sd Le.	216	
17.	*Plagiochila drepanophylla* V.d. Sd Le.		256

No.	Species	Location and Collection Number Pakararu	Derian	Pait	Condong
	Family: Lejeuneaceae (9)				
18.	*Phrognicoma polymorpha* V.d. Sd Lc,	201, 202, 231			
19.	*Microlejeunea* sp. A		206		
20.	*Microlejeunea* sp. B		207		
21.	*Leplolejeunea* sp.		209		
22.	*Lejeunea diversiloba*		206		
23.	*Lejeunea serpyllifolia*		268		
24.	*Lejeunea decursiva* V.d. Sd Lc.		225		
25.	*Lejeunea* sp. A			266	
26.	*Lejeunea* sp. B			267	
27.	*Lejeunea* sp. C			280	
	Order: Metageriales				
	Family : Pallaviciniaceae (10)				
28.	*Pallavicinia hibernica*			261	
	Family: Aneuraceae (11)				
29.	*Aneura palmata*		214	262	
30.	*Aneura* sp.			270	
31.	*Riccardia* sp.			254	
	Class : *Bryopsida*				
	Family : Fissidentaceae (12)				
32.	*Fissidens papillous* Lac.		210		
33.	*Fissidens nobilis* Griff.			244	
	Family : Leucobryaceae (13)				
34.	*Leucobryum javense.* (Brid.) Mitt.		194	239	
	Family: Calymperaceae (14)				
35.	*Mitthyridium fasciculatum* (Hook. & Grey.) Robinson		195		
36.	*Mitthyridium repens* (Harv.) Robinson			240, 258	
37.	*Leucophanes candidum* (Schwaegr.) Lindb.			245	
38.	*Calymperes* sp.		242		
39.	*Calymperes afzelii* Sw.		198		
40.	*Calymperes lonchophyllum* Schwaegr.		221		
41.	*Arthrocormus schimperi* Dozy & Molk.		195, 205, 226	238	
42.	*Syrrhopodan muelleri* (Dozy & Molk.) Lac.		195		
43.	*Syrrhopodan tristichus* Nees ex. Schwaegr.		196		
44.	*Syrrhopodan loreus* (Lac.) Ruse		197	250	
45.	*Syrrhopodan albovaginatus* Schwaegr.		204		
46.	*Syrrhopodan confertus* Lac.		228	241, 273	
47.	*Syrrhopodan spiculosis* Hook. & Grev.			276	

No.	Species	Location and Collection Number Pakararu	 Derian	 Pait	 Condong
	Family : Pottiaceae (15)				
48.	*Hyophyla javanica* (Nees) Brid.		233	251	
	Family: Rhizogoniaceae *(16)*				
49.	*Rhizogonium spiniforme* (Hedw.) Bruch.		223	274	
	Family: Hypnodendraceae (17)				
50.	*Hypnodendron junghuhnii* (C.M.) Lindb.		220	249	
	Family. Pterobryaceae (18)				
51.	*Endotrichella elegans* (Dz. et Mb.) Fleisch.		229	255	
	Family: Hookeriaceae (19)				
52.	*Chaetomitrium elongatum* Dz. et Mb.		230		
53.	*Chaetomitrium laevifolium* Dix.			237	
	Family. Leucomiaceae (20)				
54.	*Leucomium* sp. A		213, 227		
55.	*Leucomium* sp. B		217		
	Family : Thuidiaceae (21)				
56.	*Thuidium plumulosum* Doz. & Molk.		211		
57.	*Thuidium invense* (Mitt.) Jaeg.			257	
	Family : Sematophyllaceae (22)				
58.	*Sematophyllum* sp.			269	
59.	*Acanthorrhynchium papillatum* (Harv.) Fleisch.			272	
	Family: Hypnaceae (23)				
60.	*Ectropothecium ferruginianum* (C.M.) Jaeg.			260,278	
61.	*Ectropothecium* sp.			263	
62.	*Ctenidiadelphus* sp.		191		
63.	*Isopterigium* sp.			247	
64.	*Taxiphyllum* sp.			252	
	Family : Neckeraceae (24)				
65.	*Himantocladium loriforme* Fleisch.		208	279	
66.	*Himantocladium plumusa* (Nees) Fleisch.			235	
67.	*Himantocladium scrobiculatum* (Nees) Bartram			243	
68.	*Neckeropsis gracilenta* (Lac.) Fleisch.		222		

APPENDIX 5 : FISH

Species recorded from BKNP-LEWS

FAMILY	SPECIES	BKNP	LEWS
CYPRINIDAE	*Barbodes balleroides*	+	
	*Barbodes collingwoodii**	+	+
	Barbodes schwanenfeldii	+	+
	Crossocheilus cf. *cobitis*	+	
	Crossocheilus cobitis	+	
	Crossocheilus oblongus	+	
	Crossocheilus sp.	+	
	Cyclocheilichthys apogon	+	+
	Cyclocheilichthys armatus	+	+
	Cyclocheilichthys heteronema	+	+
	Epalzeorhynchus kallopterus		+
	*Garra borneensis**	+	+
	*Hampala bimaculata**	+	+
	Hampala macrolepidota	+	+
	Labiobarbus kuhlii	+	
	Lobocheilus bo	+	+
	Lobocheilus cf. *bo*	+	+
	Lobocheilus kajanensis	+	+
	Lobocheilus cf. *kajanensis*	+	
	Lobocheilus sp. 1(*)		+
	Lobocheilus hispidus	+	
	Luciosoma cf. *Spilopleura*	+	
	Luciosoma setigerum	+	
	Luciosoma sp. 1(*)	+	+
	Macrochiricthys macrochirus	+	
	Macrochiricthys maculatus	+	
	Osteocheilus borneensis	+	
	Osteocheilus enneaporus	+	
	Osteocheilus intermedius	+	+
	Osteocheilus cf. *intermedius*	+	+
	Osteocheilus hasselti		+
	Osteocheilus kahajanensis	+	

* Endemic to Borneo; (*) Possibly endemic but not yet desribed

FAMILY	SPECIES	BKNP	LEWS
	Osteocheilus microcephalus	+	+
	Osteocheilus pleurotaenia	+	
	Osteocheilus triporus	+	
	Osteocheilus waandersii	+	
	Oxygaster anomalura	+	+
	Paracrossocheilus sp.1(*)		+
	*Paracrossocheilus acerus**	+	+
	*Paracrossocheilus vittatus**		+
	Puntius banksi *		+
	Puntius cf. *Binotatus*		+
	Puntius kuchingensis		+
	Rasbora argyrotaenia	+	+
	Rasbora bankanensis	+	
	Rasbora borneensis		+
	Rasbora caudimaculata		+
	Rasbora cf. *Ennealepis*		+
	Rasbora lateristriata	+	
	Rasbora semilineata	+	
	Rasbora sp.1(*)	+	
	Rasbora sp. 2 (*)	+	
	Rasbora volzii	+	+
	Schismatorhynchus heterorhynchus	+	
	Tor douronensis	+	+
	Tor soro	+	+
	Tor tambra	+	+
	Tor tambroides	+	+
GYRINOCHEILIDAE	*Gyrinocheilus pustulosus**	+	
COBITIDAE	*Acanthopsis choirorynchos*	+	
	Acanthopsis dialuzona	+	
	Acanthopsis octoactinotos	+	
	Acanthopsoides robertsi	+	
	Botia hymenophysa	+	
	Botia macracantha	+	
	Botia reversa	+	
	Botia sp.	+	
	Pangio anguillaris	+	
	Vailliaptella maasi	+	
FAMILY	**SPECIES**	**BKNP**	**LEWS**
	Nemacheilus kapuasensis	+	

	Nemacheilus cf. *kapuasensis*		+
	Nemacheilus cf. *lactogeneus*	+	
	Nemachilus longipectoralis	+	
	Nemacheilus sarawacensis		+
	Nemacheilus spiniferus	+	
	Nemacheilus sp. 1*(*)*	+	+
	Nemachilus sp. 2 *(*)*	+	
BALLITORIDAE	*Gastromyzon embalohensis**	+	
	Gastromyzon cf. *Fasciatus (*)*		+
	*Gastromyzon fasciatus**		+
	Gastromyzon sp. 1 *(*)*	+	+
	Gastromyzon sp. 2 *(*)*		+
	Gastromyzon sp. 3 *(*)*		+
	*Glaniopsis multiradiata **	+	
	Glaniopsis sp.1 *(*)*	+	+
	Glaniopsis sp.2 *(*)*	+	
	Homaloptera nebulosa	+	+
	Homaloptera ophiolepis	+	
	Homaloptera orthogoniata	+	
	Homaloptera sp.	+	
	*Homaloptera stephensoni**	+	+
	Homaloptera tweediei	+	
	Homaloptera zollingeri	+	
	*Neogastromyzon niewenhuisi**	+	+
	Neogastromyzon sp. 1 *(*)*	+	
	Neogastromyzon sp. 2 *(*)*	+	
	Parhomaloptera microstoma	+	+
	*Protomyzon griswoldi**	+	+
	Protomyzon sp. 1*(*)*		+
BAGRIDAE	*Hemibagrus* cf. *bongan*		+
	Hemibagrus nemurus	+	
	Hemibagrus cf. *nemurus*		+
	Leiocassis micropogon	+	
	Leiocassis stenomus	+	
	Leiocassis sp.		+
FAMILY	**SPECIES**	**BKNP**	**LEWS**
	Hemibagrus planiceps	+	
	Hemibagrus cf. *planiceps*	+	

FAMILY	SPECIES	BKNP	LEWS
	Hemibagrus planiceps	+	
	Hemibagrus cf. *planiceps*	+	
	Hemibagrus singaringan	+	
MASTACEMBELIDAE	*Macrognathus aculeatus*		
	Macrognathus cf. *aculeatus*	+	+
	Macrognathus cf. *keihi*		+
	Mastacembelus unicolor	+	+
	Mastacembelus notophthalmus	+	
SISORIDAE	*Bagarius yorrelli*	+	
	Glyptothorax major	+	+
	Glyptothorax platypogon	+	
CLARIIDAE	*Clarias batrachus*	+	
	Clarias teijsmanni	+	
	Channa lucius	+	+
	Clarias sp.		+
OSPHRONEMIDAE	*Osphronemus gouramy*	+	
AKYSIDAE	*Acrochordonichthys melanogaster*	+	
	Akysis macronema	+	
	Parakysis sp.	+	
TETRAODONTIDAE	*Tetraodon leiurus*	+	
	Chonerhinus nefastus		+
GOBIIDAE	*Goby* sp. 1(*)		+

APPENDIX 6 : HERPETOFAUNA

A : Species and individuals collected during the Expedition

Species	PR[1]	DN	PT	SA	BC	NM	NJ	Total
*Leptobrachium abbotti**	4							4
*Leptobrachella mjobergi**		9	2			4	3	18
*Leptolalax hamidi**				1				1
Leptolalax sp. (*)	2							2
Megophrys nasuta			2					2
*Ansonia albomaculata**						1		1
*Ansonia leptopus**			1					1
*Ansonia longidigita**						1		1
*Ansonia minuta**			1					1
Ansonia sp. (*)				1				1
Bufo asper	2			3			9	14
*Bufo divergens**		1			1			2
*Bufo juxtasper**	2	3		6		3	2	16
Pedostibes hosii				3			1	4
*Pelophryne signata**			1					1
Pelophryne sp. (*)					2			2
Metaphrynella sundana	1					1		2
*Microhyla borneensis**			3					3
*Huia cavitympanum**						2		2
*Meristogenys phaeomerus**			2					2
*Meristogenys poecilis**	1		1			29	4	35
Phrynoglossus laevis					2			2
Limnonectes conspicillatus	3	8	4			2	1	18
*Limnonectes ibanorum**	16		4	7		5	13	45
*Limnonectes leporinus**	2	2	1			6	2	13
Limnonectes malesianus						2		2
Rana chalconota	4	2	4	3			6	19
Rana hosii	7		1	10		3	1	22
Rana laticeps						1		1
*Rana picturata**	1	1				1	1	4
Staurois latopalmatus	6	2	4	2		6		20
*Staurois natator**	12	1	6	2		3	1	25
Nyxctixalus pictus						1		1
Philautus hosii		1						1
*Philautus tectus**		1						1

Species	PR[1]	DN	PT	SA	BC	NM	NJ	Total
Philautus sp. A *(*)*		1						1
Philautus sp. B *(*)*		1						1
Polypedates macrotis						8		8
Rhacophorus appendiculatus						3		3
Rhacophorus pardalis						2	1	3
Rhacophorus sp.	1							1
Heosemys spinosa							1	1
Notochelys platynota								0
Bronchocoela cristatella								0
Draco maximus	1					1		2
Draco sp.							1	1
Gonocephalus grandis	2						3	5
Gonocephalus sp. *(*)*								0
Aeluroscalabotes felinus						1	1	2
Gonydactylus cf. *ingeri**							1	1
*Gonydactylus pubisulcus**								0
Mabuya multifasciata							1	1
Mabuya rudis						2	2	4
*Tropidophorus brookei**	1	1				2		4
Ahaetulla prasina			1					1
Amphiesma flavifrons			1			1		2
Aplopeltura boa		1						1
Boiga dendrophila	1					1		2
Dendrelaphis caudolineatus			1					1
Liopeltis tricolor			1					1
Pareas laevis								0
Pseudorabdion sp. *(*)*			1					1
Rhabdophis chrysarga		1						1
Xenochrophis trianguligera			2					2
Tropidolaemus wagleri						1		1
	70	36	44	38	5	93	55	341

[1] PR = Pakararu, DN = Derian, PT = Sg. Pait, SA = Sg. Aur (BKNP)
NM = Ng. Menyarin, NJ = Ng. Joh (LEWS)

* Endemic species
(*) Possibly endemic species, but not yet identified

B : A checklist of herpetofauna from the BKNP-LEWS

Species	BKNP	LEWS	IBBE 97
Ichthyophis sp.	+	+	
Leptobrachium abbotti *	+	+	+
Leptobrachella mjobergi *	+	+	+
Leptolalax gracilis		+	
*Leptolalax hamidi**	+		+
Leptolalax sp.	+		+ (?)
Megophrys nasuta	+	+	+
*Ansonia albomaculata**	+	+	+
*Ansonia leptopus**	+	+	+
*Ansonia longidigita**		+	+
*Ansonia minuta**	+		+
*Ansonia spinulifer**	+	+	
Ansonia sp.	+		
Bufo asper	+	+	+
*Bufo divergens**	+		+
*Bufo juxtasper**	+	+	+
Bufo melanostictus	+		
*Pedostibes hosii**	+	+	+
*Pelophryne rhopophilius**		+	
*Pelophryne signata**	+	+	+
Pelophryne sp.			+
Chaperina fusca		+	
*Kalophrynus intermedius**		+	
Kalophrynus pleurostigma	+		
*Kalophrynus punctatus**			+
*Kalophrynus subterrestris**		+	
Metaphrynella sundana		+	+
*Microhyla borneensis**	+	+	+
*Microhyla perparva**	+		
*Microhyla petrigena**	+	+	
*Ingerana baluensis**		+	
*Huia cavitympanum**		+	+
*Meristogenys phaeomerus**	+	+	+
Meristogenys poecilus *	+	+	+

* Endemic species, (*) Possibly endemic species, but not yet idemified

* Endemic species, (*) Possibly endemic species, but not yet idemified

Species	BKNP	LEWS	IBBE 97
Phrynoglossus laevis	+	+	
Rana chalconota	+	+	+
Rana erythraea	+		
Rana glandulosa	+		
Rana hosii	+	+	+
*Limnonectes ibanorum**	+	+	+
Limnonectes conspicillatus	+	+	+
Rana laticeps		+	+
Limnonectes leporinus	+	+	+
Rana luctuosa		+	
Limnonectes malesianus	+	+	+
Rana nicobariensis	+		
Limnonectes palavanensis	+	+	
Rana picturata	+	+	+
Rana signata	+		
*Staurois latopalmatus**	+	+	+
*Staurois natator**	+	+	+
*Staurois tuberilinguis**	+		
Nyctixalus pictus	+	+	
Philautus aurisfasciatus	+		
*Philautus gauni**	+	+	
*Philautus hosii**	+	+	+
*Philautus mjobergi**	+		
*Philautus refugii**		+	
*Philautus tectus**	+	+ (?)	+
Philautus sp. A	+		
Philautus sp. B	+		
Polypedates leucomystax	+		
Polypedates macrotis		+	+
*Polypedates otilophus**	+	+	
Rhacophorus appendiculatus	+	+	+
Rhacophorus bimaculatus		+ (?)	
*Rhacophorus harrisoni**		+	
Rhacophorus kajau	+		
Rhacophorus nigropalmatus		+	
Rhacophorus pardalis		+	+

* Endemic species, (*) Possibly endemic species, but not yet idemified

Species	BKNP	LEWS	IBBE 97
Rhacophorus reinwardti		+	
*Rhacophorus rufipes**	+	+	
Rhacophorus sp.	+		
Manouria emys	+		
Heosemys spinosa			+
Notochelys platynota	+		+
Dogania subplana	+		
Crocodylus porosus	+		
Tomistoma schlegeli	+		
Aphaniotis fuscus	+		
Bronchocoela cristatella	+		+
Bronchocoela jubata	+		
Draco quinquefasciatus		+	
Draco maximus	+		
Draco volans	+		
Draco sp.			+
Gonocephalus doriae		+	
Gonocephalus grandis	+	+	+
*Gonocephalus borneensis**		+	
Gonocephalus megalepis	+		
Gonocephalus sp.	+		
*Phoxophrys nigrilabris**	+	+	
Pseudocalotes saravacensis *		+	
Aeluroscalabotes felinus	+	+	+
Cosymbotus platyurus	+		
Gecko stentor	+		
Gonydactylus consobrinus	+	+	
Gonydactylus cf. *ingeri*			+
Gonydactylus malayanus	+		
*Gonydactylus pubisulcus**	+	+	+
Gehyra mutilata	+		
Hemidactylus frenatus	+		
*Ophisaurus buttikoferi**		+	
*Apterygodon vittatum**	+		
Dasia olivacea	+		
Mabuya multifasciata	+		+
Mabuya rudis		+	+

* Endemic species, (*) Possibly endemic species, but not yet idemified

Species	BKNP	LEWS	IBBE 97
Sphenomorphus sp. nov.*	+		
Tropidophorus brookei	+	+	+
*Tropidophorus beccari**		+	
Tropidophorus micropus	+		
Varanus dumerilii	+	+	
Varanus salvator	+	+	
Cylindrophis engkariensis		+	
Python curtus		+	
Python reticulatus		+	
Ahaetulla prasina	+	+	+
*Amphiesma flavifrons**	+	+	+
*Amphiesma petersi**	+		
Amphiesma saravacensis		+	
Aplopeltura boa			+
Boiga dendrophila	+	+	+
Boiga irregularis	+		
*Calamaria leucocephala**	+	+	
Chrysopelea paradisi		+	
Chrysopelea pelias		+	
Calamaria sp. Nov.(*)	+		
Dendrelaphis caudolineatus	+		+
Dendrelaphis pictus	+		
Elaphe flavolineata		+	
Gonyophis margaritatis	+	+	
*Hydrablabes periops**		+	
Lepturophis albofuscus	+		
Liopeltis baliodeirus		+	
Liopeltis tricolor	+		+
Liopeltis longicauda		+	
Lycodon aulicus		+	
*Opisthotropis typica**		+	
Pareas laevis		+	+
*Pseudorabdion albonuchalis**	+		
*Pseudorabdion collaris**		+	
Pseudorabdion sp. (*)			+
Rhabdophis chrysarga		+	+

* Endemic species, (*) Possibly endemic species, but not yet idemified

Species	**BKNP**	**LEWS**	**IBBE 97**
*Rhabdophis conspicillata**	+	+	
Xenelaphis hexagonotus	+		
Xenochrophis trianguligera	+	+	+
Xenodermus javanicus	+		
Bungarus flaviceps		+	
Maticora intestinalis		+	
Trimeresurus hageni	+		
*Trimeresurus borneensis**		+	
Trimeresurus sumatranus	+	+	
Tropidolaemus wagleri	+	+	+

APPENDIX 7 : BIRDS

A : A checklist of birds of BKNP-LEWS

Family	Species	English Name	BKNP	LEWS	Status
Anhingidae	*Anhinga melanogaster*	Oriental Darter	+	+	NT
Ardeidae	*Butorides striatus*	Striated Heron	+	+	
	*Egretta alba**	Great Egret	+		
	Egretta garzeta	Little Egret	+	+	M
Accipitridae	*Accipiter nisus**	Eurasian Sparrowhawk	+		M
	*Accipiter trivirgatus**	Crested Goshawk	+		
	*Haliastur indus***	Brahminy Kite	+	+	
	Hieraaetus kienerii * **	Rufous-Bellied Eagle	+	+	
	Ichthyophaga humilis	Lesser-fish Eagle	+	+	NT
	*Ichthyophaga ichthyaetus***	Grey-headed Fish Eagle		+	NT
	Ictinaetus malayensis	Black Eagle	+	+	
	*Microhierax fringillarius***	Black-thighed Falconet		+	
	*Milvus migran**	Black Kite	+		
	*Spizaetus cirrhatus***	Changeable Hawk-Eagle		+	
	Spilornis cheela	Crested Serpent Eagle	+	+	
	Spizaetus alboniger	Blyth's Hawk-Eagle		+	
	*Spizaetus nanus**	Wallace's Hawk-Eagle	+	+	V
Phasianidae	*Argusianus argus*	Great Argus	+	+	
	*Haematortyx sanguiniceps***	Crimson-headed Partridge		+	E
	Lophura bulweri	Bulwer's Pheasant	+	+	V,E
	*Lophura ignita***	Crested Fireback	+	+	V
	Rollulus rouloul	Crested Partridge	+	+	
Scolopacidae	*Tringa hypoleucos***	Common Sandpiper	+	+	M
Phalaropidae	*Phalaropus lobatus*	Red-Necked Phalarope	+		M
Columbidae	*Chalcopaps indica*	Emerald Dove	+	+	
	*Ducula badia**	Mountain Imperial-Pigeon	+		
	Macropygia emiliana	Ruddy Cuckoo-Dove	+		
	*Macropygia ruficeps**	Little Cuckoo-Dove	+		
	*Treron capellei***	Large Green Pigeon		+	NT

* Recorded by Raharjaningtrah and Prayogo, November-December 1996, Embaloh Basin, BKNP

** Recorded by Grubh (1994) and Kavanagh (1981), LEWS

E = endemic, M = migrant, NT = near threatened, V = vulnerable

Family	Species	English Name	BKNP	LEWS	Status
	*Treron curvirostra***	Thick-billed Green Pigeon		+	
	*Treron fulvicollis***	Cinnamon-headed Green Pigeon		+	NT
	*Treron olax***	Little Green Pigeon		+	
Psittacidae	*Loriculus galgulus*	Blue-crowned Hanging-Parrot	+	+	
	*Psittacula longicauda**	Long-Tailed Parakeet	+		
	*Psittinus cyanurus***	Blue-Rumped Parrot		+	NT
Cuculidae	*Cacomantis variolosus***	Brush Cuckoo		+	
	*Cacomantis sonneratii***	Banded Bay Cuckoo		+	
	Centropus bengalensis	Lesser Coucal		+	
	Centropus sinensis	Greater Coucal	+	+	
	*Chalcites xanthorhynchus***	Violet Cuckoo		+	
	*Cuculus canorus**	Common Cuckoo	+		
	Cuculus merulinus	Plaintive Cuckoo	+	+	
	*Cuculus micropterus***	Indian Cuckoo	+	+	
	Cuculus saturatus	Oriental Cuckoo	+		
	*Cuculus vagans***	Moustached Hawk-Cuckoo		+	
	Eudynamis scolopaceae	Asian Koel	+		
	*Phaenicophaeus curvirostris***	Chesnut-Breasted Malkoha	+	+	
	Phaenicophaeus javanicus	Red-Billed Malkoha	+	+	
	*Phaenicophaeus sumatranus**	Chesnut-Bellied Malkoha	+	+	
	Phaenicophaeus chlorophaeus	Raffles's Malkoha	+	+	
	*Phaenicophaeus diardii**	Black-Bellied Malkoha	+	+	
	Surniculus lugubris	Drongo Cuckoo	+	+	
Strigidae	*Bubo sumatrana***	Barred Eagle-Owl		+	
	Ketupa ketupu ***	Buffi Fish-Owl	+	+	
	*Ninox scutulata***	Brown Boobook		+	
	*Otus rufescens***	Reddish Scopsowl		+	
	*Phodilus badius***	Oriental Bay Owl		+	
Caprimulgidae	*Eurostopodus temminckii*	Malaysian Eared-Nightjar	+	+	
Apodidae	*Apus affinis***	Little Swift		+	
	*eHirundapus gigantea***	Brown-backed Needletail		+	
	Hydrochous gigas ***	Giant Swiftlet	+		

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Family	Species	English Name	BKNP	LEWS	Status
	Rhaphidura leucopygialis	Silver-Rumped Swift	+	+	NT
Hemiprocnidae	*Hemiprocne longipennis* * **	Grey-Rumped Treeswift	+	+	
	Hemiprocne comata	Whiskered Treeswift	+	+	
Trogonidae	*Harpactes diardii*	Diard's Trogon	+	+	
	Harpactes duvaucelli	Scarlet-Rumped Trogon	+	+	
	*Harpactes orrhophaeus***	Cinnamon-Rumped Trogon		+	
	Harpactes kasumba	Red-Naped Trogon	+	+	
	Harpactes whiteheadi	Whitehead's Trogon	+		
Alcedinidae	*Actenoides concretus*	Rufous-Collared Kingfisher	+	+	
	Alcedo atthis * **	Common Kingfisher	+	+	
	Alcedo euryzona	Blue-Banded Kingfisher	+	+	M
	Alcedo meninting	Blue-Eared Kingfisher	+	+	
	Ceyx erithacus	Black-Backed Kingfisher	+	+	
	Ceyx rufidorsa	Rufous-Backed Kingfisher	+	+	
	*Halcyon coromanda**	Ruddy Kingfisher	+		
	*Halcyon pileata***	Black-Capped Kingfisher	+	+	M
	Lacedo pulchella	Banded Kingfisher	+	+	M
	Pelargopsis capensis	Stork-Billed Kingfisher	+	+	
Meropidae	*Merops viridis* **	Blue-throated Bee-eater		+	
	Nyctyornis amictus	Red-bearded Bee-eater		+	
Bucerotidae	*Aceros comatus***	White-Crowned Hornbill	+	+	
	Aceros corrugatus * **	Wrinkled Hornbill	+	+	V
	Aceros undulatus	Wreathed Hornbill	+	+	
	*Anorrhinus galeritus***	Bushy-Crested Hornbill	+	+	
	*Anthracoceros albirostris**	Oriental Pied Hornbill	+		
	Anthracoceros malayanus	Black Hornbill	+	+	NT
	Buceros rhinoceros	Rhinoceros Hornbill	+	+	
	Buceros vigil	Helmeted Hornbill	+	+	
Capitonidae	*Calorhampus fuliginosus*	Brown Barbet	+	+	
	Megalaima chrysopogon	Gold-Whiskered Barbet	+	+	
	Megalaima australis	Blue-Eared Barbet	+	+	
	Megalaima eximia	Bornean Barbet	+	+	E
	*Megalaima henricii***	Yellow-Crowned Barbet	+	+	

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Family	Species	English Name	BKNP	LEWS	Status
	Megalaima mystacophanos	Red-Throated Barbet	+	+	
	*Megalaima pulcherrima***	Golden-Naped Barbet	+	+	E
	*Megalaima monticola**	Mountain Barbet	+		E
	Megalaima rafflesii	Red-Crowned Barbet	+	+	
Indicatoridae	*Indicator archipelagicus***	Malaysian Honeyguide		+	
Picidae	*Blythipicus rubiginosus*	Maroon Woodpecker	+	+	
	Dendrocopus canicapillus	Grey-Capped Woodpecker	+	+	
	*Dinopium javanense**	Common Goldenback	+	+	
	*Dinopium rafflesiii***	Olive-Backed Woodpecker	+	+	
	Dryocopus javensis	White-Bellied Woodpecker		+	
	Hemicircus concretus	Grey and Buff Woodpecker	+	+	
	Meiglyptes tristis	Buff-Rumped Woodpecker	+	+	
	Meiglyptes tukki	Buff-Necked Woodpecker	+	+	
	*Micropternus brachyurus***	Rufous Woodpecker		+	
	*Mulleripicus pulverulentus***	Great Slaty Woodpecker		+	
	Picoides moluccensis	Sunda Woodpecker	+	+	
	*Picus mentalis***	Checker-throated Yellownape		+	
	*Picus miniaceus**	Banded Woodpecker	+		
	Picus puniceus	Crimson-Winged Woodpecker	+	+	
	Reinwardtipicus validus ***	Orange-Backed Woodpecker	+	+	
	*Sasia abnormis***	Rufous Piculet	+	+	
Eurylaimidae	*Calyptomena hosii*	Hose's Broadbill		+	E
	Calyptomena viridis	Green Broadbill	+	+	
	Calyptomena whiteheadi	Whitehead's Broadbill	+		E
	*Corydon sumatranus**	Dusky Broadbill	+	+	
	Cymbirhynchus macrorhynchos	Black and Red Broadbill	+	+	
	Eurylaimus javanicus	Banded Broadbill	+	+	
	Eurylaimus ochromalus	Black and Yellow Broadbill	+	+	
Pittidae	*Pitta arquata* **	Blue-Banded Pitta		+	E
	Pitta baudii	Blue-Headed Pitta	+	+	NT,E
	Pitta brachyura **	Blue-Winged Pitta		+	
	Pitta granatina	Garnet Pitta	+	+	
	*Pitta guajana***	Banded Pitta	+	+	
	*Pitta nympha**	Fairy Pitta	+	+	

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** Recorded by Grubh (1994) and Kavanagh (1981), LEWS

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Family	Species	English Name	BKNP	LEWS	Status
Hirundinidae	*Hirundo rustica***	Barn Swallow		+	M
	*Hirundo tahitica***	Pacific Swallow		+	
Campepha-gidae	*Coracina fimbriata**	Lesser Cuckoo-Shrike	+		
	Coracina larvata	Sunda Cuckoo-Shrike	+		
	*Coracina striata***	Bar-Bellied Cuckoo-Shrike		+	
	Hemipus hirundinaceus	Black-Winged Flycatcher-Shrike	+	+	
	Pericrocotus flammeus	Scarlet Minivet	+		
	*Pericrocotus solaris***	Grey-Chinned Minivet		+	
Chloropseidae	*Aeghitina tiphia*	Common Iora	+		
	Aeghitina viridissima ***	Green Iora	+	+	
	Chloropsis cochinchinensis	Blue-Winged Leafbird	+	+	
	Chloropsis cyanopogon	Lesser Green Leafbird	+	+	
	Chloropsis sonneratii	Greater Green Leafbird	+	+	
Pycnonotidae	*Alophoixus bres*	Grey-Checked Bulbul	+	+	
	*Alophoixus ochraceus***	Ochraceus Bulbul	+	+	
	Alophoixus phaeocephalus	Yellow-Bellied Bulbul	+	+	
	*Criniger finschii***	Finsch's Bulbul	+	+	
	Hypsipetes flavala	Ashy Bulbul	+	+	
	Iole malaccensis	Common Streaked Bulbul		+	
	Iole olivaceae	Buff-Vented Bulbul	+		
	*Ixos malaccensis**	Streaked Bulbul	+		
	*Pycnonotus atriceps**	Black-Headed Bulbul	+	+	
	*Pycnonotus brunneus***	Red-Eyed Bulbul	+	+	
	Pycnonotus cyaniventris	Grey-Bellied Bulbul	+	+	
	*Pycnonotus erythrophthalmos***	Spectacled Bulbul	+	+	
	*Pycnonotus flavescens***	Flavescent Bulbul	+	+	
	*Pycnonotus melanicterus***	Black-Crested Bulbul	+	+	
	*Pycnonotus plumosus**	Olive-Winged Bulbul	+		
	Pycnonotus simplex	Cream-Vented Bulbul	+	+	
	*Pycnonotus squamatus***	Scaly-Breasted Bulbul	+	+	
	Pycnonotus zeylanicus	Straw-Headed Bulbul	+	+	V
	Pycnonotus eutilotus	Puff Backed Bulbul	+	+	
	*Pycnonotus melanoleucos***	Black and White Bulbul	+	+	

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Family	Species	English Name	BKNP	LEWS	Status
	*Setornis criniger***	Hook-Billed Bulbul	+	+	NT
	Tricholestes criniger	Hairy-Backed Bulbul	+	+	
Dicruridae	*Dicrurus aeneus*	Bronzed Drongo	+	+	
	Dicrurus annectans	Crow-Billed Drongo	+	+	
	Dicrurus paradiseus	Greater Racket-Tailed Deongo	+	+	
	Dicrurus hottentotus	Spangled Drongo	+		
Oriolidae	*Oriolus xanthonotus**	Dark-Throated Drongo	+	+	
	Irena puella	Asian Fairy-Bluebird	+	+	
	*Corvus macrorhynchos**	Large-Billed Crow	+		
	Dendrocitta cinarascens	Bornean Treepie	+		
	Platylophus galericulatus	Crested Jay	+	+	
	Platysmurus leucopterus	Black Magpie	+	+	
	*Pityriasis gymnocephala***	Bornean Bristlehead		+	NT
Sittidae	*Sitta frontalis***	Velvet-Fronted Nuthatch		+	
Timaliidae	*Alcippe bruneicauda*	Brown Fulvetta	+	+	
	*Eupetes macrocercus***	Malaysian Rail-Babbler		+	
	Kenopia striata	Striped Wren-Babbler	+	+	
	*Macronous gularis****	Striped Tit-Babbler		+	
	Macronous ptilosus	Fluffy-Backed Tit-Babbler	+	+	
	*Malacocincla abboti**I*	Abbott's Babbler	+	+	
	Malacocincla malaccensis	Short-Tailed Babbler	+	+	
	Malacocincla perspicillata	Black-Browned Babbler	+		V,E
	Malacocincla sepiarium	Horsfield's Babbler	+	+	
	Malacopteron affine	Sooty-Caped Babbler	+	+	
	Malacopteron albogularae	Grey-Breasted Babbler	+		NT
	Malacopteron cinereum	Scaly-Crowned Babbler	+	+	
	Malacopteron magnirostre	Moustached Babbler	+	+	
	Malacopteron magnum	Rufous-Crowned Babbler	+	+	
	Napothera atrigularis	Black-Throated Wren-Babbler		+	E
	Napothera epilepidota	Eye-Browed Wren-Babbler	+		
	Pellorneum capistratum	Black-Capped Babbler	+	+	
	*Pellorneum pyrrogenys***	Temminck's Babbler	+	+	
	*Pomatorhinus montanus***	Chesnut-Backed Scimitar-Babbler	+	+	

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Family	Species	English Name	BKNP	LEWS	Status
	Ptilocichla leucogrammica	Bornean Wren-Babbler	+	+	NT,E
	Stachyris erythropthera	Chesnut-Winged Babbler	+	+	
	*Stachyris leucotis***	White-Necked Babbler	+	+	
	Stachyris maculata	Chestnut-Rumped Babbler	+	+	
	Stachyris nigriceps	Grey-Throated Babbler	+	+	
	Stachyris nigricollis	Black-Throated Babbler	+	+	
	Stachyris poliocephala	Grey-Headed Babbler	+	+	
	*Stachyris rufifrons***	Rufous-Fronted Babbler	+	+	
	Trichastoma bicolor	Ferruginous Babbler	+	+	NT
	*Trichastoma rostratum***	White-Chested Babbler	+	+	NT
	*Yuhina everetti***	Chesnut-Crested Yuhina	+	+	E
	*Yuhina zantholeuca***	White-Bellied Yuhina	+	+	
Turdidae	*Brachypteryx montana*	White-Browed Shortwing	+		
	Copsychus malabaricus	White-Rumped Shama	+	+	
	*Copsychus saularis**	Magpie Robin	+	+	
	Enicurus leschenaulti	White-Crowned Forktail	+	+	
	Enicurus ruficapillus	Chesnut-Naped Forktail	+	+	
	*Oenanthe oenanthe**	Wheatear	+		M
	Trichixos pyrrhopygus ***	Rufous-Tailed Shama	+	+	
	*Zoothera interpres***	Chesnut-Capped Thrush	+	+	
Sylviidäe	*Abroscopus superciliaris***	Yellow-Bellied Warbler		+	
	*Gerygone sulphurea**	Flyeater		+	
	Locustela lanceolata	Lanceolated Warbler	+		M
	Locustela certhiola	Pallas's Warbler	+		M
	Orthotomus atrogularis	Dark-Necked Tailorbird	+	+	
	Orthotomus cuculatus	Mountain Tailorbird	+	+	
	Orthotomus sericeus	Rufous-Tailed Tailorbird	+	+	
	Phylloscopus borealis	Arctic Leaf-Warbler		+	M
	*Prinia flaviventris***	Yellow-Bellied Prinia		+	
Muscicapidae	*Culicicapa ceylonensis*	Grey-Headed Flycatcher	+	+	
	Cyornis banyumas	Hill-Blue-Flycatcher	+	+	
	Cyornis caerulatus	Large-Billed Blue-Flycatcher	+	+	NT
	*Cyornis concretus***	Dark Blue Flycatcher		+	

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** Recorded by Grubh (1994) and Kavanagh (1981), LEWS
E = endemic, M = migrant, NT = near threatened, V = vulnerable

Family	Species	English Name	BKNP	LEWS	Status
	*Cyornis rufigastra***, †	Mangrove Blue Flycatcher	+	+	
	Cyornis superbus	Bornean Blue-Flycatcher	+	+	E
	*Cyornis turcosus***	Malaysian Blue-Flycatcher	+	+	NT
	Cyornis unicolor	Pale-Blue-Flycatcher	+	+	
	*Eumyas indigo**	Indigo Flycatcher	+		
	Ficedula dumetoria	Rufous-Chested Flycatcher	+	+	
	Ficedula hyperythra	Snowy-Browed Flycatcher	+		
	*Ficedula mugimaki***	Mugimaki Flycatcher	+	+	M
	Ficedula westermanni	Little Pied Flycatcher	+	+	
	Hypothimis azurea	Black-Naped Monarch	+	+	
	Muscicapa dauurica	Asian Brown Flycatcher	+	+	
	*Muscicapa ferruginea**	Ferruginous Flycatcher	+		
	*Muscicapa griseisticta**	Grey-Streaked Flycatcher	+	+	
	Muscicapa sibirica	Dark-Sided Flycatcher	+		M
	Muscicapella hodgsoni ***	Pygmy Blue-Flycatcher	+	+	
	Philentoma pyrrhopterum	Rufous-Winged Philentoma	+	+	
	*Philentoma velatum***	Maroon-Breasted Philentoma	+	+	
	*Rhinomyas brunneata**	Brown-Chested Jungle Flycatcher	+		V
	Rhinomyas gularis	Eyebrowed Jungle Flycatcher	+		
	Rhinomyas olivaceae	Fulvous-Chested Jungle Flycatcher	+	+	
	Rhinomyas ruficauda	Rufous-Tailed Jungle Flycatcher	+	+	
	Rhinomyas umbratilis	Grey-Chested Flycatcher	+	+	
	*Rhipidura albicollis***	White-Throated Fantail		+	
	*Rhipidura javanica***	Pied Fantail		+	
	Rhipidura perlata	Spotted Fantail	+	+	
	Terpsiphone paradisi	Asian Paradise Flycatcher	+	+	
Motacillidae	*Motacilla cinerea***	Grey Wagtail	+	+	
	Motacilla flava	Yellow Wagtail	+		
Sturnidae	*Gracula religiosa***	Hill Myna	+	+	
Nectariniidae	*Aethopyga mystacalis*	Scarlet Sunbird		+	
	*Aethopyga siparaja***	Crimson Sunbird	+	+	
	*Anthreptes malaccensis***	Brown-Throated Sunbird	+	+	

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** Recorded by Grubh (1994) and Kavanagh (1981), LEWS

E = endemic, M = migrant, NT = near threatened, V = vulnerable

** One of us (SS) has expressed reservation about the presence of this species, since it occurs in primary and secondary forests near coastal areas. The possibility exists that this record is actually *Cyorius caerulatus*, which is very similar.

Family	Species	English Name	BKNP	LEWS	Status
	*Anthreptes rhodolaema**	Red-Throated Sunbird		+	
	Anthreptes simplex	Plain Sunbird	+	+	
	Anthreptes singalensis	Ruby-Chested Sunbird	+	+	
	Arachnothera affinis	Grey-Breasted Spiderhunter	+	+	
	Arachnothera chrysogenys	Yellow-Eared Spiderhunter		+	
	*Arachnothera crassirostris**	Thick-Billed Spiderhunter	+	+	
	Arachnothera everetti	Bornean Spiderhunter	+		E
	Arachnothera flavigaster	Spectacled Spiderhunter	+	+	
	*Arachnothera juliae**	Whitehead's Spiderhunter	+		
	Arachnothera longirostra	Little Spiderhunter	+	+	
	Arachnothera robusta	Long-Billed Spiderhunter	+	+	
	Hypogramma hypogrammicum	Purple-naped Sunbird	+	+	
	Nectarinia sperata	Purple-Throated Sunbird	+		
Dicaeidae	*Dicaeum chrysorheum*	Yellow-Vented Flowerpecker	+	+	
	*Dicaeum concolor***	Plain Flowerpecker	+	+	
	Dicaeum cruentatum	Scarlet-Backed Flowerpecker	+		
	*Dicaeum everetti***	Brown-Backed Flowerpecker	+	+	NT
	*Dicaeum monticolum**	Black-Sided Flowerpecker	+		E
	Dicaeum trigonostigma	Orange-Bellied Flowerpecker	+	+	
	Prionochilus maculatus	Yellow-Breasted Flowerpecker	+	+	
	Prionochilus percussus	Crimson-Rumped Flowerpecker	+	+	
	Prionochilus thoracicus	Scarlet-Breasted Flowerpecker	+	+	
	Prionochilus xanthopygius	Yellow-Rumped Flowerpecker	+	+	
Zosteropidae	*Oculocincta squamifrons**	Pygmy White-eye	+		E
	*Chlorocharis emiliae**	Mountain Black-eye	+		
Ploceidae	*Lonchura fuscans***	Dusky Munia		+	E
	Passer montanus	Eurasian Tree-Sparrow	+		

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[**] Recorded by Grubh (1994) and Kavanagh (1981), LEWS

[E] = endemic, M = migrant, NT = near threatened, V = vulnerable

B : Species and individuals obtained from bird netting in BKNP-LEWS

Family	Species	PR*	SA	DN	BC	NM	NJ	Total
Phalaropidae	*Phalaropus lobatus*	0	1	0	0	0	0	1
Trogonidae	*Harpactes duvaucellii*	2	0	0	0	0	0	2
Columbidae	*Chalcophaps indica*	0	0	0	0	2	0	2
Alcedinidae	*Actenoides concretus*	0	0	1	0	1	1	3
	Alcedo meninting	0	0	0	0	0	1	1
	Ceyx rufidorsa/erithacus	2	2		0	3	4	11
Picidae	*Blythipicus rubiginosus*	0	2	1	1	0	0	4
	Meiglyptes tukki	1	0	0	0	0	0	1
	Sasia abnormis	3	2	0	0	0	0	5
Eurylaimidae	*Calyptomena hosei*	0	0	0	0	0	1	1
	Calyptomena viridis	1	0	2	1	0	6	10
	Cymbirhychus macrorhynchus	0	3	0	0	1	0	4
Pittidae	*Pitta baudi*	0	0	1	0	0	1	2
	Pitta granatina	0	0	1	0	1	0	2
	Pitta nympha	0	0	0	0	1	0	1
Pycnonotidae	*Alophoixus bres*	1	5	1	0	2	5	14
	Alophoixus phaeocephalus	6	2	7	0	4	7	26
	Criniger ochraceous	0	0	0	9	0	0	9
	Pycnonotus eutilotus	0	0	0	0	1	0	1
	Pycnonotus melanoleucos	0	1	0	1	0	0	2
	Pycnonotus simplex	0	0	0	2	0	0	2
	Tricholestes criniger	5	6	1	0	2	0	14
Dicruridae	*Dicrurus paradiseus*						1	1
Corvidae	*Platylophos galericulatus*						1	1
Timaliidae	*Alcippe brunneicauda*	0	0	0	0	1	1	2
	Kenopia striata	0	0	2	0	0	0	2
	Macronous ptilosus	0	0	0	1	3	1	5
	Malacocincla malaccense	3	3	2	0	5	8	21
	Malacocincla sepiarium	5	1	0	0	2	0	8
	Malacopteron affine	0	0	2	0	0	0	2
	Malacopteron cinereum	10	2	10	0	13	8	43
	Malacopteron magnirostre	0	0	2	0	0	1	3
	Malacopteron magnum	1	2	5	0	1	7	16
	Pellorneum capistratum	2	0	2	0	4	2	10
	Pellorneum pyrrhogenys	0	0	0	3	0	0	3
	Pomatorhinus montanus	0	0	0	1	0	0	1
	Ptilocichla leucogrammica	0	0	1	1	0	1	3
	Stachyris leucotis	0	0	0	1	0	0	1
	Stachyris maculata	5	1	1	0	0	0	7
	Stachyris nigriceps	0	0	0	3	0	0	3
	Stachyris nigricollis	0	0	4	0	5	3	12
	Stachyris poliocephala	0	0	2	0	5	1	8
	Trichastoma bicolor	0	2	3	0	1	1	7
	Yuhina zantholeuca	0	0	0	1	0	0	1

* PR = Pakararu, SA = Sg Aur, DN = Derian, BC = Bukit Condong,
NM = Ng Menyarin, NJ = Ng Joh

Family	Species	PR*	SA	DN	BC	NM	NJ	Total
Turdidae	*Copsychus malabaricus*	1	1	2	0	2	3	9
	Copsychus pyrrhopyga	0	0	1	0	0	0	1
	Enicurus leschenaultii	0	0	1	0	2	1	4
Sylviidae	*Locustella lanceolata*	0	1	0	0	0	0	1
Muscicapidae	*Culicicapa ceylonensis*	0	0	0	1	0	0	1
	Cyornis caerulatus	2	0	2	0	4	3	11
	Cyornis superbus	0	1	2	0	1	3	7
	Ficedula dumetoria	0	0	1	1	2	0	4
	Ficedula hyperthyra	0	0	0	1	0	0	1
	Hypothymis azurea	1	2	1	0	1	3	8
	Philentoma pyrrhopterum	3	0	0	2	0	2	7
	Rhinomyias umbratilis	2	5	0	2	0	1	10
	Rhipidura perlata	0	1	2	0	0	0	3
	Terpsiphone paradisi	2	0	0	0	0	0	2
Nectariniidae	*Aethopyga mystacalis*	0	0	0	0	1	0	1
	Anthreptes rhodolaema	0	1	0	0	0	0	1
	Anthreptes simplex	1	2	0	0	0	1	4
	Arachnothera affinis	0	1	0	0	0	0	1
	Arachnothera crassirostris	0	1	0	0	0	0	1
	Arachnothera longirostra	12	7	1	3	14	22	59
	Hypogramma hypogrammicum	2	3	1	0	1	0	7
Dicaeidae	*Prionochilus maculatus*	2	4	3	0	3	3	15
	Prionochilus xanthopygius	1	2	0	0	0	1	4
	Total	76	67	68	35	89	105	440

* PR = Pakararu, SA = Sg Aur, DN = Derian, BC = Bukit Condong, NM = Ng Menyarin, NJ = Ng Joh

APPENDIX 8 : ETHNOBOTANICAL COLLECTIONS

A : Description and background of key informants

Female informants (n=9)

Ibu Atan (Wife of Pak Atan Ak Imbaal); 30+ years old; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Ibu Buda; 30+ years old; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Ibu Deria; 30+ years old; Tamambaloh (married to an Iban called Pak Jaua); teacher; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Ibu Elizabeth; 30+ years old; housewife; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Ibu Juliana Laih; 30+ years old; housewife; Tamambaloh; Dusun Bukong, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar Indonesia.

Ibu Lagi (wife of Pak Lagi Ak Jalin); 26 years old; Iban; Dusun Kelayam, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Ibu Maria Iting; 30+ years old; housewife; Tamambaloh; Dusun Bukong, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas hulu, Kalbar Indonesia.

Ibu Petek (wife of Pak Petek); 30+ years old; Tamambaloh; Dusun Pinjawan, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Ibu Ucing; 30+ years old; housewife; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten kapuas Hulu, Kalbar, Indonesia.

Male informants (n=14)

Adik Adju, Adik Jimi, Adik Yordan; children aged 9, 10 & 11 years old; students; Ibans; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar Indonesia.

Pak David Atan Ak Imbal; 35+ years old; farmer; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Pak Garet; 50+ years old; farmer; Tamambaloh; Dusun Pinjawan, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Pak Igang; 60+ years old; Kepala Desa; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Pak Jalin (father of Pak Lagi Ak Jalin); 60+ years old; farmer; Iban; Dusun Kelayam, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar Indonesia.

Pak Jimbau; 70+ years old; Headman; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar Indonesia.

Pak Jua; 30+ years old; farmer; Iban; Dusun Sadap, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar Indonesia.

Pak Lagi Ak Jalin: 28 years old: Tuai Rumah; Iban; Dusun Kelayam, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Pak Kadie; 30+ years old; farmer; Tamambaloh; Dusun Pinjawan, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Pak Pangi; 50+ years old; farmer; Tamambaloh; Dusun Pinjawan, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Pak Petek; 40+ years old; farmer; Tamambaloh; Dusun Pinjawan, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

Pak Raggae; 30+ years old; farmer; Tamambaloh; Dusun Pinjawan, Desa Toba, Kecamatan Embaloh Hulu, Kabupaten Kapuas Hulu, Kalbar, Indonesia.

B : Ethnobotanical Specimens Collected

Family	Species	Vernacular	Uses
Annonaceae	*Artabotrys costatus*	Akar rarak	Fiber
Apocynaceae	*Willughbeia sarawacensis*	Akar tabau	Food
Aquifoliaceae	*Ilex cissoidea*	Aras	Medicinal
Araceae	*Acorus calamus*	Jeranggau	Medicinal
Blechnaceae	*Nephrolepis biserrata*	Paku keruk	Food/Medicinal
Dilleniaceae	*Tetracera korthalsii*	Mempelas	Medicinal
Elaeocarpaceae	*Elaeocarpus griffithii*	Empedu	Food/Fuelwood
Euphorbiaceae	*Antidesma montarum*	Manyi	Food
Euphorbiaceae	*Baccaurea angulata*	Buah ucong	Food
Euphorbiaceae	*Baccaurea membrancea*	Jaykar babi	Food/Fuelwood
Euphorbiaceae	*Baccaurea brevipes*	Jelentik	Food
Euphorbiaceae	*Euphorbia contarta*	Tapang ular	Medicinal
Euphorbiaceae	*Phyllanthus urinaria*	Rumput merah	Medicinal
Fagaceae	*Castanopsis costata*	Berangan mayau	Food/Fuelwood
Fagaceae	*Castanopsis evansii*	Berangan pipit	Food
Flacourtiaceae	*Flacourtia rukam*	Rukam	Food
Flagellariaceae	*Flagellaria indica*	Wi buntak	Medicinal
Gramineae	*Coix lachryma-jobi*	Engkuliset	Food
Gramineae	*Paspalum conjugatum*	Rumput Belanda	Medicinal
Gramineae	*Saccharum* sp.	Penjaga Tepang	Ritual
Gramineae	*Schizostachyum latifolium*	Buluh Engkalat	Food/Cage
Guttiferae	*Garcinia beccarii*	Kundung	Food
Hypoxidaceae	*Curculigo latifolia*	Lembak umang	Food/Fiber
Labiatae	*Ocimum carum*	Taking	Medicinal
Leguminosae	*Abrus precatorious*	Kayu manis	Yeast
Leguminosae	*Bauhinia acuminata*	Akar tekub dadaup	Medicinal
Leguminosae	*Desmodium pulchellum*	-	Fiber
Leguminosae	*Fordia splendidissima*	Beregenung	Fish Poison
Leguminosae	*Spatholobus oblongifolius*	Akar kemedu	Fiber
Leguminosae	*Spatholobus viridis*	Akar kemedu baloh	Fiber
Leguminosae	*Whitfordtiodendron nieuwenhuisii*	Buah belum	Food
Malvaceae	*Sida rhombifolia*	Rumput pupulut	Medicinal
Melastomaceae	*Bellucia pentamera*	Jambu kerak	Food
Melastomaceae	*Pternandra azurea*	Pulor	Medicinal
Menispermaceae	*Fibrauea tinctoria*	Akar kuning	Medicinal
Moraceae	*Artocarpus dadah*	Dadak	Food/Timber
Moraceae	*Artocarpus odoratissimus*	Pingan	Food
Moraceae	*Artocarpus sericicarpus*	Pedelai	Food/Basketry
Myrtaceae	*Eugenia cephalanthum*	Ubah bungkang	Food/Flavouring
Ophioglossaceae	*Helmintostachys zeylanica*	Paku manis	Food
Palmae	*Calamus javensis*	Wi batu	Basketry

Palmae	*Calamus nemtospadix*	Wi rengut	Fiber
Palmae	*Calamus scipionum*	Wi semambu	Food/Basketry
Palmae	*Calamus paspalanthus*	Wi singkau	Food/Flavouring
Palmae	*Licuala petiolulata*	Daun pelat	Food wrappers
Polygalaceae	*Xanthophyllum velutinum*	Kensei	Food/Fuelwood
Rhamnaceae	*Zizyphus calophylla*	Akar menaul	Medicinal
Rosaceae	*Prunus arborea*	Enteli	Fiber/Container
Rubiaceae	*Morinda citrifolia*	Mengkudu	Dye
Rubiaceae	*Psychotria aurantiaca*	Engkelekat	Medicinal/Dye
Sapindaceae	*Dimocarpus longan*	Merkiang	Food/Fuelwood
Sapindaceae	*Lepisanthes alata*	Engkelili	Food
Sapindaceae	*Lepisanthes amoenum*	Gegambak	Food
Sapindaceae	*Nephelium cuspidatum*	Sibau	Food
Saurauiaceae	*Saurauia glabra*	Inggur	Food
Solanaceae	*Solanum mommasum*	Torung susu	Ritual
Umbelliferae	*Eryngium foetidum*	Daun sop	Spices
Urticaceae	*Elastostema acuminata*	Rumput temayai	Medicinal
Urticaceae	*Leucosyke capitellata*	Daun teh	Food
Urticaceae	*Poikilospermum cordifolium*	Entaban	Food
Violaceae	*Rinorea anguifera*	Siku ensluai	Food/Flavouring
Zingiberaceae	*Curcuma zedoaria*	Katamu	Medicinal
Zingiberaceae	*Etlingera littoralis*	Tepus wangi	Food
Zingiberaceae	*Hornstedtia havilandii*	Penyun	Food/Roofings
Zingiberaceae	*Phrynium* sp.	Iriak	Food wrappers

C : Medicinal Plants

A. Medicinal Plants of the Dusun Sadap Ibans

Species	Vernacular	Uses	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Acorus calamus	Jerangau /Postparturition remedy	Tonic/Stomachache	Roots	+	+	+	+
Bauhinia acuminata	Akar tekup dedaup	Fever	Roots	+	-	-	-
Blechnum orientale	Kelindang	Boils	Young shoots	+	-	-	-
Blumea balsamifera	Mambong	Postparturition remedy /Itchiness on the skin	Leaves	+	+	+	+
Bellucia pentamera	Jambu monyet	Cuts & wounds	Leaves	-	+	-	-
Carica papaya	Rungan	Malarial fever	Young leaves	+	+	-	-
Caryota mitis	Mudor	Stomatitis	Young shoots	+	+	-	-
Cassia alata	Serugan	Skin diseases	Leaves	+	+	-	-
Ceiba pentandra	Kabu	Intermittent fever	Leaves	+	+	-	-
Clerodendrum paniculatum	Bunga panggil	Ritualistic healing	Whole plant	+	+	-	-
Commelina nudiflora	Rumput laru	Anti-coagulant	Young leaves	+	-	-	-
Cordyline terminalis	Daun sabang	Headache	Roots	-	-	+	+
Costus glabra	Pakbu	Intermittent coughs	Young shoots	+	+	-	-
Curcuma domesticum	Kunus	Stomach ache	Rhizomes	-	+	-	-
Curcuma zerumbet	Kantamu	Broken bones	Rhizomes	-	-	+	+
Cyrtandra sp.	Elung	Postparturition remedy	Leaves	+	-	-	-
Dillenia suffruticosa	Beringin	Bloody diarrhoea	Bark	-	+	-	-
Elatostema acuminata	Rumput temayai	Snake bite antidote	Whole plant	+	-	-	-
Eugenia cephalanthum	Ubah bungkang	High fever	Leaves	-	-	+	+
Euphorbia contarta	Tapang ular	Snakebite antidote	Sap	-	-	+	+

Species	Vernacular	Uses	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Eurycoma longifolia	Sasapah	Aphrodisiac	Roots	-	-	+	-
Fibrauea tinctoria	Akar kuning	Jaundice	Roots/Stem	+	+	+	+
Garcinia parvifolia	Kandis	Stomatitis/ Skin disease	Sap	-	+	-	-
Ilex cissoidea	Aras	Insecticides	Leaves/Stems	+	-	-	-
Koompassia excelsa	Tapang	Bloody diarrhoea	Bark	+	-	+	+
Momordica charantia	Pria	Heat prickles	Leaves	+	-	-	-
Nephrolepis biserrata	Paku keruk	Postparturition remedy	Young leaves	+	-	-	-
Ocimum canum	Selasih	Skin disease	Leaves	-	-	+	+
Parkia speciosa	Petai	Hypertension	Pods	+	-	-	-
Paspalum conjugatum	Rumput Belanda	Dysentery	Young leaves	+	-	-	-
Phyllanthus urinaria	Rumput merah	Dysentery	Roots	+	-	-	-
Physalis minima	Letup kening	Depression	Whole plant	+	-	-	-
Psidium guajava	Biabas/jambu kayu	Diarrhoea	Young leaves	+	-	+	+
Psychotria aurantiaca	Engkeretai	Cuts	Leaves	+	-	-	-
Pternandra azurea	Pulor	Conjunctivitis	Fruits	+	-	-	-
Sida rhombifolia	Pupulut	Scabies	leaves	-	-	+	+
Tetracera korthalsii	Mempelas	Intermittent fever	Root juice	+	-	-	-
Tetracera macrophylla	Mempelas	Coughs	Stem juice	-	+	-	-
Zingiber officinale	Liak	Tonic/Postpar-turition remedy	Rhizomes	+	-	-	+
Zingiber spectibile	Japa	Headache	Rhizomes	+	-	-	-
Zizyphus calophylla	Akar menaul	Coughs	Roots	+	-	-	-

D : Food Plants

Note: Food plants include all edible flora which are consumed as actual food, food flavours, natural food preservatives, beverages, fruits and seasonings.

Species	Vernacular	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Abrus precatorious	Kayu manis	Leaves	-	+	-	+
Alocasia indica	Keladi	Corms	+	-	-	-
Alpinia javanica	Banjang	Rhizomes	+	-	-	-
Amaranthus gangetica	Bayam	Leaves	+	+	+	+
Ananas comosus	Nanas	Fruits	+	+	+	+
Anona muricata	Durian belanda	Fruits	+	+	+	+
Antidesma montanum	Manyi	Fruits/Leaves	+	-	-	-
Arenga porphycarpa	Apeng	Shoots	+	-	+	-
Arenga pinnata	Ijuk / Nauh	Fruit stalk juice	+	+	+	+
Artocarpus communis	Pudau	Fruits/Seeds	+	-	-	-
Artocarpus ultilis	Sukun	Fruits	+	-	-	-
Artocarpus dadah	Dadah	Fruits	+	-	-	-
Artocarpus elacticus	Tekalong	Fruits	+	-	+	-
Artocarpus heterophyllus	Nangka	Fruits	+	+	+	+
Artocarpus integer	Cempedak/Timadak	Fruits	+	+	+	+
Artocarpus odoratissimus	Pingan	Fruits	+	-	+	-
Artocarpus sericicarpus	Pedalai	Fruits	+	-	-	-
Averrhoea belimbi	Kelumbi / Umbing tunjuk	Fruits	+	+	-	+
Averrhoea carambola	Belimbing	Fruits	+	-	-	-
Baccaurea angulata	Ucong / Umbing toan	Fruits	+	+	-	+
Baccaurea brevipes	Jelintik	Fruits/Leaves	+	-	-	-

Species	Vernacular	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Baccaurea lanceolata	Limpauh	Fruits	-	-	+	+
Baccaurea macrophylla	Lagit	Fruits	-	+	-	+
Baccaurea megacarpa	Puak	Fruits	-	+	-	+
Baccaurea membranacea	Engkuni	Fruits	+	-	-	-
Baccaurea motleyana	Rambai	Fruits	+	+	+	+
Bambusa striata	Buluh betung seri	Young shoots	+	-	+	-
Bellucia pentamera	Jambu kerak	Fruits	+	-	+	-
Blechnum orientale	Kelindang	Leaves	+	-	-	-
Brassica chinensis	Sabe	Leaves	+	-	-	-
Calamus iners	Wi batu	Fruits/shoots	+	-	+	-
Calamus nematospadix	Wi rengut	Fruits/shoots	+	-	-	-
Calamus ornatus	Wi jelayan	Shoots	-	-	+	-
Calamus paspalanthus	Wi tingkau	Fruits/shoots	+	-	+	-
Capsicum frutescens	Cabe	Fruits	+	+	-	+
Carica papaya	Betik/Rungan/Unti kayu	Fruits	+	+	-	+
Caryota mitis	Mudor	Shoot	+	-	-	-
Caryota no	Entibah	Shoots	-	-	+	-
Castanopsis costata	Berangan mayau	Fruits	+	-	-	-
Castanopsis evansii	Berangan pipit	Fruits	+	-	-	-
Citrus aurantifolia	Rangan/Limau nipis	Fruits	+	+	-	+
Citrus chinensis	Limau manis	Fruits	+	-	-	-
Citrus maxima	Limau tapah/baraa	Fruits	+	+	-	+
Cocos nucifera	Inyak	Fruits	+	+	-	+
Coffea robusta	Kopi	Seeds	+	+	-	+
Coix lachryma-jobi	Engkuliset	Grains	+	-	-	-
Colocasia esculenta	Keladi	Tuber/Leaves	+	-	+	-
Costus sp.	Riang	Shoots	-	+	-	+
Cucumis domesticum	Unus/Kunus	Rhizomes	-	+	+	+

Species	Vernacular	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Cucumis sativa	Rampou	Fruits	+	+	+	-
Curculigo latifolia	Remu/Lembak umang	Fruits	+	-	-	-
Cymbopogon citratus	Sarie	Stem	-	+	+	+
Dimocarpus longan	Markiang	Fruits	+	-	-	-
Dioscorea alata	Ubi benar	Tuber	+	-	-	-
Dysoxylum angustifolium	Amperka	Fruits	+	-	-	-
Durio zibethinus	Durian burawang	Fruits	+	-	-	-
Elaeocarpus griffithii	Empedu	Fruits	+	-	-	-
Elateriospermum tapos	Kelampai	Fruits	+	-	-	-
Eryngium foetidum	Bumbu Sop	Leaves	-	+	-	+
Etlingera elatior	Asam kecala	Flowers	+	-	-	-
Etlingera littoralis	Tepus wangi	Shoots/Fruits	+	-	-	-
Eugenia aqua	Jambu ai/Jambu kertas	Fruits	+	-	-	+
Eugenia javanica	Jambu kertas	Fruits	-	+	-	-
Eugenia cephalanthum	Bungkang	Leaves	+	+	-	-
Eugeissona utilis	Pantu	Shoot	+	-	+	-
Ficus sp.	Ara	Leaves	+	-	-	-
Flacourtia rukam	Rukam	Fruits	+	-	-	-
Garcinia beccari	Kundong	Fruits	+	-	-	-
Garcinia mangostana	Sikop/Sialau	Fruits	+	+	-	+
Garcinia parviflora	Kandis	Fruits	+	-	+	-
Gnetum gnemon	Meninjau	Fruits	-	-	+	-
Helmintostachys zeylanica	Paku manis	Leaves	+	-	-	-
Hornstedtia havilandii	Penyun	Young shoot	+	-	-	-
Hornstedtia scyphifera	Panyun	Fruits	+	-	-	-
Ipomoea batatas	Maya	Tubers	-	-	-	+
Ipomoea aquatica	Kangkong	Leaves	+	-	-	-
Lansium domesticum	Lensat	Fruits	+	+	-	+
Lasia spinosa	Tamparajang	Leaves	-	+	-	+

Species	Vernacular	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Lepisanthes alata	Engkelili	Fruits	+	-	-	-
Lepisanthes amoena	Gegambak	Fruits	+	-	-	-
Leucosyke capitella	Daun teh	Leaves	+	-	-	-
Limnocharis flava	Dengger	Leaves	-	+	-	+
Litsea garciae	Engkalak	Fruits	-	-	+	-
Luffa acutangula	Ketola	Fruits	+	-	-	-
Mangifera indica	Mangga	Fruits	+	-	-	+
Mangifera macrocarpa	Imbawang	Fruits	-	+	-	+
Mangifera odorata	Kuini	Fruits	-	+	-	-
Mangifera pajang	Mawang	Fruits	+	-	-	-
Mangifera sp.	Assam Kalimantan	Fruits	-	-	-	+
Mangifera sp.	Sumpalon	Fruits	-	-	-	+
Manihot esculentum	Empasak/Ubie	Tuber/Leaves	+	+	+	+
Metroxylon sagu	Sagu/ambulung	Starch	-	-	+	-
Momordica charantia	Pria	Fruits	+	-	-	-
Musa accuminatum x balbisiana	Pisang/Runti/Unti	Fruits	+	-	-	+
Nephelium cuspidatum	Sibau	Fruits	+	-	+	-
Nephelium maingayi	Lenkang	Fruits	+	-	-	-
Nephelium ramboutan-ake	Sibau/Sion	Fruits	+	+	+	+
Nephrolepis biserrata	Paku karau	Leaves	+	-	-	-
Oryza sativa	Pakai/Ase	Cereals	+	-	+	-
Pandanus amaryllidifolius	Pandan	Leaves	+	-	-	-
Pangium edule	Kepayang	Fruits	+	+	-	+
Parkia speciosa	Petai	Fruits	+	-	-	-
Passiflora edulis	Letup-letup	Fruits	+	-	-	-
Piper nigrum	Lada	Fruits	+	-	-	-
Poikilospermum cordifolium	Entaban	Fruits/Leaves	+	-	-	-

Species	Vernacular	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Pometia excelsa	Kangkuis	Fruits	-	+	-	+
Psidium guajava	Jambu kayu/biabes	Fruits	-	-	-	+
Pternandra azurea	Pulo	Fruits	+	-	-	-
Rinorea anguifera	Siku ensluai	Leaves	+	-	-	-
Saccharum officinalis	Tabo betung /Tabau	Stems	+	+	-	+
Saccharum sp.	Tabau merah	Stem	-	-	-	+
Salacca affinis	Limudan	Shoots	-	+	-	-
Salacca borneensis	Remayung	Fruits/Shoots	+	-	-	-
Salacca porphyrocarpa	Apeng	Shoot	-	-	+	-
Saurauia glabra	Inggur	Fruits	+	-	-	-
Sauropus albicans	Cangkuek/Kalayong sakong	Leaves	-	+	+	+
Schizostachyum latifolium	Buluh engkalat	Shoots	+	-	-	-
Shorea ochracea	Raruk	Bark	-	+	-	+
Solanum melongena	Tarung sina	Fruits	+	+	-	+
Solanum torvum	Tarung pipit	Fruits	+	+	+	+
Stenochlaena palustris	Miding /Taakas	Leaves	+	+	+	+
Theobroma cacao	Koko	Fruits	+	+	-	+
Trichosanthes cucumerina	Ketola ular	Fruits	+	-	-	-
Vernonia arborea	Entepung	Leaves	+	-	-	-
Vigna unguiculata	Retak	Pods	+	-	-	+
Whitfordtiodendron nieuwenhuisii	Buah belum	Fruits	+	-	-	-
Willughbeia sarawacensis	Akar tabau	Fruits	+	-	-	-
Xanthophyllum velutinum	Kensei	Fruits	+	-	-	-
Zea mays	Jagung	Cereals	-	+	+	+
Zingiber officinalis	Liah	Rhizomes	+	+	+	+

E : Ritual, Ceremonial and Taboo Plants

Species	Vernacular	Uses	Sadap	Kelayam	Pinjawan	Bekong
Acorus calamus	Jerangau	R	+	-	-	-
Areca catechu	Pinang	R/C	-	+	+	+
Arenga pinnata	Idjuk	C/R	+	+	+	+
Blechnum orientale	Kelindang	C	+	-	-	-
Celosia argentea	Bunga padi	R	-	+	-	+
Clerondendrum paniculatum	Bunga penggil	R	+	-	-	-
Cocos nucifera	Inyak/Noh	C/T	+	-	-	+
Cordyline terminalis	Niwang/Sabong/Daun suri	R	+	+	-	+
Costus glabra	Pakbu	R	+	-	-	-
Curculigo latifolia	Remu	C	+	-	-	-
Curcuma domesticum	Kunyit	R	+	-	-	-
Curcuma mangga	Entemu	R/T	+	-	-	-
Dillenia suffruticosa	Buan	T	+	+	-	+
Flagellaria indica	Wi buntak	R	+	-	-	-
Lycopodium campanulatum	Selapar	C	+	-	-	-
Manihot esculentum	Ubi/Empesak	T	-	+	-	-
Melastoma malabathricum	Kemunting	C	+	-	-	-
Mikania micrantha	Mambong	R	+	-	-	-
Nicolaia sp.	Tapis perangsang	R	+	-	-	+
Oryza glutinosa	Padi/Pulut kajang	R/C	+	+	+	+
Oryza glutinosa	Pulut melanau	R	-	-	-	+
Pinanga lakka	Pinang To'an	R	-	+	-	+
Piper betle	Sireh	R/C	+	+	+	+
Platycerium coronarium	Rejang	R/C	+	-	-	-

Key: R = Ritual Plant; C = Ceremonial Plant, T = Taboo Plant

Species	Vernacular	Uses	Sadap	Kelayam	Pinjawan	Bekong
Saccharum officinale	Tabo	C	+	-	-	-
Saccharum sp.	Penjaga tepang	R	+	-	-	-
Schizostachyum brachycladum	Buluh humat	C	+	-	-	-
Tobaccum herbaceum	Sigup/Tembakau	R	+	+	-	+
Uncaria gambier	Gambir/Kelait	R	+	+	-	+

Key: R = Ritual Plant; C = Ceremonial Plant, T = Taboo Plant

F : Building Materials

Species	Vernacular	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Anisoptera grossivenia	Penyauh/Meramah	Wood/Bark	+	+	+	+
Artocarpus sp.	Selanking	Wood	-	-	+	-
Bambusa striata	Buluh betung suri	Culms	+	-	+	-
Caryota no	Entibab	Stem	+	-	+	-
Cotylelobium burckii	Resak	Wood	+	-	+	-
Cotylelobium melanoxylon	Resak	Wood	+	+	+	+
Cratoxylum arborescens	Arunggang/Geronggang	Wood	-	+	+	+
Cratoxylum glaucum	Geronggang	Wood	+	-	-	-
Dactylocladus stenostachys	Jongkong	Wood	+	-	-	-
Dipterocarpus borneensis	Kelansau bukit	Wood	-	-	+	-
Dipterocarpus caudatus	Keladan	Wood	-	+	+	-
Dipterocarpus euripuchua	Kelansau bukit	Wood	-	-	+	-
Dipterocarpus oblongifolia	Tengkabau	Wood	+	-	+	-
Dryobalanops beccarii	Keladan	Wood/Bark	+	+	+	+
Dryobalanops oblongifolia	Kelansau	Wood	-	+	+	+
Dryobalanops rappa	Kelansau	Wood	-	+	+	+
Eusideroxylon zwageri	Belian/Kaolian	Wood	+	+	+	+
Fragaea fragrans	Timbasu	Wood	-	+	-	+
Garcinia parviflora	Kandis	Wood	+	-	-	-
Gluta renghas	Rengas	Wood	+	-	+	-
Hopea dasyrrachys	Tekam	Wood	+	+	+	+
Hopea sangal	Penyauh/Tekam	Wood	+	+	+	+
Koompassia excelsa	Tapang	Wood	+	-	-	-
Licuala petiolulata	Gernis	Leaves	-	+	-	+
Litsea sp.	Medang kuning	Wood	-	+	-	+

Species	Vernacular	Parts Used	Sadap	Kelayam	Pinjawan	Bekong
Melanorrhoea wallichii	Rengas	Wood	+	-	-	-
Metroxylon sagu	Ambulung	Leaves	-	+	+	+
Octomeles sumatrana	Benuang	Wood	+	+	-	+
Palaquium nyatoh	Nyatu	Wood	-	-	+	-
Prunus arborea	Enteli	Bark	+	-	-	-
Shorea amplexicaulis	Tengharung/Engkabang	Wood	-	-	+	-
Shorea asahii	Tekam padi	Wood/Bark	+	-	-	-
Shorea atrinervosa	Tekam	Wood	+	+	+	+
Shorea glaucescens	Tekam	Wood	+	+	+	+
Shorea gysbersiana	Tengharong/Tembaroang	Wood	-	-	+	-
Shorea laevifolia	Tekam	Wood	+	-	-	-
Shorea leprosula	Perawan/Meranti batu	Wood	+	+	+	+
Shorea meristpteryx	Meranti batu	Wood	-	+	+	+
Shorea pinanga	Tengharong/Engkabang	Wood	-	-	+	-
Shorea ovata	Ponga	Wood	+	-	-	-
Shorea palidifolia	Meranti batu	Wood	-	+	-	+
Shorea parvifolia	Ponga	Wood	+	-	-	-
Shorea quadrinervis	Meranti bunga	Wood	-	+	-	+
Shorea scabrida	Meranti batu	Wood	-	+	-	+
Shorea smithium	Meranti batu	Wood	+	-	+	+
Shorea teysmanniana	Meranti bunga	Wood	+	-	-	+
Shorea uliginosa	Meranti batu	Wood	-	+	-	+
Upuna borneensis	Penyauh	Wood	+	-	-	-
Vatica characea	Resak	Wood	+	-	-	-
Vatica havilandii	Resak	Wood	+	+	-	+
Vatica micrantha	Resak	Wood	+	+	-	+
Vatica nitens	Resak	Wood	-	+	+	+
Vatica vinosa	Resak	Wood	-	+	+	+
Vitex pubescens	Papa	Wood	+	-	-	

G : Miscellaneous Uses

Species	Vernacular	Parts Used	Uses	Sadap	Kelayam	Pinjawan	Bekong
Abrus sp.	Mengantung	Fruits	Poisons	+	+	-	-
Acalypha godsiefiana	Pureng	Whole plant	Ornamental	-	-	+	+
Acalypha wilkesiana	Pureng	Whole plant	Ornamental	-	-	+	+
Anisoptera grossivenia	Penyau	Wood	Oar	+	-	-	-
Antiaris toxicaria	Upas	Sap	Poisonous	+	-	-	-
Aquilaria malaccensis	Gaharu	Heartwood	Incense wood	-	-	+	+
Areca catechu	Pinang	Fruits	Masticatory	+	+	+	+
Arenga porphycarpa	Apeng	Rachis	Blowpipe darts	+	-	-	-
Artabotrys costatus	Akar rarak	Bark	Tying	+	-	-	-
Artocarpus elasticus	Tekalong	Bark	Container, tying	+	-	-	-
Artocarpus utilis	Takalong	Bark	Fibre	-	-	+	+
Atropa belladona	-	Fruits	Poison	-	+	-	-
Calamus caesius	Uwi saka	Cane	Handicrafts	-	-	+	+
Calamus iners	Wi batu	Cane	Basketry	+	+	-	-
Calamus javensis	Wi batu	Cane	Basketry	+	-	-	-
Calamus nematospadix	Wi rengut	Cane	Basketry	+	-	-	-
Calamus optimus	Wi segak	Cane	Basktery	+	-	-	-
Calamus scipionum	Uwi semambu/ Wi jelayan	Cane	Handicrafts/ Basketry	-	-	+	+
Calamus sp.	Uwi duduk	Cane	Handicrafts	-	-	+	+
Castanopsis costata	Berangan mayau	Fuelwood		+	-	-	-
Ceiba pentandra	Kabu	Seedcoat	Cotton	+	-	-	-
Cratoxylon glaucum	Geronggang	Wood	Handicraft	+	-	-	-
Cocos nucifera	Noh	Fruits	Fibre	-	-	+	+
Codiaceum variegatum	Pureng	Whole plant	Ornamental	-	-	+	+
Curculigo latifolia	Remu	Leaves	Fiber;tying	+	-	-	-

Species	Vernacular	PartsUsed	Uses	Sadap	Kelayam	Pinjawan	Bekong
Daemonorops didymophylla	Wi duduk	Cane	Basketry, /Fruit-dye	+	-	-	-
Daemonorops sabut	Wi lepoh	Cane	Basketry	+	-	-	-
Daemonorops semoi	Wi tot	Cane	Basketry	+	-	-	-
Derris elliptica	Tubai /akar panua	Root	Fish poison	+	+	+	+
Desmodium pulchellum	-	Bracts	Pillow	+	-	-	-
Dimocarpus longan	Merkiang	Wood	Fuelwood	+	-	-	-
Donax canua	Bemban	Stem	Mats	+	+	+	+
Duabunga moluccana	Sawe	Wood	Household implements	-	+	-	-
Eugeissona utilis	Pantu	Rachis	Blowpipe darts	+	-	-	-
Fleminggia glabra	Kabu-kabu	Fiber	Pillow	+	-	-	-
Fordia splendidissima	Beregantung	Juice	Fish poison	+	-	-	-
Gossypium herbaceum	Tayah	Fruit	Fiber	+	-	-	-
Hevea braziliensis	Karet/getah	Latex	Rubber	+	-	+	+
Lagenaria siceraria	Genouk	Fruits	Household implements	+	+	-	-
Licuala longipes	Gernih	Leaves	Food wrapper	+	-	-	-
Licuala petiolulata	Pelat	Leaves	Food wrapper	+	-	-	-
Licuala phaseolus	Gernih	Leaves	Food wrapper	+	-	-	-
Morinda citrifolia	Mengkudu	Leaves	Dye	+	+	-	-
Musa paradisiaca	Pisang hutan	Stem	Cooking tripod	+	-	-	-
Pandanus sp.	Perupok	Leaves	Handicraft	+	-	-	-
Phrynium sp.	Iriak	Leaves	Food wrapper	+	-	-	-
Piper betle	Sireh	Leaves	Masticatory	-	+	+	+
Prunus arborea	Enteli	Bark	Rice container	+	+	-	-
Psychotria aurantiaca	Engkeebai	Fruits	Dye	+	-	-	-
Schizostachyum brachycladum	Buloh hamat	Culm	Household implements	+	-	-	-
Sida rhomifolia	Puupulut	Bark	Fibre	-	-	+	+

Species	Vernacular	Parts Used	Uses	Sadap	Kelayam	Pinjawan	Bekong
Shorea laevifolia	Penyauh	Wood	Boat making	+	-	-	-
Shorea leprosula	Perawan	Wood	Boat making	+	-	-	-
Spatholobus oblongifolius	Akar kemedu	Bark	Tying	+	-	-	-
Solanum marginatum	Suka manok	Fruits	Poison	-	+	-	-
Tabernaemontana megacarpa	Kara mandung		Latex Poisons	+	-	-	-
Tobaccum herbaceum	Sigup	Leaves	Cigarettes	+	-	-	-
Tristania whitiana	Malaban	Wood	Agricultural implements	+	-	-	-
Uncaria gambier	Gambir/Kalait	Leaves	Masticatory	+	-	+	+
Upuna borneensis	Penyauh	Wood	Boat making	+			

APPENDIX 9 : SOCIOECONOMIC OBSERVATIONS

(i) Rh. Dayung, Tapang Pungga

This was the first and the smallest longhouse we visited during the study. Six families live in this longhouse. The average age of the family heads was 50.3 years which was close to a post productive economic age. Total number of dwellers was 40; average size of family was 6.7 people. The longhouse was an old structure in need of repair. According to the inhabitants they had no plans for renovation. Most of the young family members went away to look for work.

(ii) Rh. Ipang ak Ningkan, Ng. Delok

This longhouse consisted of 14 doors or apartments, and in some apartments there were two to five families. Four of the 119 dwellers were single persons consisting of three young women and one young man, and the ten married couples had a total of 95 children. Average family size at 11.9 was the highest among the longhouse dwellers.

A sculptor by the name of Gu and his assistant Agang were in the process of completing a beautiful *Kenyalang Burong* (hornbill figure), symbolic of a spirit in Iban mythology. They told us that they learned to make this bird from people of Ng. Badau across the border. Gu only made this figure after having repeated dreams. He reported that if he had refused he would have become ill, or worse. The figure would be used in *Gawai Kenyalang* in the longhouse and become Gu's personal belonging. The price of a beautifully carved bird nowadays can be as high as 1000 Malaysian Ringgit.

After a lengthy discussion among themselves, the Dayak decided to offer a ceremony of *Kenyalang Burong* to the visiting researchers, their honoured guests. They did not want to miss the opportunity to stage this important ritual. A known *Lemambang* was summoned to chant *mupu Kenyalang* (Kenyalang verses). Some of the verses included praise for *Kenyalang Burong* and requests for its protection. According to the myth, at its creation the bird was female but later was transformed into a male.

During the second part of the ceremony, the guests were invited to offer donations to *Kenyalang Burong*, so that he (she) could buy fine clothes. After the donations, each guest's name was mentioned, praised and blessed through

Lemambang verses. An assistant carefully watched the receptacle where the donation was placed, and relayed the name and amount of donation to the chanting *Lemambang*. Late in the afternoon the celebration ended. The guests were invited to stay for the evening and were then presented with a *ngajat* session and smoked red telapia fish.

If the *Kenyalang Burong* were finished and painted sometime in early June (before the rice planting season begin) the longhouse would stage a big gawai or feast and invite guests from the surrounding area. After that the bird would be paraded around the area on request, and donations for village welfare collected. In the old days at the end of a big feast the bird was hoisted on top of a tall pole, which was then cut down to test its strength. Most of the time the birds were destroyed by such treatment. If the bird withstood the impact it would be preserved by the longhouse. Today the bird would not have to undergo such ordeal, instead it is kept in the longhouse in a special chamber and occasionally dressed and fed.

Judging by the way it was conducted and perhaps modified from its original form the *Kenyalang Burong* ritual served as a vehicle for a number of purposes: (1) preserving a link with the spirit world, (2) preserving unity within and among the longhouses. (3) rallying support for the welfare of the longhouse, (4) presenting local culture as tourist attraction, and (5) preserving local art, particularly carving and painting. In recent times, the figures of *Kenyalang Burong* have been produced in significant numbers and sold to tourists.

Rh. Ipang was governed, as in other longhouses, by the *Jawatankuasa Kemajuan dan Keselamatan Kampung* consisting of *Penasihat* (chief), *Pengerusi* (planner), *Setiausaha* (secretary), *Bendahari* (treasurer), and *Ahli-ahli* (members). The chief was also *Tuai Rumah* or head of the longhouse.
Each longhouse in this area was named after the *tuai rumah* or headman. As such, knowing the name of the longhouse one also knows the name of the chief. This system seemed very practical. If, however, the *tuai rumah* moved out or died, would the name also change? If so, future travellers or map publishers would have a hard time to keep track of these changes.

(iii) Rh. Endan ak Luyuh, Ulu Batang Ai

This longhouse consisted of 24 *bilek* but only 11 *bilek* were occupied. Occupants of the other 13 *bilek* already had moved to the resettlement scheme at Skrang in 1964. The youngest *tuai bilek* was 36 years old and the oldest 80 years old. The old people stayed here to plant rice. At the end of each rice-planting season they return to the resettlement scheme at Skrang.

The Iban tradition considers an apartment empty undesirable. Therefore they impose a system of fines (*berau basah*) for absence. If a bilek is left untended for a whole month the owner must pay the longhouse MR1 plus a piece of iron. If the owner is absent for more than one month the fine is increased to MR5 plus a piece of iron and one chicken. The chicken is used in a *biau* ritual which includes recital of verses *(sampi-sampi)*, killing the chicken and wiping its blood (*sapui darah*) on every door of the longhouse.

(iv) Rh. Radin ak Meragan, Ulu Batang Ai

Rh. Radin was across the river from Rh. Endan. During study a hanging bridge was under construction to connect the two longhouses across Ulu Batang Ai. The longhouse was building a tourist quarters managed under the Batang Ai Cooperative. Rh. Endan already had such quarters which they used for tourists.

The total number of people living in this longhouse was 139. 45 people had left the longhouse, among whom 9 were in school and the rest were either working or just lived with their family in new settlements.

(v) Rh. Ngumbang ak Janguk, Ng. Sumpa

When the National Park was gazetted in 1991 this longhouse assumed a different name, Rh. Along ak Dana. It enjoys all the privileges stipulated under Section 7(2) of the National Park Ordinance. When this study was conducted, Ngumbang ak Jangu became the new *tuai rumah*. This longhouse was the largest that was visited. The total number of people originally living in this longhouse was 135 but 17 of them had departed in search of work. Seven women became single mothers due to separation or death of spouses. All the *bilek* in this longhouse were occupied because none of the residents had moved to join the resettlement scheme.

One of the privileges that this longhouse received as a gazetted area was the right to transport tourists from Pengkalan into the park. Tourist business in this area was conducted through Borneo Adventure. This company appointed Yonathan ak Jarau as representative in Ng. Sumpa which included Rh. Ngumbang, Rh. Kasi, and Rh. Changing. According to the arrangement made by Borneo Adventure each apartment could send one person to work as tourist transportation crew. Yonathan supervised the rotation so that every member got his turn. In order to take full advantage of this arrangement some *tuai* *bilek* purchased outboard engines and boats as listed below. There were two brands of outboard engines that people chose in this area, namely Yamaha and Marina. The price for 15HP engine was about MR3,500 and MR4,000 for 25HP engine. There were several ways to buy outboard engines, most commonly with a loan from Borneo Adventure. Among the terms of the loan was that the boat could not be used to serve other travel agents, although the boat could be used for other purposes. Some people obtained personal loan from shopkeepers in Lubok Antu or Sri Aman.

Some families had members working elsewhere, e.g., offshore drilling rigs or as semi-skilled labour in Miri, Kuching and Brunei. They would often remit money home which the family could then use to purchase outboard engines or other equipment.

Tourists who came to Rh. Ngumbang did not spend much money to purchase local products. They might buy a chicken, bottles of *tuak* or pieces of cloth woven by local women. Usually when there was a large group of tourists visiting the longhouse they would be invited to a brief party where the group could survey *puak* or cloth woven by the longhouse women and participate in *ngajat* Iban dance.

The longhouse charged tourists the following rates: MR6 per person to stay at the longhouse *ruai* or hall; MR10 per person to have *ngajat*; and MR10/day per person for full day cooking or MR6 for a half day.

The most significant income contribution came from transport activities. The charter price of speedboats varied according to destination. Between Pengkalan or Terminal to Rh. Ngumbang was MR180, and the cost for 8 gallons of gas at MR5.50 a gallon was MR44 plus the cost for oil approximately MR12, leaving take-home pay of MR124 per boat. Since the two crews who operated each boat were usually family members, all the money went to boat owners. All the boats in this longhouse averaged 2 trips every month. Costs between the terminal and Rh. Radin were MR260, between Rh. Radin and Kemujan MR80, and between Rh. Radin and Wong Tibu, MR50. Those who did not own a boat could rent one from boat owners for MR15/day for 15HP engine and MR25 for 25HP engine. Other people who did not take part in tourist transport resorted to umai bukit or hillside farming, fishing, hunting, and making clay pots for sale in the city through an agent. Some of them *kerja balak* or cut timber for timber companies in other areas.

(vi) Rh. Kasi ak Sanggong, Jambu

Rh. Kasi is located in a remote upstream area. The longhouse was a dilapidated building with weakening substructure. The host explained that they had already collected material for a new longhouse but needed more time to prepare for the construction. Most of the young people from this longhouse were on *bejalai,* working in distant places, and occasionally sending money back to their relatives in the longhouse.

(vii) Rh. Changing ak Resa, Pala Taong

Rh. Changing was having a ritual of *buka pantang* to release the restriction imposed on members of the longhouse because of the death of an old man. The restrictions among others included prohibition on wearing jewellery and displaying merriment.

The ritual began by a visit to the grave. The close relatives of the deceased formed a group and left the longhouse followed by a woman, probably a daughter of the deceased, who brought a gong and struck it along the way to the grave yard. When they returned, the *badara* ritual meant to release the community from their period of mourning, was conducted. Then the guests were offered food and drink consisting of rice cooked in bamboo sections, *tuak* or rice wine, and liquor bought the from local store.

The atmosphere then was transformed and community life returned to normal life. The final part of the gathering was a free discussion on what to do with the apartment and other belongings of the deceased.

APPENDIX 10 : ORGANIZERS AND PARTICIPANTS

A PATRONS

Bapak Djamaludin Suryohadikusumo
The Minister of Forestry, Republic of Indonesia

Yang Amat Berhormat Datuk Patinggi Tan Sri (Dr) Haji Abdul Taib Mahmud
The Chief Minister of Sarawak

Bapak H. Aspar Aswin
The Governor of West Kalimantan Province, Republic of Indonesia

B JOINT STEERING COMMITTEE

International Tropical Timber Organization:
Dato' Dr. B.C.Y. Freezailah, ITTO Executive Director, Chairman
Dr. Efransjah, ITTO Projects Manager, Reforestation and Forest Management

Malaysian Members :
Tan Sri Hamid Bugo, State Secretary to Sarawak
Mr. Cheong Ek Choon, Director of Forests, Sarawak
Datuk Leo Chai, Adviser to Sarawak Ministry of Resource Planning
Mr. James Dawos Mamit, ITTO Projects Coordinator
Dr. Paul Chai P.K., National Coordinator, Malaysia
Mr. Robert Stuebing, Expedition Joint Rapporteur

Indonesian Members:
Mr. Soemarsono, Director General of Forest Protection and Nature Conservation
Mr. Koes Saparyadi, Director of National Parks and Nature Conservation
Mr. B. Ediwiyoto, Director of Programs, Forest Protection and Nature Conservation
Dr. Herwasono Soedjito, National Coordinator, Indonesia
Mr. M. Kuswanda, Expedition Coordinator

C EXPEDITION PARTICIPANTS

Indonesia

	Indonesian Institute of Science (LIPI)
Dr. Tukirin Partomihardjo	Forest Ecology
Dr. Johanis P. Mogea	Botany/Taxonomy
Dr. Djunaedi Gandawidjaja	Botany/Taxonomy
Dr. Harry Wiradinata	Botany/Taxonomy
Ike Rachmatika	Ichthyology

	WWF IP / BK National Park
Dr. Herwasono Soedjito	Forest and Human Ecology
Syahirsyah	Forest Ecology
Albertus	Forest Ecology
Hari Prayogo	Ornithology
Mering Ngo	Anthropology
	Forest Research Development Agency
Adi Susilo	Primatology
Sofian Iskandar	Primatology
	Forest Protection and Nature Conservation
Slamet Rohadi	Ecotourism
Heri Sujadmiko	Bryophyte Taxonomy
Supardiyono	Ethnobotany
	Universities
Dr. Syamsuni Arman, U of Tanjungpura	Sociology
Dr. Kunkun Gurmaya, U of Padjadjaran	Primatology
Dr. Djoko Iskandar, ITB	Herpetology
	NGO
Taufik Rahzen	Ecotourism
Malaysia	
	International Tropical Timber Organization Consultants
Dr. Paul Chai P.K.	Forest Ecology
Robert Stuebing	Herpetology
	Sarawak Forest Department
Runi Sylvester	Forest Ecology
Julaihi Abdullah	Ethnobotany & Ecology
Mohizah bt Mohammad	Botany
Stephen Teo	Botany
Awang Enjah Bin Awang Kipli	Botany
Rantai AK Jawa	Botany
Yahud bin Haji Wat	Botany
Sim Lee Kheng	Ornithology
Stephen ak Antang	Ornithology
Shahbudin Sabky	Zoology
Munau ak Jawa	Zoology
Engkamat Lading	Primatology
Jack Dering Misiam	Primatology

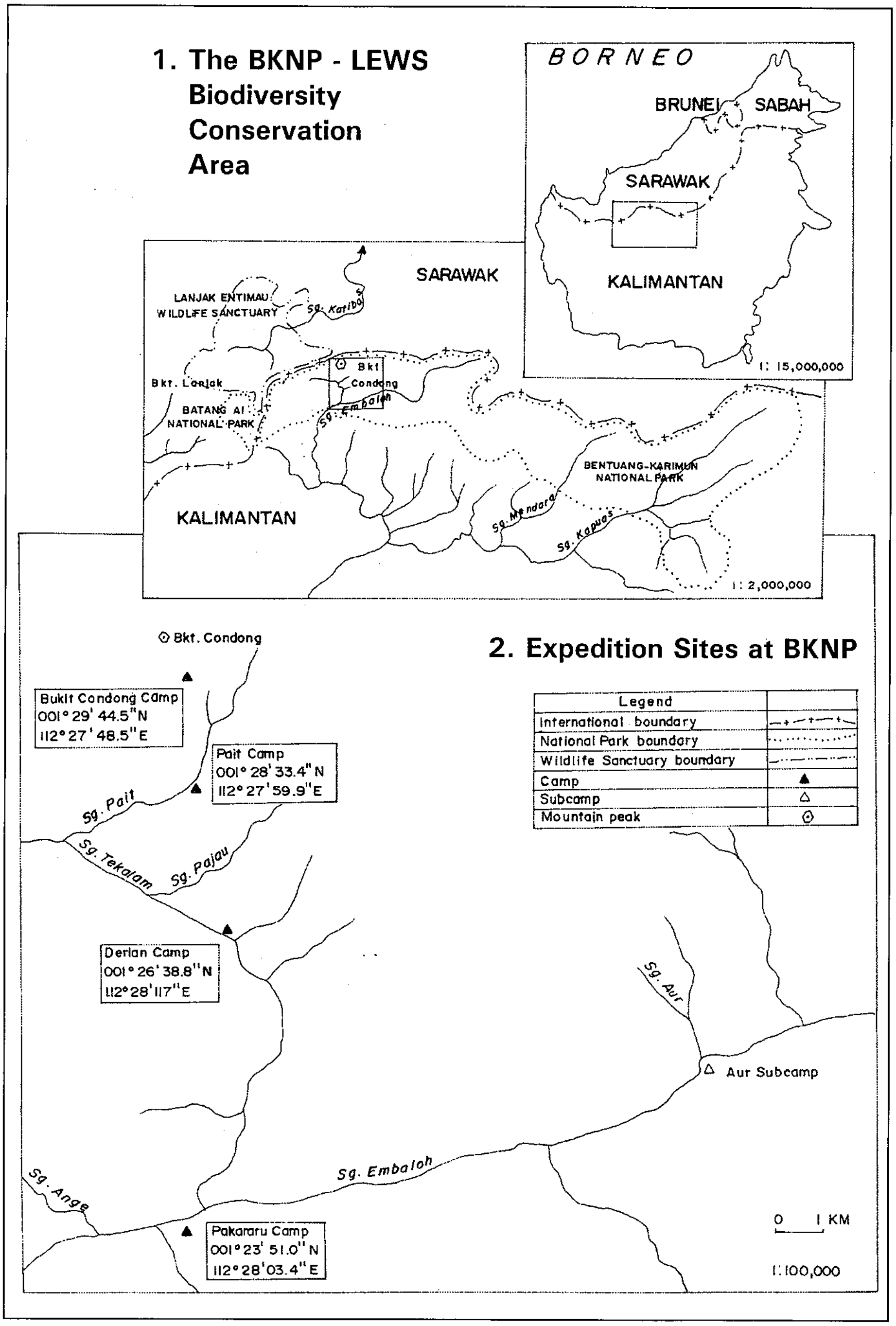
	Forest Research Institute Malaysia
Dr. Lillian Chua	Forest Ecology
Julia ak Sang	Botany
	Sarawak Museum
Dr. Charles Leh	Ichthyology
	Sabah Museum
Joseph Guntavid	Ethnobotany
Anna Wong	Ichthyology
	Malaysian Nature Society
Ivy Wong Ling Ping	Ichthyology/Herpetology
	Other Scientists
Satish Sreedharan	Ornithology
Dr. Katharine Pearce	Botany

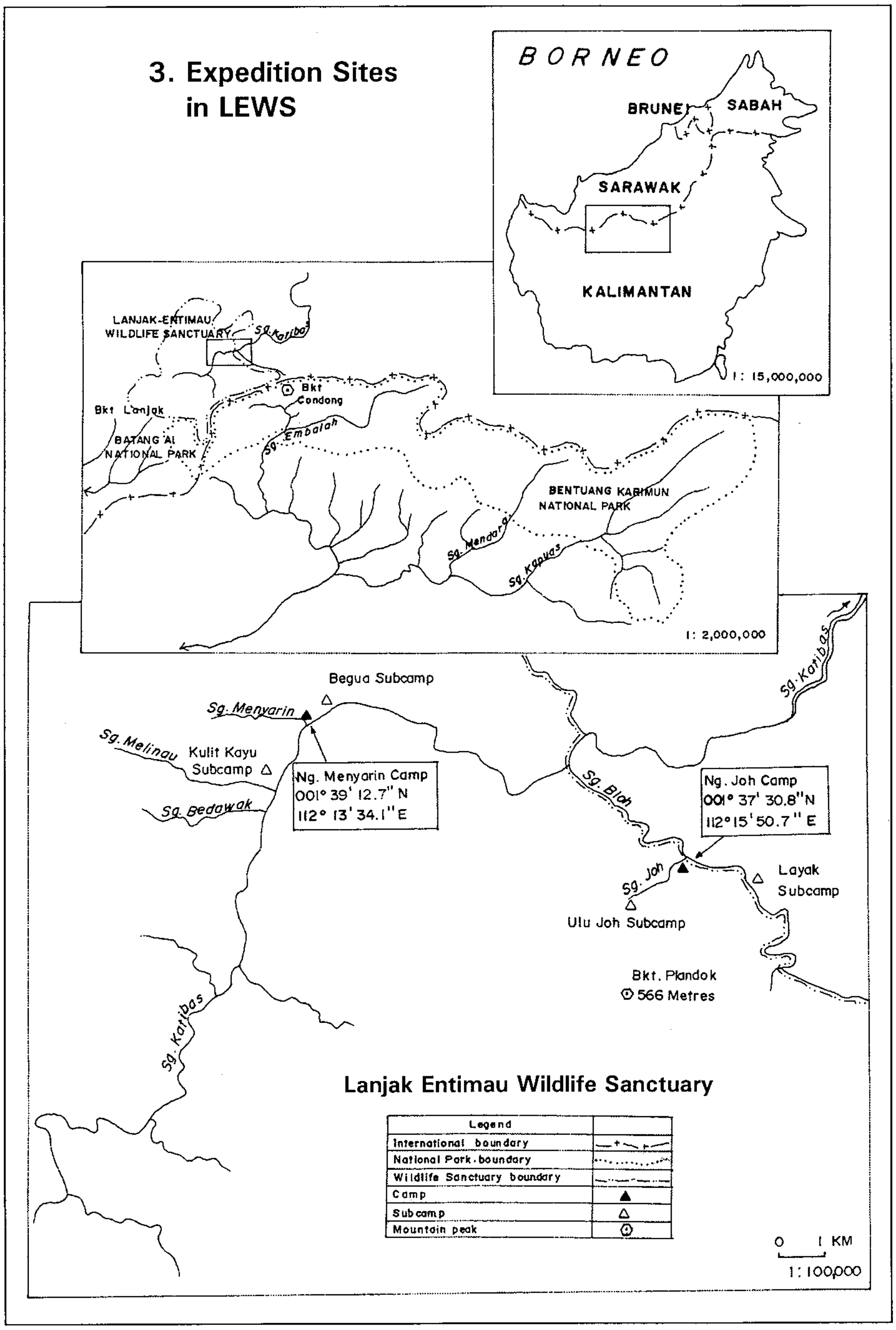
D OTHER EXPEDITION PARTICIPANTS

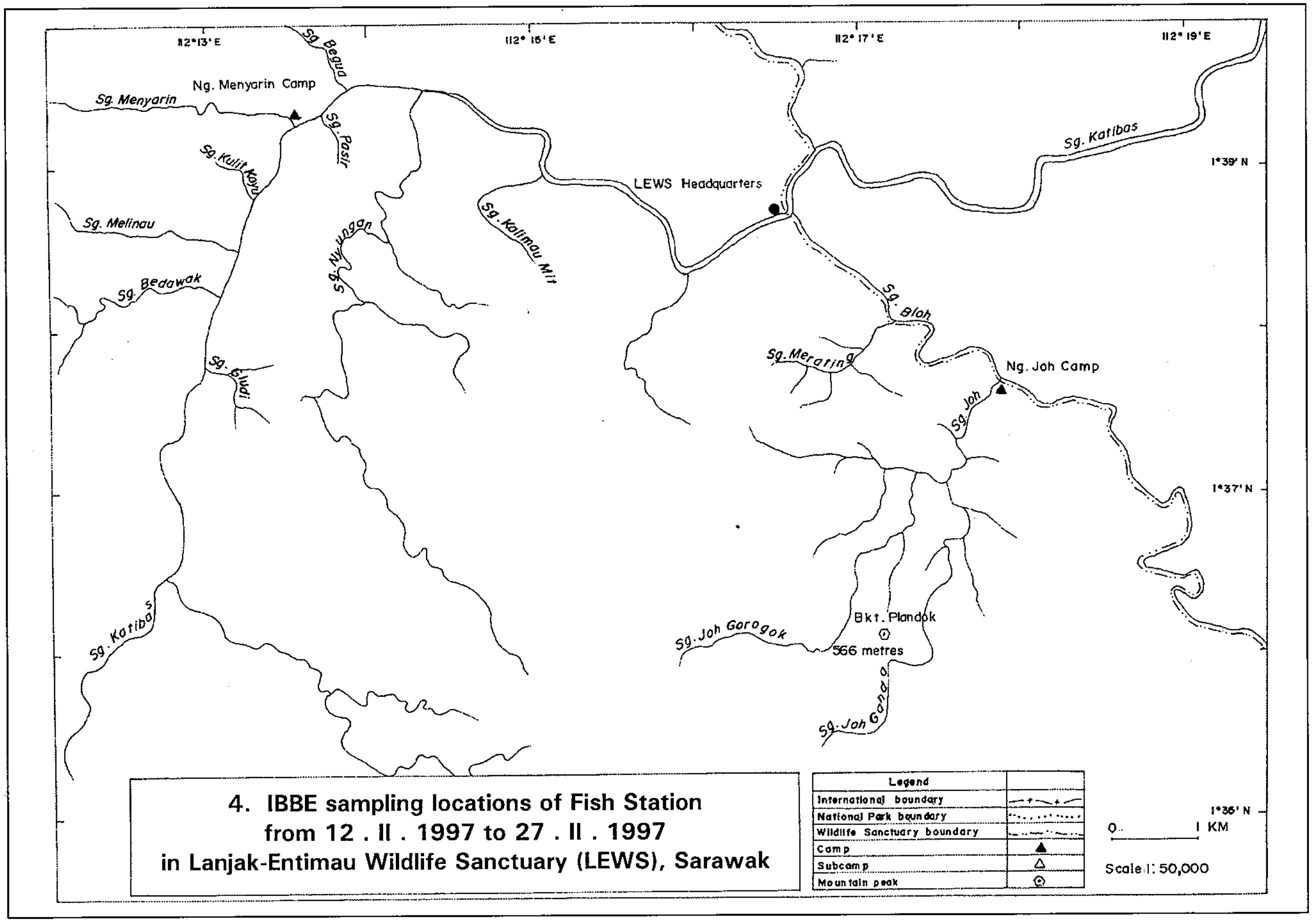
	The World Conservation Union (IUCN)
Dr. Donald A. Gilmour	Forest Ecology
	International Plant Genetic Resources Institute (IPGRI)
Dr. Selvadurai Dayanandan	Geneticist
	Royal Geographical Society, London
Lisa Sykes	Writer
	Writer / Photographer
Christopher P.A. Bennett	Expedition Joint Rapporteur
Kim Lee	Writer
Douglas Wechsler	Photographer
Voon Joon Hee	Photographer
Alain Compost	Photographer
	Volunteers
Clifford Chai	Malaysia
Rose Au	Malaysia
Goh Yan Yih	Malaysia

VIII

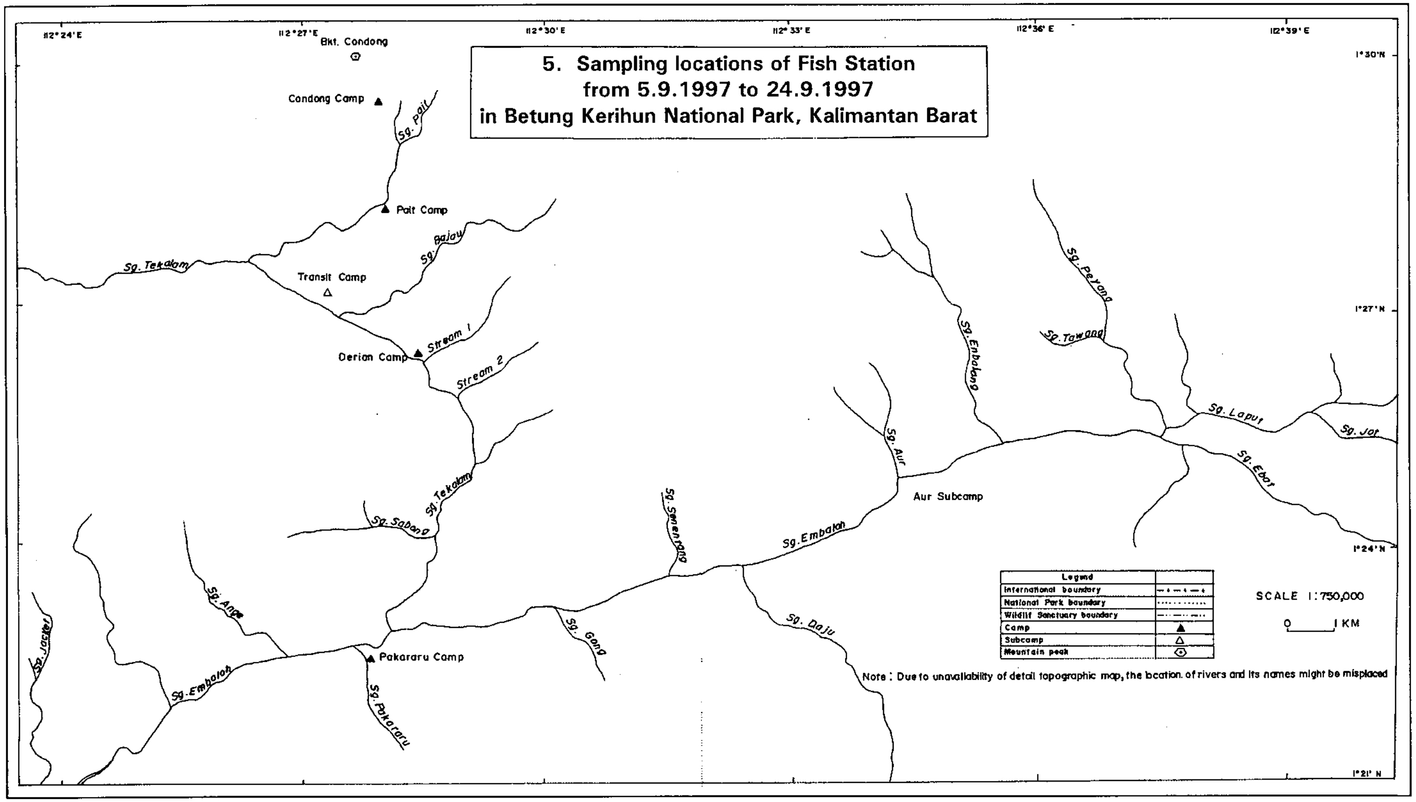
MAPS


1. The BKNP - LEWS Biodiversity Conservation Area
BORNEO
BRUNEI
SABAH
SARAWAK
KALIMANTAN
1: 15,000,000
SARAWAK
LANJAK ENTIMAU WILDLIFE SANCTUARY
Sg. Katibas
Bkt. Lanjak
BATANG AI NATIONAL PARK
Bkt Condong
Sg. Embaloh
BENTUANG-KARIMUN NATIONAL PARK
Sg. Mendaram
Sg. Kapuas
KALIMANTAN
1: 2,000,000
Bkt. Condong
2. Expedition Sites at BKNP
Legend
International boundary
National Park boundary
Wildlife Sanctuary boundary
Camp
Subcamp
Mountain peak
Bukit Condong Camp
001° 29' 44.5"N
112° 27' 48.5"E
Pait Camp
001° 28' 33.4" N
112° 27' 59.9"E
Sg. Pait
Sg. Tekalam
Sg. Pajau
Derian Camp
001° 26' 38.8"N
112° 28' 117"E
Sg. Aur
Aur Subcamp
Sg. Embaloh
Sg. Ange
Pakararu Camp
001° 23' 51.0" N
112° 28' 03.4" E
0 1 KM
1:100,000


3. Expedition Sites in LEWS
BORNEO
BRUNEI
SABAH
SARAWAK
KALIMANTAN
1: 15,000,000
LANJAK-ENTIMAU WILDLIFE SANCTUARY
Sg. Katibas
Bkt Condong
Bkt Lanjak
BATANG AI NATIONAL PARK
Sg. Embalah
BENTUANG KARIMUN NATIONAL PARK
Sg. Mendalam
Sg. Kapuas
1: 2,000,000
Begua Subcamp
Sg. Menyarin
Sg. Melinau
Kulit Kayu Subcamp
Ng. Menyarin Camp
001° 39' 12.7" N
112° 13' 34.1" E
Sg. Bedawak
Sg. Katibas
Sg. Bloh
Ng. Joh Camp
001° 37' 30.8" N
112° 15' 50.7" E
Sg. Joh
Layak Subcamp
Ulu Joh Subcamp
Bkt. Plandok
566 Metres
Sg. Katibas
Lanjak Entimau Wildlife Sanctuary
Legend
International boundary
National Park boundary
Wildlife Sanctuary boundary
Camp
Subcamp
Mountain peak
0 1 KM
1: 100,000



4. IBBE sampling locations of Fish Station from 12 . II . 1997 to 27 . II . 1997 in Lanjak-Entimau Wildlife Sanctuary (LEWS), Sarawak


5. Sampling locations of Fish Station
from 5.9.1997 to 24.9.1997
in Betung Kerihun National Park, Kalimantan Barat
112°24'E
112°27'E
112°30'E
112°33'E
112°36'E
112°39'E
1°30'N
1°27'N
1°24'N
1°21'N
Bkt. Condong
Condong Camp
Sg. Pait
Pait Camp
Sg. Bajau
Sg. Tekalam
Transit Camp
Stream 1
Derian Camp
Stream 2
Sg. Tekalam
Sg. Sabang
Sg. Ange
Sg. Jacker
Sg. Embaloh
Pakararu Camp
Sg. Pakararu
Sg. Gong
Sg. Senenrang
Sg. Embaloh
Sg. Daju
Sg. Aur
Aur Subcamp
Sg. Enbalang
Sg. Peyang
Sg. Tawang
Sg. Laput
Sg. Jar
Sg. Ebat
Legend
International boundary
National Park boundary
Wildlif Sanctuary boundary
Camp
Subcamp
Mountain peak
SCALE 1:750,000
0 1 KM
Note : Due to unavailability of detail topographic map, the location of rivers and its names might be misplaced

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