

Rapid Assessment on Biodiversity in Logged Forest of Tesso Nilo, Riau Province, Sumatra (Penilaian cepat keanekaragaman hayati di hutan bekas tebangan di Tesso Nilo, Provinsi Riau, Sumatra)

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ABSTRACT

Tesso Nilo area which is located at Riau province covers an area of 188.00 ha. Recently, it is famous because of a sharply increased in encroachment activities for forest conversion, especially for oil palm plantations and village sites. It was conducted in logged forest around Segati river, Toro river, Mamahan river and Sawan river in June 2003. The results showed that the area had the high richness of plant species which was indicated by the high value of Mennhenick index. Records from the 1 ha studied plot identified a total of 360 species included 165 genera and 57 families with 215 tree species 305 sapling species. Some important tree species which were included in the Red List of IUCN were 'gaharu' (*Aquilaria malaccensis*), 'ramin' (*Gonystylus bancanus*), *Shorea* spp. and *Dipterocarpus* spp. The local community utilized 83 species of medicinal plants and 4 species of toxic plants for fishing. The total number of recorded bird species was 114 species represented 29% of the total Sumatran bird species. The most important bird species were the Wrinkled Hornbill (*Aceros corrugatus*), Crestless Fireback (*Lophura erythrophthalma*), Crested Fireback (*Lophura ignita*) and Hooked-billed Bulbul (*Setornis criniger*). The total number of recorded mammal species was 34 species or 16.5% of 206 species of Sumatran mammals. The most important mammal species included Sumatran tiger (*Panthera tigris sumatrae*), Sumatran elephant (*Elephas maximus sumatrensis*), the Sun bear (*Helarctos malayanus*) and three species of primates: *Hylobates agilis*, *Presbytis femoralis* and *Macaca nemestrina*. The herpetofauna contained 15 reptile species and 18 amphibian species. The most important herpetofauna was the endangered False Gharial (*Tomistoma schlegelii*) and the vulnerable Common Soft-shelled turtle (*Amyda cartilaginea*). The number of recorded fish species was 50 represented 18% of the total Sumatran fish species (272 species). The important fish species were *Breinsteinea* sp. and *Chaca bankanensis* which were unique and rare. Since insects are the largest group of animal, this study only focused on beetles. The identified beetles were classified into 644 species and 34 families. The important beetles were the Longhorn beetles (Cerambycidae) and the Scarab beetles (Scarabaeidae). The small mammal parasites consisted of ectoparasites which were categorized into 14 species and endoparasites which were categorized into 2 orders and 3 species.

Keywords: biodiversity, logged forest, richness, Sumatran tiger, Sumatran elephant

ABSTRAK

Wilayah Tesso Nilo terletak di Provinsi Riau dan memiliki luas 188.000 ha. Akhir-akhir ini sangat terkenal karena adanya perambahan yang semakin marak untuk dialih fungsikan terutama untuk dijadikan kebun kelapa sawit dan lokasi pedesaan. Penelitian dilakukan pada bulan Juni 2003 di lokasi hutan bekas tebangan di sekitar sungai Segati, Toro, Mamahan dan Sawan. Hasil penelitian menunjukkan bahwa wilayah ini memiliki kekayaan jenis tumbuhan yang tinggi yang bisa dilihat dari nilai indeks Mennhenick. Hasil identifikasi pada cuplikan habitat seluas 1 ha tercatat sebanyak 360 spesies tumbuhan termasuk 165 genera dan 57 famili yang terdiri dari 215 spesies pohon dan 305 spesies anakan pohon. Jenis pohon penting yang termasuk dalam *Red List of IUCN* antara lain adalah 'gaharu' (*Aquilaria malaccensis*), 'ramin' (*Gonystylus bancanus*), *Shorea* spp. dan *Dipterocarpus* spp. Masyarakat lokal telah menggunakan 83 spesies tumbuhan obat dan 4 spesies tumbuhan beracun untuk memancing ikan. Jumlah jenis burung yang tercatat yaitu 114 spesies atau sekitar 29% dari total spesies burung Sumatra. Jenis burung penting adalah Julang jambul hitam (*Aceros corrugatus*), Sempidan merah (*Lophura erythrophthalma*), Sempidan biru (*Lophura ignita*) dan Empuloh paruh kait (*Setornis criniger*). Jumlah jenis mamalia yang tercatat sekitar 34

spesies atau 16.5% dari total 206 spesies mamalia di Sumatra. Mamalia yang terpenting adalah harimau Sumatra (*Panthera tigris sumatrae*), gajah Sumatra (*Elephas maximus sumatrensis*), beruang madu (*Helarctos malayanus*) dan tiga jenis primata: *Hylobates agilis*, *Presbytis femoralis* dan *Macaca nemestrina*. Herpetofauna terdiri dari 15 jenis reptil dan 18 jenis amfibi. Herpetofauna yang sangat penting adalah buaya senyulong (*Tomistoma schlegelii*) dan bulus (*Amyda cartilagenia*). Jumlah jenis ikan yang tercatat 50 spesies atau sekitar 18% dari total spesies ikan di Sumatra (272 spesies). Jenis ikan yang terpenting adalah *Breinsteinea* sp. dan *Chaca bankanensis* yang unik dan jarang. Karena serangga adalah kelompok binatang yang sangat besar, maka dalam studi lebih fokus pada kelompok kumbang. Kumbang yang teridentifikasi dikelompokkan kedalam 644 spesies dan 34 famili. Kumbang yang terpenting adalah kumbang sungut panjang (Cerambycidae) dan kumbang Scarabaeidae. Parasit pada mamalia kecil terdiri dari ektoparasit yang dikelompokkan menjadi 14 spesies dan endoparasit yang terdiri dari 2 ordo dan 3 spesies.

Kata Kunci: biodiversitas, hutan tebanan, kekayaan jenis, harimau sumatran, Gajah sumatran

INTRODUCTION

Sumatra is the sixth biggest island in the world and a part of Sundaic sub-region which exhibits 'great oriental fauna' similar to Malay Peninsula and Kalimantan. Also, it is famous as having high diversity of plant species which can be found in ecosystem of lowland forest, montane forest, peat swamp forest and mangrove (Whitten *et al.* 1987). Those ecosystems are the habitat of many species of flora and endangered fauna including Sumatran tiger, elephant, rhino, tapir, orang utan, sun bear and false gharial. However, in the last few decades, the rate of deforestation in Sunda lowland forests especially in Sumatra island increased with 'immense speed' (Lambert & Collar 2002). It was affected by massive forest destruction because of extensive logging and land conversion for agriculture, development of other infrastructure, forest fragmentation and housing. Riau is the largest province in Sumatra and possesses good quality of lowland forest which has been threatened by legal concession companies and illegal logging. A part of those lowland forest is Tesso Nilo forest (previously called Air Sawan forest) which is located in four districts: Indragiri Hulu, Kuantan Sengingi, Pelalawan and Kampar.

Tesso Nilo forest covered an area of 188.000 ha, previously this area was stated by the government for production forest to supply

logged wood and other wood products. Although it was considered as having the top rank on vascular plants of lowland forest diversity in the world and it is one of the last remaining habitat of Sumatran elephants which has been threatened (Gillison 2001). As consequences, since 1980 there were many conflicts between elephant and people. The area was then planned to be a nature reserve for conserving Sumatran elephants. As a primary requirement of being proposed and declared for conservation area, the biodiversity in the area should be assessed. Therefore, the main objective of this paper is: to provide scientific data on the biodiversity of Tesso Nilo such as: plant diversity, medicinal plants, diversity of birds, mammals, reptiles, amphibians, fishes, insects and parasites of small mammals.

Currently, some parts of the Tesso Nilo area, approximately 38.576 ha was gazetted as a national park by the Decree of the Ministry of Forestry No. 255/Men-Hut II/2004 on 19 July 2004 and expanded to 83.068 ha by the Decree of the Ministry of Forestry No. 663/Men-Hut II/2009 on 15 October 2009 for conserving the habitat of Sumatran elephant and Sumatran tiger.

MATERIALS AND METHODS

Tesso Nilo area is located between 0°0'5,1" and 0°14'56" South and between 101°31'14,6"

and 101°52'1,9" East, at altitude 100-200 m asl with topography relatively flat and rather wavy with elevation 10-15°. Its climate is categorized as wet with total rainfall 2000-3000 mm per year. The border in the east is Kerumutan Wildlife Preservation and in the west is bordered with Bukit Rimbang Nature Reserve. The selected survey areas were logged forest near Segati river, Mamahan river, Toro river, tributary of Mamahan river, Sengkalalo river and Sawan river (Figure 1).

Plant survey was conducted using quadrat method (100 x 100 m or a 1 ha plot) at selected site and general observation. The 1 ha plot was intended to describe community types, floristic composition, forest structure, economically species distribution and to study forest demography pattern. It was divided into sub-plots with size 10 x 10 m and 5 x 5 m. Sampling of all trees (diameter stem > 10 cm) was done in plot 10 x 10 m, however for sapling (diameter stem 1.0-9.9 cm) was on sub-plot size 5 x 5 m. The parameters used were stem diameter (for trees measured dbh and for sapling measured 50 cm on the ground), total height and trees coordinate (position in plot). The vouchers for identification were collected from all trees and saplings which have been measured. The general observation was conducted to obtain common illustration about plant diversity, since the quadrat method cannot give a complete figure of

species diversity, especially for endemic and endangered species.

The survey was conducted by interviews and direct observation in the field. The interviews were aimed to obtain data on the traditional knowledge of the local people about plant resources.

Bird survey was conducted by capture and recapture method using mistnets, opportunistic observations and interviews. Data collections by using mistnets were prioritized for the understorey species since they are most vulnerable to forest fragmentation and the impact of logging (Ford & Davison 1995 in Lambert & Collar 2002). Nine mistnets were mounted in three sites of two locations (Figure 1). These mistnets were set up in line with total length 108 m. They were opened between 06.00 and 18.00 hours. Data collections were conducted for 3 days in each site. The mistnets were monitored and checked every 30 minutes or 60 minutes. The captured birds were identified, measured and banded before being released back to the forests. If they could not be identified, the captured birds were collected for the specimen of Museum Zoologicum Bogoriense (MZB). Opportunistic observations were done to complete data on the diversity of birds. We recorded bird species either seen or calls heard and numbers of observed individuals. Interviews were conducted to three local villagers who have well experienced in catching, hunting or keeping birds. The interviews were done by using A Guidebook of the Birds of Sumatera, Jawa, Bali and Kalimantan (MacKinnon *et al.* 1992). In order to calculate the diversity index of bird species, data of captured individuals were analysed using Shannon-Wiener index (Ludwig & Reynolds 1988).

The methods for mammal survey included reconnaissance survey, camera trapping, trapping and mistnetting and interviews. In reconnaissance survey, observations were carried out twice a day (Newing *et al.* 2002). The first observation was

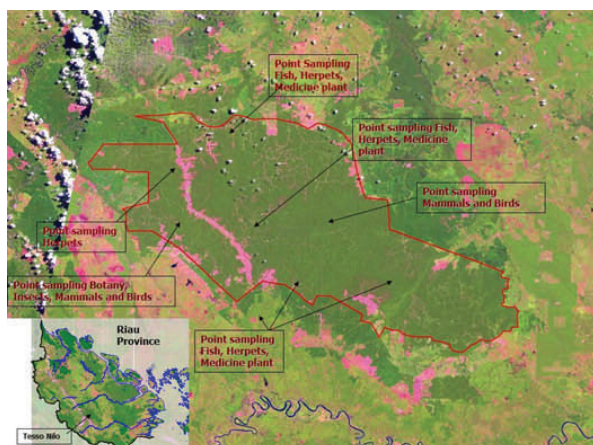


Figure 1. Survey location at Tesso Nilo forest

conducted between 06.00 and 11.00 hours, and the second between 14.00 and 17.00 hours. The data covered species, number of individuals, distance between animal and transect, direction of encounter, time of encounter and indirect encounter such as foot prints, calls and other prints left by animals. Camera trapping was conducted using five cameras equipped with heat sensor which were set around mammals' tracks. Trapping and mistnetting at the study plot (100 x 100 m) were implemented for small mammals (rodents and bats) which are active during the day or at night. In total, there were 326 traps x days and nights and 11 mistnets x nights. The abundance of small mammals was estimated by using Capture (C)/R(recapture) method with two samples followed Lincoln-Petersen method modified by Chapman 1951 (in Nichols & Dickman 1996). However, the abundance of bats was estimated using capture per unit effort (C/E) method (Lancia & Bishir 1996). Interviews were done to local people by showing the mammal pictures and asked them which pictures were familiar to them. The estimation of diversity index using Shannon-Wiener Index with the basis of \log_2 (Odum 1994) was applied to all combined data collected by reconnaissance survey, trapping and mistnetting.

Reptile and amphibian surveys were carried out by line and stream or riverine walk transect (Erdelen 1988) at Situgal village, Upstream of the Simpang forest at Hulu Anak Air Sawan river, Toro river and Anak Mamahan river. In addition, short census about 3 km long to downstream and 1 km to upstream was conducted at Segati river. The riverine walk transect was conducted by walking along pre-determined trails and recorded encountered species of reptiles and of amphibians, number of individuals of each species, sex and time of day. Calculation of diversity index of herpetofauna species was based on data of captured individuals which were analysed using Shannon-Wiener index (Ludwig & Reynolds 1988).

Fish survey was carried out by fish sampling on the streams or rivers. Fish sampling was conducted by angling with small and the big hook and electric fishing (12 V, 10 A). Collected fish specimens from the samplings were identified using Weber & de Beaufort (1913, 1916, 1922 & 1929), Brittan (1954), Kottelat *et al.* (1993), Ng & Siebert (1998), Tan & Ng (2000). Simpson index (range from 0 to 1) was applied to analyse data for species diversity and evenness referred to Ludwig & Reynolds (1988) and Odum (1971).

Insect survey was focussed to obtain data on the diversity of beetles (Coleoptera) which is the largest order. It was conducted using light traps (Taylor & Taylor 1977), malaise trap, dung trap, pitfall traps, yellow pan traps, banana traps, branch traps of *Artocarpus* sp. and *Ficus* sp. and active collections by sweep sampling, beating and breaking down wood decay. Collected insect specimens were identified until family level following Borror *et al.* (1989), Kalshoven (1981), Lawrence & Britton (1994), Makihara *et al.* (2002) and Noerdjito *et al.* (1998 a, b).

Survey on parasites of small mammals was carried out at the logged forest around Segati river. It was conducted along with the survey on small mammals (hosts). Hosts of the parasites (small mammals) were collected by live traps for rodents and tree-shrews and mistnets for bats. A total of 50 live traps were set in the survey plot (100 x 100 m) and 52 live traps were set up along the transect with a distance of 20 m for each live trap. In the survey plot, the traps were set as long as two times for three days. In the transect, the traps were set in a series as long as two days and were observed in the morning and evening. The ectoparasites were collected with brushing method, the specimens were taken by using fine forcep, small stick or small drawer brush, then kept in small vial containing 70% ethyl ethanol. The endoparasites or helminths were collected from hosts' stomach, intestine, caecal, rectal, liver, lung,

heart and other internal organs, that were removed and put in a petridish and searched for worms. The specimen of worms were collected and killed into hot water, preserved in 70% ethanol, then mounted in lactophenol before examination for identification with standard method (Suhardjono 1999).

RESULTS

Diversity of plant

The result of plant survey on 1 ha (100 x 100 m²) plot indicated that the richness of Tesso Nilo lowland forest was very high. The identification of plant species in 1 ha sampling plot recorded 360 species from 165 genus and 57 families consisting of 215 tree species and 305 sapling species (Table 1).

Diversity of medicinal plant

Local people around Tesso Nilo have utilized at least 82 medicinal plant species and 4 plant species for fishing. The medicinal plant species were categorized into 78 genus and 46 families. Those were used to treat 38 diseases. The important medicinal plant species were 'pagago' (*Centella asiatica*) and 'patalo bumi' (*Eurycoma longifolia*). The community already planted 'pagago' in their backyard. Although 'patalo bumi' was often being used and has economical value, they have not planted in their backyard so they always collected it from the forest.

Diversity of birds

Bird survey was conducted in three sites in two locations. Two sites were located in the forest near Segati river (0°08.898' South, 101°34.281' East, 133 m asl) with 0.5 km distant and one site was near Mamahan river (0°10.227' South, 101°40.725' East, 133.3 m asl). The survey recorded 109 bird species from 29 families: Ardeidae (1 species), Accipitridae (2 species), Phasianidae (5 species), Turnicidae (1

Table 1. Data on trees and saplings in the 1 ha studied plot at Tesso Nilo.

	Trees	Samplings
Species number	215	305
Genera number	118	147
Families number	48	56
Density per ha	557	1102
Basal area / ha	26.17	3.94
Richness index	9.11	9.19
Averages of diameter (cm)	21.87	2.86
Percentage of small diameter < 20 cm	53.41	-
Percentage of large diameter > 50 cm	3.05	-

Table 2. Number of species, diversity index (H') and evenness (J) of birds caught by mistnets in Tesso Nilo.

Site	1	2	3	Tesso Nilo
No of species	20	12	26	41
Shannon index (H')	4.019	3.228	4.470	4.905
Evenness (J)	0.661	0.653	0.748	0.599

species), Columbidae (8 species), Psittacidae (3 species), Strigidae (1 species), Cuculidae (5 species), Trogonidae (1 species), Alcedinidae (3 species), Bucerotidae (5 species), Capitonidae (2 species), Picidae (6 species), Eurylaimidae (3 species), Pittidae (1 species), Apodidae (1 species), Pycnonotidae (12 species), Aegithalidae (6 species), Turdidae (3 species), Timaliidae (17 species), Sylviidae (2 species), Rhipiduridae (2 species), Muscicapidae (2 species), Dicaeidae (1 species), Nectariniidae (5 species), Ploceidae (2 species), Sturnidae (2 species), Dicruridae (3 species) and Corvidae (3 species). The diversity index of captured birds was high (Table 2). This is because the understorey of the remnant forest was still dense, though the forest was logged selectively.

There were 20 bird species which are important in this area (Table 3). Most of those species are protected by Indonesian laws (*PP No. 7 / 1999*) and there were some vulnerable species which are not protected yet.

Diversity of mammals

Similar to bird survey, mammal survey was conducted in two locations i.e. at the logged forests

Table 3. Important bird species recorded from mistnetting, observations and interviews.

Family	Species	Status
Accipitridae	<i>Spilornis cheela</i>	P
Falconidae	<i>Microchierax fringillarius</i>	P
Phasianidae	<i>Lophura erythrophthalma</i>	Vu
Phasianidae	<i>Lophura ignita</i>	Vu
Phasianidae	<i>Argusianus argus</i>	P
Alcedinidae	<i>Ceyx rufidorsa</i>	P
Alcedinidae	<i>Lacedo pulchella</i>	P
Alcedinidae	<i>Halcyon pileata</i>	P, M
Bucerotidae	<i>Aceros corrugatus</i>	P, Vu
Bucerotidae	<i>Anorrhinus galeritus</i>	P
Bucerotidae	<i>Anthracoceros malayanus</i>	P
Bucerotidae	<i>Buceros rhinoceros</i>	P
Bucerotidae	<i>Buceros bicornis</i>	P
Pycnonotidae	<i>Setornis criniger</i>	Vu
Muscicapidae	<i>Copsychus malabaricus</i>	P
Nectariniidae	<i>Anthreptes simplex</i>	P
Nectariniidae	<i>Anthreptes malaccensis</i>	P
Nectariniidae	<i>Hypogramma hypogrammicum</i>	P
Nectariniidae	<i>Arachnothera longirostra</i>	P
Nectariniidae	<i>Arachnothera crassirostris</i>	P

Notes: P : protected by Indonesian Laws (PP No. 7 / 1999), Vu: Vulnerable (IUCN status), M: migratory

around Segati river and Mamahan river. A total of 34 mammal species or 16.5% of 206 mammal species in Sumatera were recorded by *reconnaissance survey* (RS) and capture and recapture method using traps and mistnets (Table 4). Based on *reconnaissance survey*, the diversity index of both locations was 3,696 which means that the diversity of mammal was high if we assumed that the diversity < 1 very low, 1 - 2 low, 2 - 3 medium, 3 - 4 high, > 4 very high (maximum Shannon-Wiener index = 5). However, in the study plot (100 x 100 m), the density of small mammals was small and reached 10 individuals/ha using Lincoln-Petersen method modified by Chapman 1951.

Diversity of herpetofauna

Herpetofauna surveys were conducted in some locations which were forests and rivers including Air Sawan, Sengkalalo, Toro and its tributaries, Segati and Mamahan rivers. The survey recorded 33 species of Herpetofauna consisting of 15 species

Table 4. Number of individuals of mammals found in Tesso Nilo from combined results of Reconnaissance survey, trapping and mistnetting.

Species	No. of individuals	Status (IUCN & RI laws)
I. Chiroptera		
<i>Balionycteris maculata</i>	1	-
<i>Cynopterus brachyotis</i>	1	-
II. Scandentia		
<i>Tupaia glis</i>	4	-
III. Primata		
<i>Hylobates agilis</i>	39	NT
<i>Presbytis femoralis</i>	31	NT
<i>Macaca nemestrina</i>	8	Vu
IV. Artiodactyla		
<i>Cervus unicolor</i>	6	P
<i>Muntiacus muntjak</i>	7	P
<i>Tragulus javanica</i>	1	P
<i>Sus scrofa</i>	13	-
<i>Sus barbatus</i>	3	NT
V. Perissodactyla		
<i>Tapirus indicus</i>	5	Vu, P
VI. Carnivora		
<i>Panthera tigris sumatranus</i>	1	E, P
<i>Neofelis nebulosa</i> (?)	4	Vu, P
<i>Prioniturus bengalensis</i>	2	P
<i>Helarctos malayanus</i>	2	Vu, P
<i>Lutrogale perspicillata</i>	5	Vu
VII. Rodentia		
<i>Callosciurus nigrovittatus</i>	2	-
<i>Callosciurus prevostii</i>	3	-
<i>Maxomys rajah</i>	5	-
<i>Maxomys surifer</i>	12	-
<i>Maxomys whiteheadi</i>	7	-
<i>Sundamys muelleri</i>	1	-
T o t a l	162	

Notes: E: Endangered (IUCN status), NT : Near Threatened (IUCN status), P : protected by Indonesian laws (PP No. 7 / 1999), Vu: Vulnerable (IUCN status)

of reptiles and 18 species of amphibians (Table 5). The reptiles were 8 species of snake, 2 species of agamids, 1 species of flying lizard, 1 species of skink, 1 species of varanid, 1 species of crocodile and 1 species of fresh water turtle. The Shannon-Wiener index of captured reptile and amphibian was 0.98 and 0.94 (< 1) which means that their diversity was low. The important of herpetofauna species were the False gharial (*Tomistoma schlegelii*) which is categorised as endangered and the common Soft-shelled turtle (*Amyda cartilaginea*) which is categorised as vulnerable.

Table 5. Species, number of caught individuals, diversity index (Shannon-Wiener) and protection status of reptiles and amphibians.

Species	Habitat	No. of individuals	Status (IUCN, RI Laws, CITES)
Reptile			
1. <i>Ramphotyphlops braminus</i>	Primary forest	1	-
2. <i>Elaphe flavolineata</i>	Rubber plantation	1	Non App. CITES
3. <i>Xenochrophis trianguligerus</i>	Secondary forest	1	
4. <i>Maticora intestinalis</i>	River bank of logged forest	1	
5. <i>Naja sumatrana</i>	Logged forest	1	App. II CITES
6. <i>Ophiophagus hannah</i>	Secondary forest	1	
7. <i>Python curtus</i>	Agriculture land	1	App. II CITES
8. <i>Python reticulatus</i>	Logged forest	1	App. II CITES
9. <i>Bronchochela jubata</i>	Herbaceous plant	1	Non-App. CITES
10. <i>Draco v. volans</i>	Rubber plantation & logged forest	2	Non-App. CITES
11. <i>Gonocephalus grandis</i>	Logged forest	1	
12. <i>Mabuya multifasciata</i>	River bank, grass land	4	Non-App. CITES
13. <i>Varanus s. salvator</i>	River bank	1	
14. <i>Tomistoma schlegelii</i>	Logged forest	10	En, P, App. I CITES
15. <i>Amyda cartilaginea</i>	Secondary forest	1	Vu, Non-App. CITES
Total individuals of reptile species		28	
Amphibian			
1. <i>Leptobrachium hendricksoni</i>	River bank	3	-
2. <i>Bufo asper</i>	Rubber plantation, logged forest, grass land, open area	8	-
3. <i>Bufo melanostictus</i>	Agricultural land, river bank	6	-
4. <i>Kalophrynus pleurostigma</i>	Secondary forest, logged forest	72	-
5. <i>Microhyla heymonsi</i>	Secondary forest, logged forest	10	-
6. <i>Fejervarya cancrivora</i>	Rubber plantation	6	-
7. <i>Fejervarya limnocharis</i>	Agriculture land, River bank, secondary forest	8	-
8. <i>Limnonectes leporinus</i>	Secondary forest, river bank	6	-
9. <i>Limnonectes malesianus</i>	River bank	7	-
10. <i>Limnonectes macrodon</i>	River bank	3	-
11. <i>Occidozyga sumatrana</i>	Dry evergreen, secondary forest	1	-
12. <i>Rana chalconota</i>	Logged forest, river bank, herbaceous plant	22	-
13. <i>Rana erythraea</i>	Primary forest	1	-
14. <i>Rana glandulosa</i>	Primary forest, grass land	9	-
15. <i>Rana hosii</i>	Logged forest, river bank	6	-
16. <i>Rana nicobariensis</i>	Primary forest, river bank	11	-
17. <i>Rana signata</i>	Agriculture land, river bank, herbaceous plant	39	-
18. <i>Polypedates leucomystax</i>	Agriculture land	3	-
T o t a l		221	

Table 6. Number of species, diversity and evenness indexes of fishes in the surveyed area.

River/ stream	No. of species	Diversity (H')	Evenness (J)
Toro river	32	0.914	0.344
Segati river	24	0.906	0.423
Mamahan river tributary	19	0.830	0.288
Accummulation of species number and average of diversity	50	0.883	0.352

Diversity of fish

Fish surveys were conducted at Sawan, Sengkalalo, Toro, Segati and Mamahan rivers. In general, fish diversity in the surveyed areas was high which was indicated by high number of species and high diversity index (Table 6). There were 50 fish species or 18% of the total Sumatran fish species (272 species) recorded from the area which represented 31 genera, 16 families and 4 orders. The large number of collected fish was categorized into Cyprinidae (18 species or 37.50%), Bagridae (5 species or 10.42%), Belontiidae (4 species or 8.33%) and Siluridae (4 species or 8.33%).

Diversity of insect

Insect survey, in particular beetles (Coleoptera) was conducted at the logged forest of Segati river. The survey recorded 644 beetle species which were grouped into 34 families. Two beetle families which had high diversity were Cerambycidae (81 species) followed by Scarabaeidae, 76 species.

Diversity of parasites of small mammal

A total of 14 species of ectoparasites and 3 species of endoparasites were recorded from 4 species of rats (*Maxomys surifer*, *M. whiteheadi*, *M. rajah* and *Sundamys muelleri*), Common tree shrew (*Tupaia glis*) and Spotted-winged fruit-bat (*Balionycteris maculata*).

The ectoparasites consisted of 4 species of ticks (Acarina: Ixodidae), 6 species of mites (Acarina other ticks), 1 species of lice (Anoplura: Hoplopleuridae) and 2 species of fleas (Siphonaptera). The Red spiny rat (*Maxomys surifer*) was a dominant ectoparasite host since it carried 3 species of ticks (*Amblyomma* sp., *Dermacentor* sp, *Ixodes* sp.), 6 species of mites (*Demodex* sp., *Echinolaelaps* sp., two species of *Laelaps* spp., 2 species of Trombiculidae) and 1 species of lice (*Polyplax* sp.). The endoparasites consisted of 2 species of Cestodes (*Hydatigera taeniaeformis* and *Hymenolepis* sp.) and 1 species

of Acantocephala (*Moniliformis* sp.).

DISCUSSION

Flora

In terms of plant diversity, Tesso Nilo forest had the highest diversity (Mennhenick) index than the other lowland forest in Sumatra. This study showed that the diversity index of Tesso Nilo forest was 9.11 (Table 7) which was higher than the forest at the edge of Alas river (Sambas 1999), lowland forest at Ketambe (Abdulhadi *et al.* 1984), Rimbo Panti (Yusuf *et al.* 2005), Rimbo Panti swamp (Yusuf & Purwaningsih 2009) and Batang Gadis (Kartawinata *et al.* 2004).

Although the forest suffered from heavy disturbances by logging, the remnant forest contained high diversity of flora which was confirmed by Gillison (2001) as the top rank on lowland forest biodiversity in the world. The population of protected but threatened species such as *Irvingia malayana*, *Koompasia malaccensis*, *Dyera polyphylla*, *Sindora sumatrana*, *Sindora brugemanni*, *Sindora leiocarpa*, *Sindora velutina*, *Scorodocarpus borneensis*, *Fagraea fragrans* was very poor. The other species included in the Red List of IUCN such as 'gaharu' *Aquilaria malaccensis*, 'ramin' *Gonystylus bancanus*, *Dialium* spp., *Shorea* spp., *Dipterocarpus* spp. and durian *Durio* spp. were only remnant saplings (Purwaningsih & Ismail 2003).

Most of the encountered medicinal plant species have been recorded in the book of Inventory of medicinal plant of Indonesia (Syamsuhidayat & Hutapea 1991; Hutapea 1993, Hutapea *et al.* 1994, Djumidi *et al.* 1997, 1999). In addition, similar medicinal plant species have been recognized and used by the local people in Tesso Nilo and Lembah Harau Nature Reserve - West Sumatra (Susiarti 2001) and Bukit Tigapuluh National Park-Riau (Rahayu *et al.* 2000).

Table 7. Comparison of plant diversity in field studies of Sumatran lowland forests.

Research Location	Size (ha)	No of species	Density per ha	Diversity (Mennhenick)	Sources
Tesso Nilo forest	1	215	557	9.11	This study
Edge of Alas river, South-east Aceh	1	81	542	3.48	Sambas 1999
Lowland forest at Ketambe Research	1.6	132	480	4.76	Abdulhadi <i>et al.</i> 1984
Rimbo Panti (800 m asl.)	1	145	429	7.00	Yusuf <i>et al.</i> 2005
Rimbo Panti swamp (200 m.asl.)	5	136	335	3.32	Yusuf & Purwaningsih 2009
Batang Gadis, North Sumatra	1	184	583	6.34	Kartawinata <i>et al.</i> 2004

Fauna

The survey recorded 109 bird species. However, if this result was combined with the preliminary survey by Rasfianto in 1992 (for a review see Gillison 2001), the diversity of birds of Tesso Nilo area would reach 114 species or 29% of the total number of 397 bird species in Sumatera (MacKinnon *et al.* 1992). The important bird species was the Wrinkled Hornbill (*Aceros corrugatus*) which have been protected by Indonesian laws (PP No. 7 / 1999) and categorised as vulnerable species. The other vulnerable species which are not protected yet were Crestless Fireback (*Lophura erythrophthalma*), Crested Fireback (*Lophura ignita*), and Hooked-billed Bulbul (*Setornis criniger*). The study also recorded the presence of White-throated Fantail (*Rhipidura albicollis*) at Tesso Nilo forest which was a new record for its distribution (Prawiradilaga & Marakarmah 2003). The species was known previously to occupy forest at 900 – 2400 m asl. (MacKinnon *et al.* 1992), however, it was recorded at 133 m asl. Although all species in the family of Nectariniidae have been protected, they were common in the area. Their protection status could be because their important role in polination.

The presence of three primate species i.e. *Hylobates agilis*, *Presbytis femoralis* and *Macaca nemestrina* in TessoNilo area indicated that the quality of the forest was still good. Primates usually select to forage in the middle and top of canopy. The canopy is very important for dispersion of mammal species. Since there were some protected

large mammals such as the Sumatran tiger (*Panthera tigris sumatrae*), the Sumatran elephant (*Elephas maximus sumatranus*), Sunbear (*Helarctos malayanus*) and Tapir (*Tapirus indicus*), Tesso Nilo area indicated high conservation value. Indeed, the presence of Sumatran tiger (*Panthera tigris sumatrae*) as the top predator and its prey such as Wild boar (*Sus scrofa*), Sambar deer (*Cervus unicolor*) and Barking deer (*Muntiacus muntjak*) was a good indicator for the quality of the forest.

The results showed that the density of small mammal population in the studied plot was low only 10 individuals/ha. This indicated that the forest of Tesso Nilo was relatively good because in heavily disturbed forest, the density of small mammals could reach 20 individuals/ha (Suyanto unpublished data). Instead of density, other indicator of disturbed habitat was an increase in the number of commensal or semi commensal of small mammals such as house rat (*Rattus tanezumi*), wood rat (*R. tiomanicus*) and short-nosed fruit-bat (*Cynopterus brachyotis*). However, the survey did not record those rats and only 1 individual of Short-nosed fruit-bat was recorded.

The important reptile was the endangered false gharial (*Tomistoma schlegelii*) which has been protected by Indonesian law (PP No. 7/1999) and is classified as endangered by IUCN and Common soft-shelled turtle (*Amyda cartilaginea*) which is categorised as vulnerable by IUCN . The amphibians were *Leptobranchium* sp., *Bufo* spp., *Kalophrynus* sp., *Microchyla* sp., *Fejervarya* spp., *Limnonectes* spp., *Rana* spp., and *Polypedates* sp.

Among those amphibians the Spotted stream frog (*Rana signata*) could be used as bio-indicator of good forest (Sidik & Maharani 2003).

None of the recorded fish species was categorized as threatened species by IUCN. in 2001 (Wargasmita 2002). Toro river had the highest species (32 fish species) and the highest diversity index (0.914) (Table 6). It was not surprising because previously the vegetation of the bank in this area was dense primary forest. Important fishes for swamp ecosystem i.e. 9 species of *Rasbora* spp., *Lucio cephalus pulcer*, *Hemirhamphus pogonognathus* and *Spaerichthys osphromenoides* were collected from Toro and Sawan rivers. Edible fishes which have high economical value were *Hemibagrus nemurus*, *Channa lucidus*, *C. striata*, *Clarias* sp., *Ompok hypophthalmus*, *Cyclocheilich thysarmatus* and Barau fish (*Hampala macrolepidota*). Ornamental fishes included *Epalzeorhynchus kallopterus*, *Rasbora heteromorpha* and *Betia fusca*. However, unique fishes because of their form and very rare were *Breinsteinea* sp. and *Chaca bankanensis*, recorded at Toro river and Mamahan river. The threatened Arowana fish *Sclerophagus formosus*, which was already included in CITES Appendix 1 was known to be at Segati river of Gunung sahilan village. However, this survey did not record it.

Cerambycidae and Scarabaeidae are important insect families in the order of Coleoptera as they indicated the good quality of the forest. Most of Cerambycidae larvae are wood borer, so the high diversity of Cerambycidae showed the high diversity of vegetation (Noerdjito *et al.* 2003). In addition, the high diversity of Scarabaeidae especially subfamily of Coprinae (Scarabaeinae) which feed on the faeces of various mammal species indicated the richness of mammal species in the Tesso Nilo forest.

Parasites are good indicator of high diversity of wildlife especially wild small mammals in a forest, because each parasite species needs a specific

host for its life cycle (Saim & Suyanto unpublished data). As a consequence, the presence of ectoparasites and endoparasites indicates high diversity of wild animals in Tesso Nilo forest. Although this survey recorded the ectoparasites i.e. Amblyomma, Dermacentor and Haemaphysalis from small mammals, these parasites have been known to have large mammals and carnivore as their specific hosts.

CONCLUSIONS

The study in the logged forests showed the richness of biodiversity in Tesso Nilo area, especially on the diversity of plant species which had been proved to be the highest among other lowland forest in Sumatra island and even in the world. If the area was left alone, the forest would have been recovered and back to the previous condition before being logged.

However, since the area has been heavily encroached, it is important to reassess its biodiversity. The results would possibly show the biodiversity loss which may guide the forest manager to formulate wise conservation strategies.

The area is a home for globally threatened animal species such as Sumatran tiger, and the False gharial. Therefore, it is important to maintain their population by conserving their required habitat and eliminating conflicts with human beings.

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