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Studies on the Small Mammal Fauna of Sabah, East Malaysia I. Order Chiroptera and Genus *Tupaia* (Primates)[1]

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Abstract

Tree-shrews, *Tupaia montana*, *T. tana* and twenty-four species of Chiroptera are studied in this paper. Among twenty-four bat species, *Cynopterus horsfieldi* is new to Sabah, while two bats, *Myotis siligorensis* and *Miniopterus magnater* are the first to be reported from Borneo Island. The last species, *Miniopterus magnater* was formerly treated as a subspecies of *M. schreibersi*, but the authors have come to the conclusion by the present re-examination that this animal is not *schreibersi* but a different form which has never been described as a species. As they show good specific characters, the present authors have shifted its taxon to the species rank. Some ecological data for these species which were recorded in three major caves on the east coast are also given.

Some statistical analyses are tried for the population of *Tupaia montana*, and the results are compared with the ecological data.

Small mammals in Sabah have long been in the consideration of European scientists, who had listed over 100 species from there. Today, most of Asian mammalogists, especially scientists of the peninsular Malaysia, hold their keen interest on it and are making their vast effort on completion of the faunal list.

The authors had concentrated all their effort on resolving the interspecific relations and congeneric divergence which might be preceding in this area. For realizing this purpose, the fieldwork was carried on the following areas: 1. Kinabalu National Park, and Ranau; 2. Sandakan, Batu Puteh, Gomantong and Madai. On the latter three localities, fieldowrks had been limited to the limestone cave and its neighbouring areas, because of the present survey items for these localities were sample-collecting and to search their mode of life.

In the present paper, the authors report a part of the result of their examination. The fieldwork was carried in 1976 (T. Kobayashi and M. Hotta, 1979) and 1979 (in March and August), present paper deals all these three collections.

The authors must express their sincere thanks to the following gentlemen, they gave us heartly support for carrying this study on. Their names are Messrs. P. F. Cockburn, former Botanist of Forest Research Center (F. R. C.) of Sabah, Liew That

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Chiroptera of Sabah

A sum total of twenty-four species which have compiled from three collections corresponds to about one third of chiropteran fauna of Sabah listed today. Among them, thirteen species had been collected in caves, nine species were caught by mist net in the open field or in the forest. The rest two species, *Scotophilus temmincki* and *Myotis siligorensis*, were collected from a housing or in a fissure of a rock-heap at the river basin, respectively (Table 1).

One cave-roosting species of Megachiroptera, *Cynopterus horsfieldi*, and *Myotis siligorensis* (Microchiroptera) are new record to Sabah and Borneo Island respectively. The known record of distribution for these species are as follows.

Cynopterus horsfieldi; Java, Sumatra, Peninsula Malaya, Southern Thailand.
Myotis siligorensis; Kumaoh, Nepal, Sikkim, Southern China, Indochina, Thailand, Peninsula Malaya.

In the present paper, the authors have used a new specific name for large Schreiber's long-winged bat of Sabah, *Miniopterus magnater*. This animal had been described originally by Sanborn, C. C. (1931) under the name of *Miniopterus schreibersi magnater* from New Guinea. Present authors have shifted up its taxonomical rank by several reasons. The detailed report relating to this shifting will be appear in the proceeding report.

Roost and Population

Madai Cave (Fig. 1): Twelve species were collected (Table 1). Among them, *Cynopterus horsfieldi*, *Myotis horsfieldi* and *Miniopterus magnater* had not been in the previous list (Chasen, F. N., 1931) in which appeared ten species of Chiroptera from Madai Cave. Also the name of *Myotis macrotarsus* was absent in Chasen's list, but the present authors think this animal might be conspecific to Chasen's *Myotis sp.*, because their taxonomical characters well fit to the present sample, as already Davis, D. D. (1962) had pointed out.

Table 1. The list of the collection from respective localities. (ex.··· ♂, ♀ together)

	Gomantong cave Sep., 1976	Gomantong cave March, 1979	Madai cave Sep., 1976	Madai cave Aug., 1979	Batu-Puteh caves March, 1979	Batu-Puteh caves No. I Aug., 1979	Batu-Puteh caves No. II Aug., 1979	Batu-Puteh caves No. III Aug., 1979	Sandakan	Near Gommantong cave	Ranau	Poring	Head Quarters	Penanpang	Kota Kinabalu
Pteropus vampyrus															2♂ 1♀
Pteropus hypomelanus									1♂						
Cynopterus brachyotis										7♂ 7♀		8♂ 6♀		9♂ 11♀	
Cynopterus horsfieldi				1♂											
Aethalops alecto													12♂ 12♀		
Megaerops ecaudatus													1♂ 1♀		
Eonycteris spelaea												1♂		1♂ 1♀	
Macroglossus lagochilus												2♂			
Emballonura rivalis					6♂ 9♀		12♂ 4♀					25♂			
Hipposideros diadema	1♂ 3♀	1♂ 2♀		9♂ 7♀								2♂			
Hipposideros galeritus				15♂ 3♀	13♂ 22♀	36♂ 7♀						37♂ 81♀			
Rhinolophus creaghi	8♂ 8♀	4♂ 3♀	29 (ex.)	7♂ 16♀	20♂ 16♀		30♂ 57♀	8♂ 4♀							
Rhinolophus borneensis			1 (ex.)												
Rhinolophus philippinensis	1♀			7♂ 2♀											
Myotis muricola													1♀		
Myotis siligorensis											1♂				
Myotis horsfieldi			1 (ex.)	12♂ 9♀	1♂ 4♀		5♂ 8♀								
Myotis macrotarsus				1♂ 1♀											
Nyctalus stenopterus												1♂			
Scotophilus temmincki														7♂ 12♀	
Miniopterus australis	1♂ 5♀		40 (ex.)	170♂ 132♀	2♂		2♂ 3♀	14♂ 13♀							
Miniopterus schreibersi			1 (ex.)	32♂ 11♀											
Miniopterus magnater	1♀		3 (ex.)	6♂ 9♀			1♂						5♂ 1♀		
Tadarida plicata	81♂ 99♀	21♂ 3♀	16 (ex.)	53♂ 68♀											

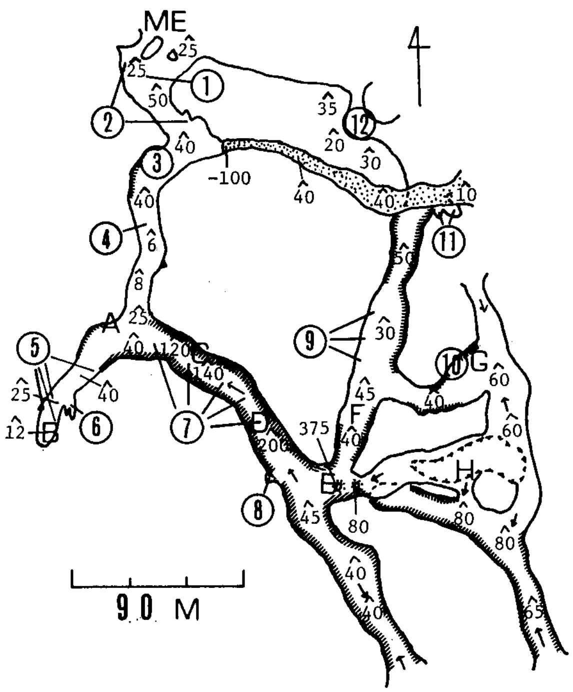

Fig. 1. Roost site map of Madai Cave. Cave map is redrawn from Wilford (1961). Among abbreviations, open circles with number indicate roosts. Alphabetical letters indicate the point of temperature recording. Areas shaded with dots are unexplored portion. Oblique line indicate the soiled portion with cave guano. Other symbols are followed after the conventional usage in speleology.

Gomantong Cave: Six species are recognized among present collection (Table 1). From its size and scale, it was supposed that this huge tunnel of limestone corrosion might have carried more complicated chiropteran fauna. It was easily thought that the present result was affected by the relatively short term (3 days in total) of collecting work. In the Chasen's list of bats living in that cave, we can see three forms of Microchiroptera, *Hipposideros galeritus, Hipposideros diadema, Rhinolophus creaghi.* In addition to this list, following four species must be listed, *Rhinolophus philippinensis, Miniopterus australis, Miniopterus magnater* and *Tadarida plicata. Hipposideros galeritus* had appeared in his list but absent from the present collection.

Batu Puteh Caves (Fig. 2): There is no report about chiropteran fauna of these caves. Among the present collection, six species were recognized by one of junior authors (Table 1). There appeared only one specimen of *Miniopterus magnater* (♂) in the present collection, but it may probably true that its true colony have roosted at somewhere in the neighbouring cave. For, the present collection made from three accessible caves out of five conspicuous cave group. The rest of them are still remained in unexplored.

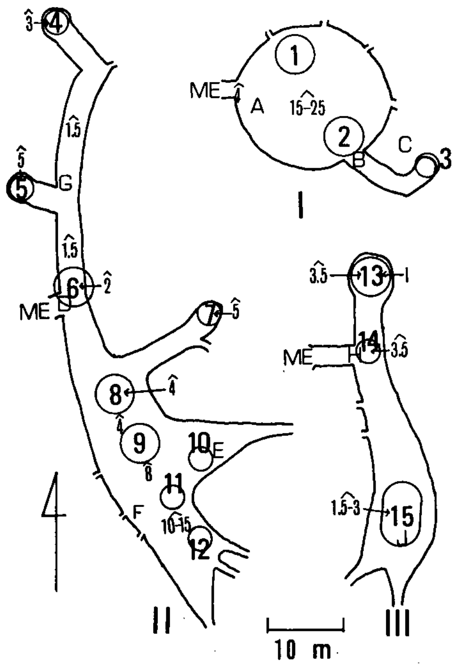

Fig. 2. Cave map of Batu Puteh Caves. Abbreviation are same as in Figure 1.

As a consequence of each tunnel size in Batu Puteh Caves is rather small, stability of the environmental factor was rather worse, temperature and humidity fluctuate according to the time. And also they changed according to the place as in the Table 3. In general, it might be said that humidity and moisture in the atmosphere seem somewhat in low compared with Madai and Gomantong Caves. The uniformity of the environmental factor at roosting site, rather dry condition in the caves, might resulted in avoiding the rich fauna which may settle in one cave.

Among limestone caves on the east coast, *Emballonura rivalis* was found only from this caves, but this species was found moderately in this area.

Tadarida plicata, which was found in numerous number from Gomantong Cave and Madai Cave, was not found in these caves. It seems that this species likes much larger caves.

Population and Colony

Names used in this paper are followed a precedants, Davis, D. D. (1962) and Medway, L. (1971), with exception of *Miniopterus magnater*, in which some taxonomical problems have been found. Taxonomical studies are now going into details, and the result will be appeared in due time.

Tadarida plicata: On account of this bat, as the resting site was in some height (40–200 m above the cave floor), the real colony and roost were not observed. In general, the colony formation and distribution was conducted completely different way to compare with that in Japan and adjacent territories. In the temperate zone like in Japan, the colony is made up by numerous number of aggregated individuals, sometime it is formed by a heap or doubled animals as a thick mat of bats along the side of the cave.

Contrasting to above mentioned phenomenon, *Hipposideros diadema, Hipposideros galeritus, Miniopterus schreibersi, Rhinolophus creaghi* and *Emballonura rivalis* showed scattered arrangement of individuals in wide range by spacing each other, in a distance of about 10–30 cm, with exception of few cases. In these few cases, 2–5 individuals clustered in one group and hung from the rocky wall as in dispersed individuals (plate 1–C, D).

The height of the roosting site of these species were in 2–15 m above the cave floor.

On the contrary to these species, *Myotis horsfieldi* were roosting in "bell hole" (Wilford, G. E., 1966) which were positioned at a low roofing of the cave (1.5–2.5 m from floor level), forming a small group of 1 or 2, with the largest one of 6 bats, or by single bat (Plate 2) as see in the following Table.

Colony size	1	2	3	5	6
No. of observed colony (%)	34 (66. 7)	10 (19. 6)	4 (7. 8)	2 (3. 9)	1 (2. 0)

Among the sex determined individuals of eleven colonies, eight were single male and the rest were, two females, two males and one male+five females.

Miniopterus australis: The roosting site was on the open wall or in a bell hole on it, sometimes they selected a bird-nest as a roost which had not be stained by the cave guano as in the Medway's description (1971). The colony of this species was found by single animal or by small group (2–7 bats). From the collecting results which were derived by using mist net in the cave, numerous number of this animals could be caught in a short time. It may be supposing that they live in huge number and roosting on somewhere else in the same cave.

The result of observation is presented in the following.

Colony size	1	2	3	4	5	6	7
No. of observed colony (%)	70 (80. 5)	5 (5. 7)	7 (8. 0)	2 (2. 3)	1 (1. 1)	1 (1. 1)	1 (1. 1)

* August 9–14, 1979.

Among the observed eighty-seven colonies, seventy (80.5%) were singular. According to the result by Medway, L. (1971) in Subis Cave (November, Feburary and May) and Madai Cave (July), there appeared 20% and 58% of colonized bats was in singular, respectively. The present singular rate is too high compared with that of Medway's. It is possible to mention that the reason is uncountable but the difference might be caused by the different breeding condition in each population.

Medway had also noted on the "harem" which was consisted by single male and

Table 2. Observed combination of individuals. It is clear that the greater parts of individuals roost in solitary state, not in group as Medway reported from Madai and Subis. (Observed on *Miniopterus australis* of Madai Cave)

		Number of females			
		0	1	2	total
	0		10	1	11
Number of males	1	16	2	1	19
	2	1	—	—	1
total		17	12	2	31

several (2–6) females from Subis and Madai Cave at the rate of 48.5% and 20.8% of total animals, respectively. Also he had reported the paired bats from Subis and Madai Caves, on the level of 19.7 and 12.5%. In the present observation, it had not counted so high as Medway's observation on paired and halem colony (Table 2).

The reason why this phenomenon differed between these observations is not yet clear.

Environmental Conditions

1) Temperature

Temperature and humidity were recorded in several position which have showed in Fig. 1, 2 and summerized in the Table 3.

Interior of the Madai Cave showed relatively constant temperature of about 25–26°C with sharply contrasting to the shading outside point which was selected in the aborginal bird-nest collecter's hut. The later place showed the maximum temperature beyond 30°C in the afternoon and fell down to the minimum of 23°C at early morning. The range of temperature fluctuation in a day was usually about 10°C at the outside environment, but it was very small in the interior of the cave.

This stable inside temperature may give some advantage to the colonized bat inside the cave.

Batu Puteh Caves (Fig. 2), showed rather different condition of temperature. The windy path of the cave interior showed 28–31.5°C in the daytime, and fell down to 26°C at morning. On the otherhand, at the ill-ventilated path-ways in the cave, temperature was 27–28°C at daytime and 26.5°C at morning (Table 3).

2) Humidity

Madai Cave; Cave interior showed constantly high humidity with slight modification at the well ventilated place, meanwhile, in the base camp (B.C., outside open place), it fluctuates with the change of temperature. At the open cave-mouth (like entrance of the cave branch, Fig. 1–G) showed a trend of lowering humidity.

Batu Puteh Caves; Temperature had recorded on 10 points of Batu Puteh Caves, of which 3 points were cave I, 4 points were in Cave II and the rest 3 were in Cave III

Table 3. Temperature and humidity in the interior of Madai Cave, Batu Puteh Caves and shading outside place. Temperature and humidity were recorded for Madai Cave, from August 9th to 14th, and August 2nd, for Batu Puteh Caves.

Madai Cave

Recording spot	A	B	C	D	E	F	G	H	M. E.	B. C.
Temperature variance	26. 0 (2;00)	26. 0 (2;55)	26. 2 (3;10)	27. 0 (3;10)	26. 5 (4;20)	27. 0* (9;45)*	25. 7 (9;15)	26. 2 (9;15)	26. 0 (2;00)	31. 5 (11;30)*
in recording spot	25. 0 (7;10)*	25. 0 (6;55)			25. 0 (3;05)				24. 0 (7;35)	23. 0 (5;30)*
Humidity (%)	98. 5	100	100	100	—	95	100	98. 5	100	88. 5 100

* Asterisked time are in the morning, non-asterisked in the afternoon. M.E. Main Entrance. B.C. Base Camp. Time showed in ( ) indicates the recording time.

Batu Puteh Caves

Recording Spot	A	B	C	D	E	F	G	H	I	J
Temperature	31. 0	30. 0	29. 0	31. 5	28. 0	28. 0	30. 5	28. 0	28. 3	27. 3
Humidity (%)	63	72	78	64	89	85	72	83	83	90

* Recording time 2;40–4;10 a.m.

(Fig. 2, Table 3). The lowest humidity were always observed at the point of main entrance (ME-A, D, H, for respective cave). In general, at a far more distant point from the cave mouth, temperature was going to decrease and humidity was going to increase to the point of saturation, as it was observed at Madai Cave. In the case of the observation at Batu Puteh, saturated humidity was not observed at any observatory, because of their much smaller size.

Emergence and Homing Time

Emergence and homing time was checked at Madai Cave for two days on August 1979. Five species out of three genera, *Hippossideros diadema, H. galeritus, Miniopterus schreibersi, M. australis, Myotis horsfieldi,* were observed their respective timing. The result is showed in following.

	Emergence	Homing
Hipposideros diadema	6:00–7:05 p.m.	5:45–6:50 a.m.
H. galeritus	6:10–6:25 p.m.	3:15–3:30 a.m.
Miniopterus schreibersi	6:30–6:45 p,m.	5:30–5:40 a.m.
M. australis	6.10–6:25 p.m.	

The record for *Myotis horsfieldi* is omitted from these data, because of its incompleteness being caused by human disturbance on the normal behavior. Their roost site positioned on the low wall (1.5–2 m above the cave floor) and easily react to moving man and flew away from the roost. The homing time of *Miniopterus australis* has not been determined, their homing time widely overlaped to the emergence time of *Callocalia* sp. at their roost. This caused severe confusion on observation.

Tupaia

Tupaia montana

Materials used for studying *Tupaia* were compiled from three collection as already mentioned for Chiroptra. As for *Tupaia* itself, each collection was made up as follows.

Collection of the first expedition was gathered from Kinabalu National Park (11♂♂, 14♀♀) and Gunon Arab (2♂♂, 1♀). Among these specimens 2♂♂ (one each from respective locality) are omitted from the present study, by the reason of severely injured by flesh eating insects.

The second collection was gathered between march 17 and 25, which was made up by 15♂♂, 20♀♀ and 2 sex undetermined specimens, which have been omitted from the sex-relating datum. The collecting work was restricted to Kinabalu National Park, especially to the walking trails around the area of park headquaters. From the result of above mentioned consideration, total samples would be called as the population sample of respective habitat, the montane oak forest. This type of habitat growing on the slope of Mt. Kinabalu and its neighbouring Crocker Range (Kobayashi and Hotta, op. cit.) at the elevation of about 1,400 m, sometimes called as low montane oak forest. The most dominant species of small mammal at this elevation was *Tupaia montana*, and the rest of *Tupaia* was not collected in both year.

Contrasting to this animal, sciuroid and murid animal, which have been appeared in the same niche together with tree-shrew, were very hard to collect in abundance, but they have appeared in wide variety of species in the present collection. The most part of these small mammalls are arboreal in this area, which have developed under the condition of specially low productivity of the forest floor in tropical rainforest. The scarcity of small mammal at the forest floor and the numerousity on the tree trunks are the characteristic feature of the tropical zone.

Measurements were recorded by millimeters and grams, directly on the fresh carcas which were obtained by killing animals which caught by the alive-trap. Sex was checked by the direct examination for the gonad. Existance of disease spots of liver, parasitic demorphism and activity of gonad were also examined and recorded.

Individual measurement was grouped according to sex, locality and collection, and compared with respective counterparts. Means (x), standered errors (SE) and t-value for $P=0.05$ were calculated for each sample.

Result

Estimated values for two collections which were collected in 1976 and 1979 from Kinabalu National Park are showed in Table 4. There are no significant differences found between two collections, except ear length. The sample means indicate that the animal had slightly short ear in March 1979. With the 1979-collection, the sample range of ear length is 12–16 mm, meanwhile in the 1976-collection it is 12.5–17 mm. As one understand from these two sample ranges, it is clear that the most of measurements fall in about same range of measurement. This significance of difference is resulted from the different figure formation in respective collection. Namely, the proportion of small eared animals in 1979-collection is 40.2%, and the same proportion in 1976-collection is much lower (20.0%).

The major factor affected to this result is not known, but it is possible to think that the age structure of two samples differ each other, or it is affected by some artifacts appeared in the course of measurement, because these two collections were gathered in the same area.

There is no important difference between two collection, the whole samples are mixed in one and redivided into sexed samples. The estimation for sexed samples is showed in the Table 4. The difference between sample means is not significant in any of their dimensions.

From above mentioned result, it is clear that there is no significant reason to split these samples into parts. In this paper, the authors think much of this conclusion and decided that all the specimens collected from Kinabalu National Park area must be treated as a single sample.

Measurement; (sample means with standard error, sample size in parenthesis)

Head and body length together, 165.5±1.0998 (N=61); tail length, 141.9±1.1756 (N=61); fore foot, 21.9±0.1451 (N=61); hind foot, 37.8±0.140 (N=59); ear length, 13.9±0.1602 (N=60); tail ratio (tail/head and body ×100), 86.0±0.753 (N=61).

Confidence limits of population means are; head and body length together, 163.3–167.7; tail length, 139.5–144.2; fore foot, 21.6–22.2; hind foot, 37.3–38.2; ear length, 13.6–15.3; tail ratio, 84.5–87.5.

Coat color; dorsum basically deep dark-brown, looking bushy appearance by its dense and long hair. Central portion of its dorsum, with a fairly darker wide longitudinal area. Venter, dull brown with a light orange hair. Fore and hind foot uniformly black and with distinguishable five digits.

Table 4. Comparison between two samples collected in 1976 and 1979, and sexes. Specimens used for comparison are compiled with adult and sub-adult animals. Every dimension was measured by mm and showed by sample-means±standard errors. (abbreviations; H & B head and body length together, T tail length, H. F. hind foot length, E ear length, T/H & B tail ratio in %)

Sample	H & B	T	H.F	E**	T/H & B
1976	169. 05± 1. 3043(21)	141. 55± 1. 7403(19)	38. 53± 0. 3277(19)	14. 50± 0. 2513(20)	83. 82± 1. 1546(19)
1979	168. 59± 1. 2824(27)	144. 07± 1. 8681(27)	37. 66± 0. 3211(25)	13. 81± 0. 2272(26)	82. 76± 1. 0615(27)
Sex					
♂	167. 55± 1. 3678(20)	142. 32± 1. 9392(19)	38. 39± 0. 3993(19)	14. 37± 0. 3218(19)	85. 16± 1. 1249(19)
♀	169. 70± 1. 2169(27)	140. 00± 4. 4177(27)	37. 78± 0. 3001(25)	13. 93± 0. 1900(27)	84. 75± 1. 0987(27)

* Sample size is showed in the parentheses.

** Two sample means are significantly different (t=2.0355, $d.f.$=44, 0.05>P>0.03).

Dentition: i2/3, c1/1, pm3/3, m3/3=38, pm3 shows a retrogression in size and structure. m3 of both jaws reducing its size but fundamental structure still distinguishable. Incisor row on the upper jaw, with an open space at the front center, as in chiroptera. Rostrum, moderately projected forwardly.

Ecology

Habitat: Present specimens were collected entirely on the forest floor, not on tree-trunks. The trapping success for 100 trap-nights was about 7–8 for both 1976 and 1979. This count tells us that the montane oak forest at National Park abounds with *Tupaia montana*. Generally, 100 trap-night count for single species is as low as 2–3, in the tropical zone. Acturely we could have a time to look one *Tupaia montana* was eating bananas on the ground. Though, it has been said that the treeshrew spent greater part of their life on the tree trunks, *Tupaia montana* act more frequently on the ground than it is said, at least on these areas. It is probable that they act on the ground in cases of food searching, searching for opposite sex and even in the case of moving to elsewhere.

Breeding: Among the collection of 1976, animals with scrotal testes were 9 and not scrotal were 3. On March, 1979, they were 10 and 3, respectively. Among the later 3, one was judged as withered testis by its appearance. The rest of them showed smooth and hard oval in their shape, but this peculiar testis had rugose and limp appearance.

The size of scrotal testis is (in mm), 9×4–13×6, with mean of 10.5×4.9 in 1976, and 8×5–12×7 (mean 10.8×5.6) in 1979. Abdominal testis is 4×4–7×4 (6×4) and 5×2.5–5×3 (5×2.8) in respective year.

External characters: The mean external measurement of scrotal male (with sample range) is as follows;

Body weight, 117.8 (110–150); head and body, 168.9 (162–178); tail, 141.3 (132–156); hind food, 39.0 (36–41); ear, 14.9 (12.5–17). Abdorminal male is;

Body weight, 102.0 (100–104); head and body, 152.0 (139–158); tail, 142.5 (136–148); hind foot, 37.8 (37–38); ear, 12.6 (11–14);

Female; The age class was defined as follows; Class I—Animals with not elongated uteri (immature animals), Class II—Animals with elongated uteri but without foetus (subadult animal), Class III—Animals with foetus, placental scar, corpus luteum or lactating mammae.

Structure of female population is presented in next table.

Age class Year	I	II	Pregnant	No. of* foetus	Postnatum	Placental** scars
1976	3	2	5	(1.8)	3	(2)
1979	4	4	5	(2)	6	—

*, ** mean size in respective individuals.

Class I is compiled from the small individuals. Their size is as follows (mim.–max. =mean).

Body weight, 73–108=92.1; head and body, 152–171=159.5; hind foot, 33–38=36.7; ear, 13–15=13.7.

Class II. group of medium sized animals. From this size, these animals might be young adult but not post-natal or old ones.

Pregnant and post-natal mathers were the main part of matured females which occupied about 60% of female specimens (there was no significant difference between 1976 and 1979).

The size of Class III is as follows.

body weight, 109.5 (102–153); head and body, 169.7 (156–181); tail, 147.0 (135–162); hind foot, 38.2 (36–41); ear, 14.1 (12–15).

Age structure of samples were examined by using above criteria. The collection was not so significantly different on the age structure, that these two collection of respective year were combined in one sample.

	Juvenile	Subadult	Adult	Total
Male	6(24%)	19(76%)		25
Female	6(19.3%)	6(19.3%)	19(61.4%)	31

For the adult male, there is no definite border between subadult and adult on the morphological data. The juvenile rate for revealed population is about 20%, but it seems like that there is still unrevealed portion (such as youngs just after weaning) remained. There is slight difference between sexes. These lacking of infant animals and sex-dependent difference might be caused by their own trappability and growing rate.

Among the adult population, about 20% were judged as newly matured adult (young adult) for female.

It seems that the population structure is remarkably stable for years and seasens. There might be some security mechanism to keep it, for instance, constant addition to each age class by equal volume to losing number from age classes. This constant adding mechanism may be produced from the year-round production of offsprings and steady development of them.

Tupaia tana

Specimen examined; One female from Telupid.

Measurements; Body weight, 230. Head and body, 209; tail, 162; fore foot, 28.5; hind foot, 44; ear, 17; tail ratio, 77.5%.

Breeding condition; pregnant with 2 foetus (2 corpora lutea in the right ovary).

Tupaia glis

Specimen examined; Two females from Telupid.

Measurements; Body weight, 142 and 225. Head and body, 181 and 202;

tail, 178 and 198; fore foot, 26 and 28.5; hind foot, 47 and 48; ear, 14 and 14.5; tail ratio, 98.3 and 98.0%.

Breeding condition; The former one had undeveloped uterine (juvenile). The later, matured with no foetus.

Discussion and Conclusive Note

Tupaia montana

It is desired that the exact age of an animal should be cleared for any of field collections. The information about age of certain animals is surely important to declare the exact form of concerned animal's life, and then, it is respected to become useful guidane to understand what has been going about animals in the nature. For instance, if one could know the population structure of certain animal, from which he may understand their life span, maturity age, potentials for production and so on.

In the present study, the authors had tried it by using an external measurements and succeeded in part. Namely, two age classes (juvenile and adult) for male and three (juvenile, subadult and adult) for female are come into distinguishable. But they failed to find out exact and more detailed one, which is important to know the detailed mode of life. The present criterion, in a conventional use, was useful for dividing samples into age classes. From the result of present studies, it is probably possible in common use that the body weight and the head and body length may set up the class-limit. That is as follows,

1. Upper limit of juvenile; 105 grams and 165 mm..............................juvenile
1'. Individuals over this limit...2
2. Male and female with elongated uteri..adult
2'. Female without elongated uteri...Subadult

By using this simplified criteria, it has been thought that about 10% of total individuals which have close measurement to the limit, will be misjudged. Although this simplified method bring in some misjudgement, the out-line of their population structure will come into clear.

Tupaia montana seems the dominant and real habitant of the montane oak forest, especially that of Kinabalu National Park, in Sabah. The trapping success revealed that the capture rate of this species was about 7–8% on this area. The capture rate for same species on Gunon Arab and Mamut was about 3 and 10%, respectively. At some lowland area, the capture rate was fell down to about 0. Furthermore, any of other species of *Tupaia* was too hard to capture in the montane oak forest of National Park. It seems as if this species is the only species living in the area of National Park Headquaters.

As already mentioned *Tupaio montana* is almost only habitant of treeshrews in Park Headquaters area and it may be supposed that the same condition appear on Gunon Arab. These localities are located on the same height of Crocker Range, the western coast watershred. In this area, the mode of life appears in very similar way of squirrels living in the temperate zone, especially similar to Far Eastern ground squirrels, in its stability and high density of populations. Generally, the stability of populations is the result of constant addition of new individuals to the population (reprodutive rate) which is balancing with falling out individuals (mortality, moving-out rate). It may be supposed like this, the similar mechanism is existing in these populations. Further study might be expected.

Tupaia montana can bear youngs at all season of the year, but the resting interval of pregnancy is not clear. Average litter size for examined fourteen cases, was two but

	Foetus+placental scar	Foetus+placental scar+ corpus luteum
August 1976	1.8(1-2)	1.7(1-2)
March 1979	2.4(2-4)	2.3(2-4)

there were few exceptions. In 1976, two females were found as single foetus pregnancy, and multiple foetus was found in 1979 from one female. The foetus of this species developes hairs on their back at the time just ahead to delivery. Eyes still inclosed, concha spread up and the mouth widely opened, but its teeth is undeveloped (Plate 4). From these condition, it is possible that the report about two youngs of Cologne Zoo which left their nest on the twenty-seventh day after birth (Walker, E. P. 1968).

Chiroptera

Bats of the tropical zone are still in obscure condition as for its greater parts of life. In this paper, we could offer some ecological informations for Chiropteran fauna from the East Coast of Sabah. In general, the more colossal caves the more complex fauna they can keep in, as in Madai Cave (Table 5). In these colossal caves individual bats select their most favorable spot as a roost. Usually these selected places have a stable heat condition of atmosphere, that is always lower than out door temperature in the daytime. And it is as damp as almost saturated. The roost site at the huge cave interior are usually divided into three strata by height from the cave floor and be cocupied by respectively special species. The strategy of roosts seems that the places are selected according to the inclination or resting habit of each spesies on the wall, ceiling or fissure and dint on the wall. It must be think of the inter-specific relation existing between these species which may strongly affect to the roost distribution in the cave. In the present paper, we have no detailed information about this relation.

It is also suggestive habit developed widely at the temperate zone, which is called "clouded colony" making at the overwintering roost. This type of clouded colony could find not only at the wintering roost but also found in every colony throughout the year. But, in the present survey, we could not find any of this aggregative colony in Madai, Gomantong, Batu Puteh Caves. Moreover, every colony showed individually distributed in rather disperse pattern (Plate 1-C, D). This might be expedient to prevent epidemics, exoparasites, and polluted air caused by their own respiration. All these disorderness of environment generally goes the more it become hot, the more powerfully they affected to the inhabitant.

Table 5. Estimated colony size of bats in Madai Cave.

Roost site	Species		Estimated colony size	Hight of the roost
1	*Hipposideros galeritus*		100	40 m
2	*Myotis horsfieldi*	each	10–15	1.5–2.5 m
3	*M. horsfieldi*		15	1.5 m
4	*Hipposideros diadema*		1,000	2–15 m
5	*Myotis horsfieldi*	each	10–15	2 m
6	*Rhinolophus creaghi*		100	4–10 m
	R. philippinensis			
7	*Tadarida plicata**	some	100,000s	50–200 m
8	*Miniopterus schreibersi*		1,000	6–20 m
9	*M. australis*		200	
	Rhinolophus spp.		50	4–15 m
	Hipposideros diadema		50	
10	*Rhinolophus* spp.		100	10–15 m
11	*Miniopterus australis*		200	
	Rhinolophus creaghi		100	4–15 m
	R. philippinensis			
12	*Hipposideros galeritus*		2,300	6–30 m

* Colony size and height of roost were not diretly observed, these are supposing values based on the trapping results.
Roost site numbers are same as in Figure 2.

It seems reliable to think the idea which their dispersed roost was original to them, and it developed the adaptive meaning for infectious prevention in the complexed fauna. It gradually changed by spreading their distribution to the north —namely, the aggregative colony which meant adaptive habit for the coldness developed as its distribution expanding towards the north.

As the result of the present study, the authors have been keenly impressed that Sabahan nature needs more and detailed examination to understanding its real state.

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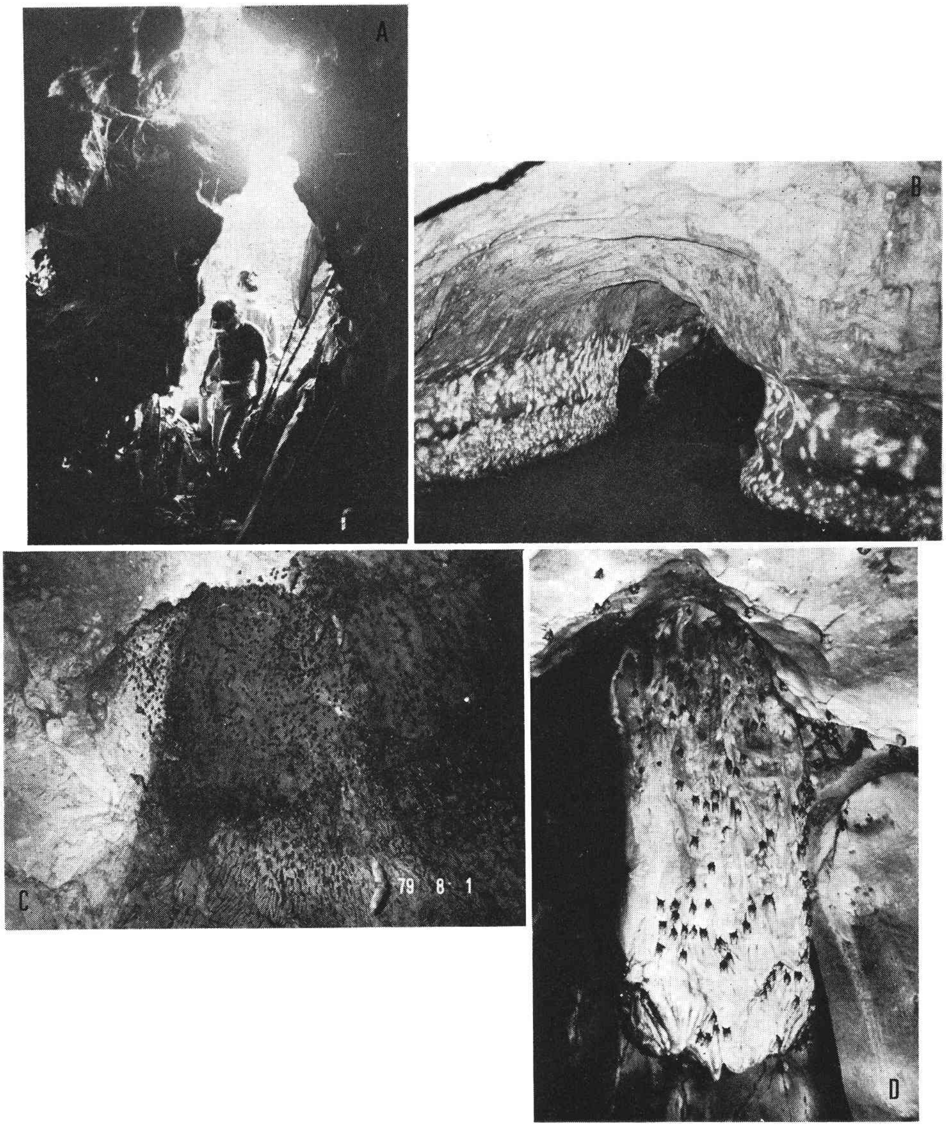

Plate 1

A. One of the cave entrance of Batu Puteh Caves. (Phot. by Y. Tempo)

B. Cave interior of Batu puteh, the wall was soiled by cave guano. (Phot. by Y. Tempo)

C. Dispersed roosting of Batu Puteh bat colony. This photograph shows one of three major colony of *Hipposideros galeritus* found in the Cave I. Bats were hunging individually. (Phot. by Y. Tempo)

D. Bats are resting moderately apart from each other. (Batu Puteh. Phot. by Y. Tempo)

Plate 2

A. Swiflets (*Callocalia sp.*) built their nests on the cave wall, and some of the bat (*Myosis horsfieldi, Miniopterus australis*) co-existed among them. (Phot. by Y. Tempo)

B. *Miniopterus australis* is hunging from the bird's nest. (Phot. by Y. Tempo)

C. "Bell hole" is found in places at the cave interior, and some of them are used as a roosting site of singular bat (*Myotis horsfieldi.*) (Phot. by Y. Tempo)

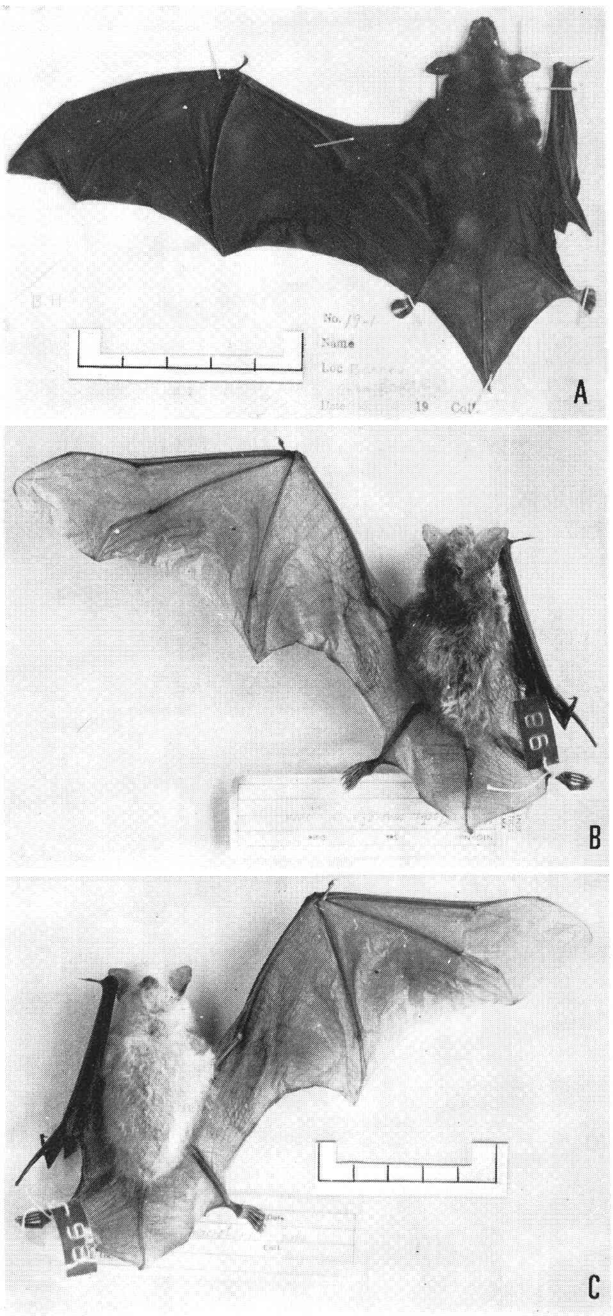

Plate 3

A. *Myotis siligorensis*, found from the fissure of rock-heap. Near Ranau.
B, C. *Myotis macrotarsus*, collected from the Madai Cave.

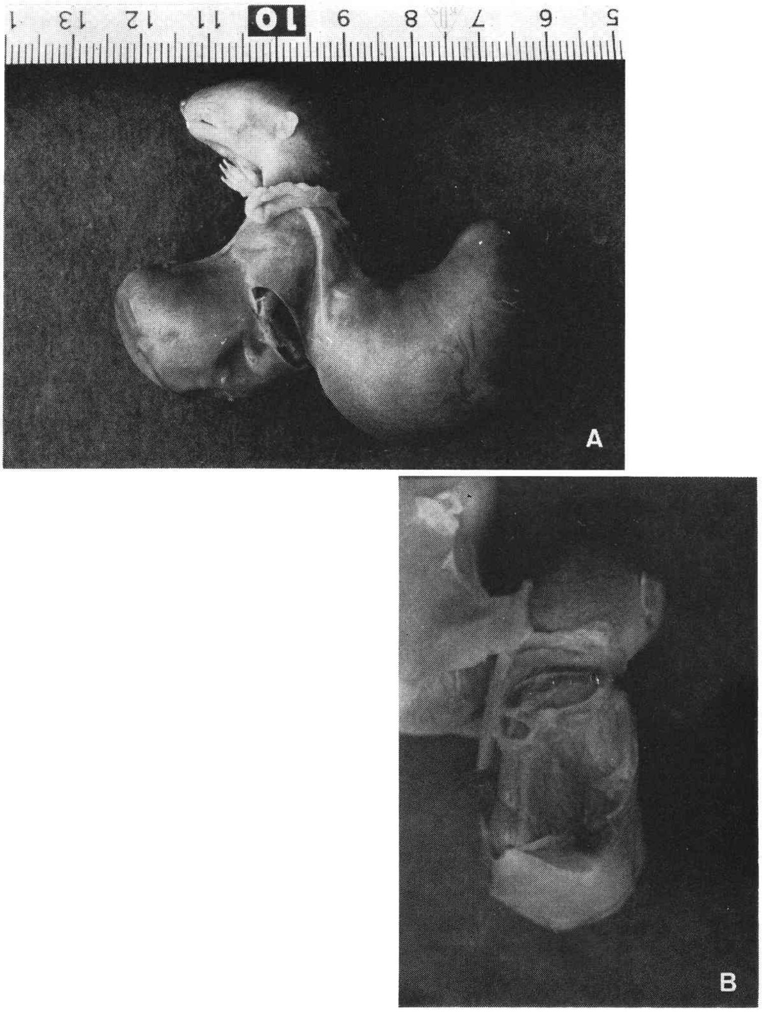

Plate 4

Foetus of *Tupaia montana*, lying in the uteri. The head of one foetus appears from the cervix. A. Total view. B. In back view.