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FAUNA OF THE DARK CAVE, BATU CAVES, KUALA LUMPUR, MALAYSIA[1]

By H. Elliott McClure[2], Boo-Liat Lim[3], and Sarah E. Winn[4]

Abstract: Observations and collections of the fauna of the Dark Cave of Batu Caves at Kuala Lumpur, Malaysia, were made between May 1959 and January 1961. The caverns have an extensive invertebrate population, many species of which remain unidentified. Twenty-three species of vertebrates were observed, the most abundant being *Eonycteris spelaea* and *Hipposideros diadema*. The collections included 151 identified species of 94 families of invertebrates. Coprophagous mites of several species and Diptera were the most abundant arthropods. Populations and species make-up varied from the entrance to the rear of the caverns. Most species developed maximum populations where light and moisture conditions were optimum.

The Batu Caves massif is 11 km NE of Kuala Lumpur at 3°N and 102°E. It was first explored by H. C. Syers in April 1879 and reported to the Royal Asiatic Society by D. D. Daly (1879). It was further explored and the animal life described by H. N. Ridley (1898), N. Annandale, J. Coggin Brown, & F. H. Gravely (1913), Cedric Dover & Mercia Heynes-Wood (1929). Dover's collections were the most extensive and many new species were described. W. S. Bristowe (1952) explored the caverns for arachnids in the winters of 1930 and 1931, and again in February 1961. His observations in 1961 revealed that the same species were present as 30 years before, but in different population densities.

Eric G. Holland's (1955) "A Guide to Batu Cave" describes the caverns and discusses some of the fauna.

The Malayan Nature Society is sponsoring an effort to have enough of the massif set aside as a national monument to preserve the caverns from destruction by quarries (McClure 1961).

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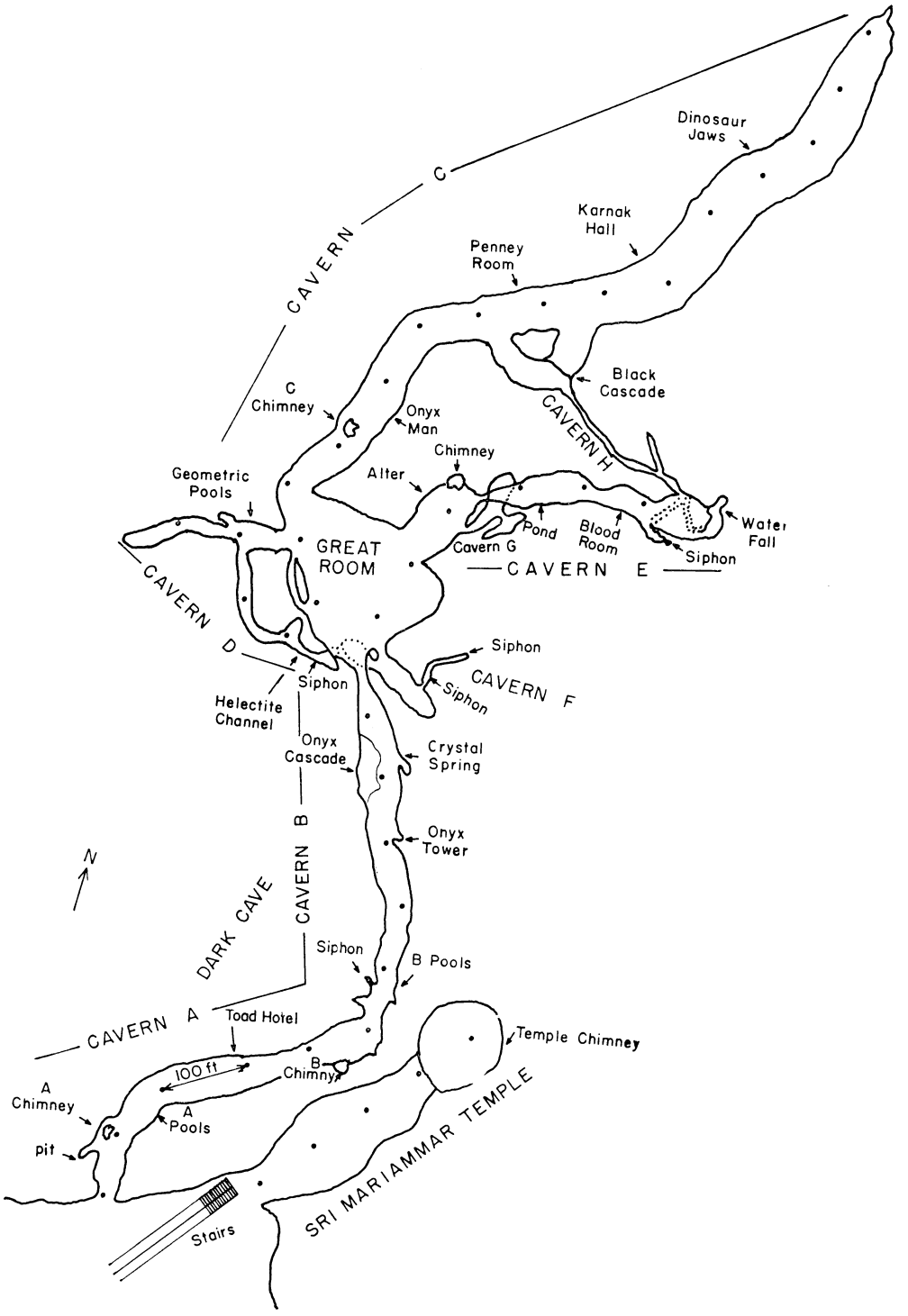

Fig. 1. Batu Caves, Kuala Lumpur, Malaya.

THE CAVERNS

The 150 meters bluff is a fragment of a permocarboniferous limestone mantle over 100 meters thick which once covered much of Malaya. Exposed on the surface of the bluff are deep crevices and pits, the eroded remains of channels and rooms, while scattered over it are the exposed ends of siphons now become chimneys which let light and life into the intact caverns beneath.

Two caverns are open to the public. The smaller one, which includes a vaulted chamber with a large collapsed room at one end, has been dedicated as the Hindu Sri Maniam temple since the last century. A much larger and longer Dark Cave (fig. 1) parallels and extends beyond the temple cave. These two channels are branches of one cavern complex that opens at a height of 45 meters above the surrounding plain. Dover identified the separate channels with a system of lettering which has been retained. A short sunlit entryway opens into a large perforated chimney (Chimney A) from which Cavern A extends about 120 meters to another perforated chimney (Chimney B). Because of light seepage at either end Cavern A is in twilight and supports the largest fauna of hypogean forms. Since guano mining has removed guano and phosphate impregnated soils from the floor to depths of six to nine meters, the original floor contours are much distorted throughout the length of Caverns A, B, and C. Digging in Chimney A exposed a small room the entrance to which had been blocked by mud and onyx and this is referred to as "The Pit."

The main channel (Cavern B) continues north from Chimney B for 150 m before entering the Great Room. This corridor, 15 m wide and as much as 30 m high, narrows to about 5 m in diameter at the Onyx Cascade thereby creating a shaft through which air flows rapidly, usually from the Great Room. Occasionally with a change in temperature and wind direction outside of the bluff the wind reverses.

From the Great Room, which covers more than two acres, six channels radiate (fig. 1). Caverns A to C all harbor bats as does the Great Room, but D to H are not heavily utilized by bats with an equivalent reduction in other forms of life. Steep inclines drop down into Caverns D, F and G which extend beneath C and E and which may be parts of the same channel buried when a rock collapse created the Great Room. A large perforated chimney at the end of the Room permits sunlight to enter and casts a greenish glow since algae cover the walls where light will permit. Cavern E extends from beneath the chimney and is often flooded with water collecting from drip. Water pouring over formations flows down a steep falls into a pit 15 m deep from which a small channel (Cavern H) extends to Cavern C and opens at the base of a large black flowstone falls (Black Cascade). Water from Cavern C once flowed down this channel into E from which a siphon, that is now blocked, carried it further. Now seepage water finds its way out through other crevices.

Cavern C, the main channel continuing in a northerly direction from the Great Room, is the most massive corridor with 15–30 m ceilings and widening to more than 30 m in places. A small perforated chimney lights the end near the Great Room but the remainder is in total darkness. Its fauna is extensive and varied. The various formations were named for convenience of identification and are shown in the accompanying map.

Air temperature in the caverns at 10 : 00 a. m. averaged 24.5°C which was about the

Table 1. Physical conditions in the Dark Cave.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean air temperature (°C) at 0730 outside of the cave	1960	23.11	23.0	23.44	24.0	24.44	23.88	23.61	23.66	23.88	23.83	23.61	23.61
Air temperature (°C) inside of the cave at 0900	1959	—	—	—	—	—	—	—	—	—	—	—	23.88
	1960	24.44	24.44	25.00	25.00	25.00	25.00	24.44	25.00	24.44	24.44	23.88	23.88
Water temperature (°C) in cave at 0900	1959	—	—	—	—	—	—	—	—	—	—	—	23.33
	1960	23.33	23.33	23.33	23.33	24.44	23.88	23.33	23.88	23.33	23.33	23.33	23.33
Rainfall in cm	1959	5.4	7.1	21.3	38.1	27.2	25.4	17.8	3.3	30.5	52.3	30.7	22.1
outside the cave	1960	11.9	3.6	22.1	34.3	12.2	10.9	18.3	—	37.6	27.9	33.0	36.6
Flow of Crystal Spring in Cavern B	1959	—	—	—	—	—	—	—	—	—	Flow	Flow	Dry
	1960	Dry	Dry	Occ. Flow	Flow	Occ. Flow	Dry	Dry	Dry	Flow	Dry	Flow	Flow
General cave moisture	1959	—	—	—	—	Dry	Damp	Dry	Dry	Damp	Wet	Wet	Damp
	1960	Dry	Dry	Damp	Damp	Damp	Dry	Dry	Dry	Damp	Dry	Damp	Dry

median outside temperature (Table 1). Water temperature at 10 : 00 a. m. averaged 23.4°C. Humidity was the most variable factor in atmospheric conditions within the cave. During October and November 1959 there were almost daily heavy rains and within the caverns the walls and ceilings streamed with moisture which condensed in the atmosphere as a thin fog. During dry months stalactites ceased to drip, streams and springs dried up, and the mud of Caverns A and C became dry enough that mole crickets could again burrow in it.

METHODS

After initial exploration established that the cavern fauna was most abundant in A, B, and C, collections were made in these at weekly intervals from May 1959 to June 1960, followed by monthly collections until January 1961. A few collections were made in Caverns D to F. Most observations were made between 9 : 00 a. m. and 1 : 00 p. m. but occasional observations were made in the afternoon and at night to note diurnal variations. Insects attracted to light were collected by placing flashlights above wide mouthed bottles containing alcohol. Such traps were placed at two sites in Cavern A, two in B, six in C, and one in D. Ordinary torchlight batteries provided light for two to three hours. The traps were in operation for three hours in Cavern A and B and for progressively less time to about 30 minutes at the end of Cavern C. Samples of the soil and guano fauna were preserved in 70% alcohol.

The numbers of conspicuous invertebrates such as the cave centipedes, *Liphistius* and *Bagauda* were counted at selected places to indicate relative abundance. Larvae of some species were reared for adult identifications. Vertebrates were identified by Lim Boo-Liat and the less abundant species were counted. Bat numbers were indicated by relative abundance. Invertebrate collections were shipped to Bishop Museum where they were sorted and mailed to taxonomists.

DISCUSSION

Within the caverns there was an energy exchange related to time of day, moisture, and

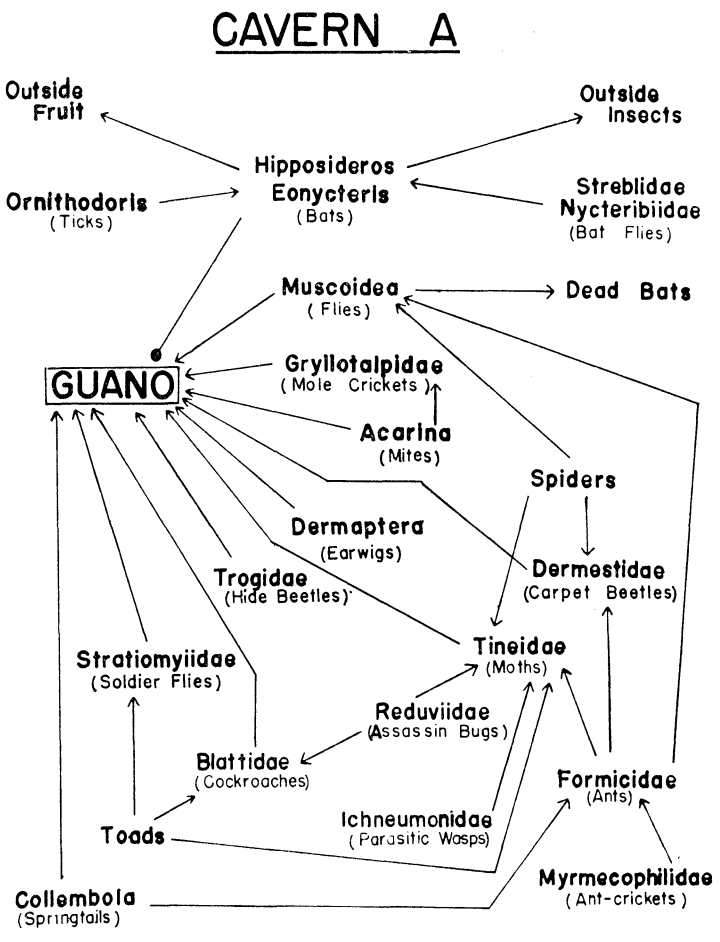

Fig. 2. Food chains in Cavern A.

distance from light. Species as well as population densities changed under the varying cavern differences.

Food Chains: The obvious food chains differed as the light intensity decreased and resulting invertebrate species changed. Fig. 2 illustrates that of Cavern A where the guano was attacked by numerous mites and collembola later to be further utilized by roaches and tineid moth larvae. These in turn were the prey of *Bagauda*, spiders and toads. Here the cavern conditions rapidly changed from very wet to very dry. When the floor and guano were water soaked stratiomyid fly larvae were numerous. Neither the stratiomyid nor tineid adults remained in Cavern A in numbers comparable to the number of larvae present.

Fig. 3 illustrates the food chains in Cavern C. The moisture was not as variable as in A and there was no light, therefore many of the invertebrate species involved were different from those of Cavern A. Guano from the bats was the primary source of energy

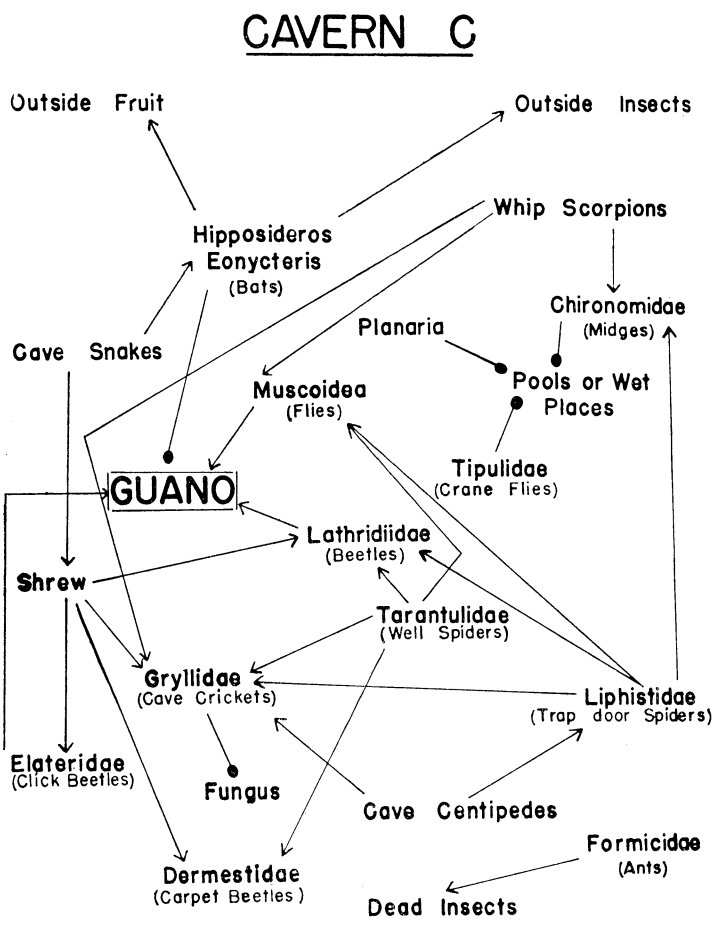

Fig. .3 Food chains in Cavern C.

and it was also attacked by mites and by annelids, Roaches were fewer in numbers and cave crickets were prey of the centipedes, *Liphistius* and well spiders.

Photo or Diurnal Periodicity: As would be expected of animals in the threshold zone, diurnal periodicity was retained in Cavern A. Throughout the entire cavern bats retained their periodicity - leaving at sundown and returning at dawn. In Cavern C where this flow of activity would be evident even though there was no light many other species also retained their periodicity. This was most evident in the shrews that began to move about just after sundown. One unexplained difference was related to the attractiveness of lights to insects. This reached peak intensity in mid-morning. Insects were less attracted in the evening and at night.

Relationship to light: Many species occurred throughout the length of the caverns but were abundant where light or its absence was optimum for them. Some species abundance was poorly related to the light, i. e., *Liphistius* was distributed throughout. The toads, *Bagauda*, stratiomyids, roaches, and bat ticks were abundant in Cavern A. Well spiders,

cave crickets, cave centipedes, dermestids, and elaterids were in peak abundance in the dark areas of Cavern C.

Relationship to Moisture: Most of the invertebrates responded to the cavern moisture. Heavy moisture drove hide beetles, mole crickets, roaches to the soil surface while during dry periods they burrowed deeply. Several species of coprophagous mites, the stratiomyids, and psychodids greatly increased when the guano was soaked. These differences were most obvious in Cavern A where there was greatest change in cavern moisture.

Relationship to Bats: Bats were not only the primary source of energy in the caverns but affected the invertebrate life in other ways. When *Hipposideros* was present in numbers their droppings, composed of chitinous insect remains, were attacked by staphylinids. During February, March, and April, when *Hipposideros* was present and had brood flocks, the streblids and ticks increased to peak numbers. At the same time, a heavy mortality of young and adults provided food sources for shrews and carrion feeding insects.

All of these major changes in physical conditions of the caverns brought side effects such as increases in predation by *Bagauda*, attacks upon the earwigs by mites, increases in the parasitism by ichneumonids and chalcids and shifts in the movements of ants and their guests. Some of the population changes for conspicuous species are shown in fig. 4.

ANNOTATED LIST OF SPECIES AND GROUPS IDENTIFIED

AVES

APODIDAE. *Collocalia* sp., swiftlets, trogloxene, rare visitor. Many caves in SE Asia have large populations of swiftlets, but only two unidentified individuals were seen in the Pit, 10.XI.1959, and 18.X.1960.

HIRUNDINIDAE. *Hirundo daurica* (Cassin), Cliff Swallow, threshold, permanent resident, aerial feeder, nested on outside walls of massif and was seen to enter cave only to hawk insects in entrance as far as Chimney A.

TURDIDAE. *Myophoneus flavirostris dicrorhynchus* Salvadori, Whistling Thrush, threshold, permanent resident, predator. At least two pairs made extensive use of the caverns from the entrance as far back as Cavern C, feeding upon roaches, *Trox* larvae, Giant African Snails, and beetles. A nest was built in a crevice 14 m inside the entrance to Cavern A and two young were reared in October 1959.

MAMMALIA

RHINOLOPHIDAE. *Rhinolophus affinis superans* And., *R. luctus morio* Gray, *Hipposideros bicolor* (Temminck), *H. galiterus* Cantor, *H. armiger debilis* And., *H. diadema vicarius* And., Horseshoe Bat, Tables 2, 3, trogloxene, intermittent resident insectivorous. Early in April 1959 many dead and dying *H. diadema* were found in Cavern A and tissues from adults and young were injected into mice, but no pathogens were isolated. A heavy bat tick population was also present. The numbers of dead *Hipposideros* found each week decreased in May and following this the tick population subsided. This proved to be a cyclic event for again in March and April 1960 more bats died in Cavern A and subsequently there have been similar losses in 1961, 1962, and 1963. During these months Cavern A

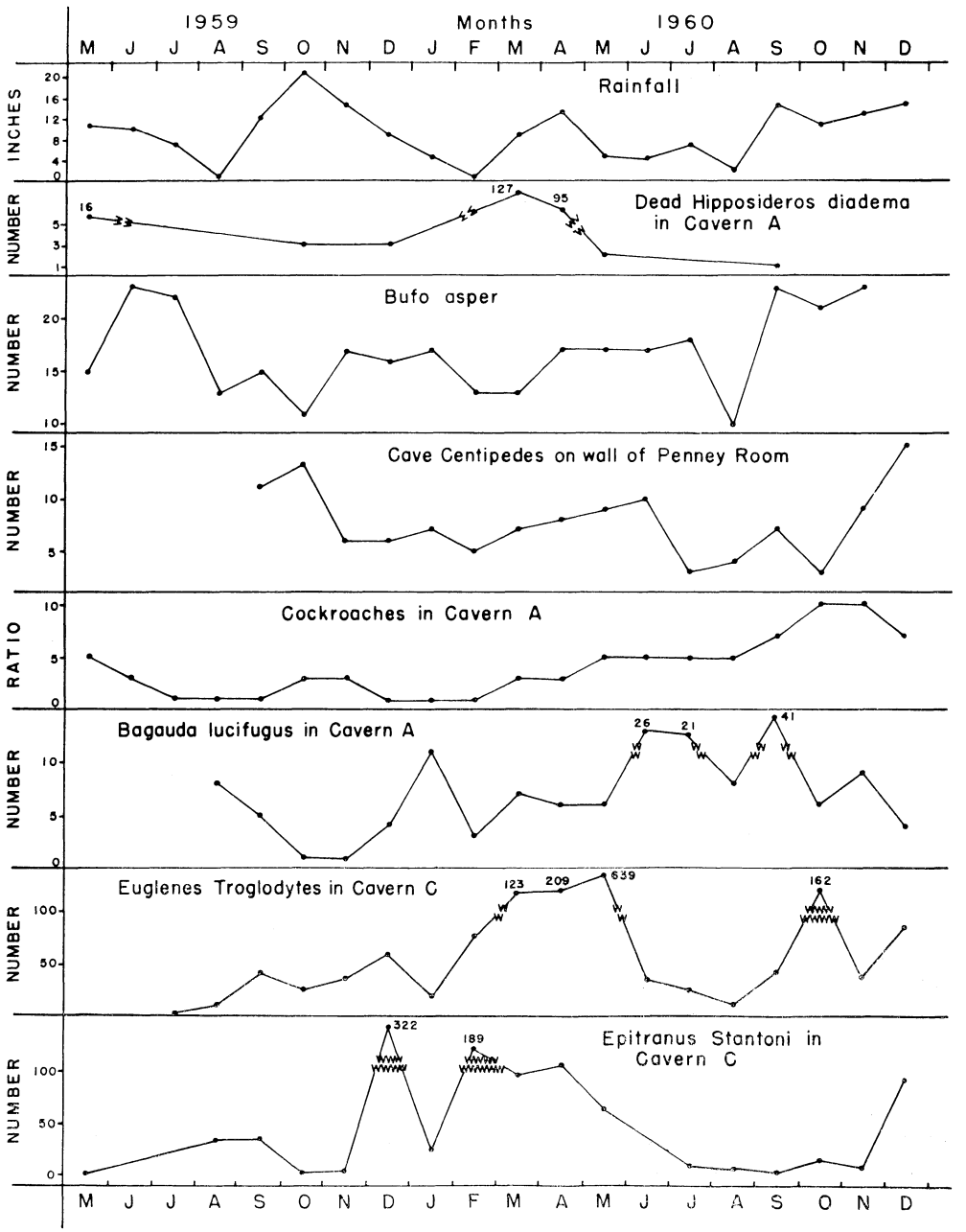

Fig. 4. Some of the phenological patterns of residents of Batu Cave.

was brood chamber for the entire cavern complex and thousands of *Hipposideros* crowded in with equal thousands of *Eonycteris*. The *Eonycteris* were regular residents and non-breeding at this time but the resulting competition for space became so violent that both

parents and young *Hipposideros* were precipitated to the floor 30 m below. At first only young incapable of supporting themselves on their wings came down. Then as the young grew they weighted the females so heavily that if they lost a foothold they could not support the load and volplaned downward. Even probing the roof with a strong beam of light would bring the laden females down.

The guano of Cavern A was strewn with bones of *Hipposideros*. Farther back in other caverns was additional evidence that there had been death of *Hipposideros* each year. The two species, *Hipposideros diadema* and *Eonycteris spelaea*, were the abundant forms. *Eonycteris* roosted en masse and greatly outnumbered *Hipposideros* which roosted in rows along the walls and ceiling, each bat out of reach of others. *Hipposideros* occurred sporadically and no relationship with the mortality other than that of breeding was evident. At other times there seemed to be periods of abundance and periods of poverty, but at no time did *Hipposideros* numbers approximate those of *Eonycteris*.

Most of the caverns' history had been destroyed by guano digging, but several hundred square meters of soil in the Penny Room had not been mined. A layer of several cm of mud covered the almost level onyx floor and before the cave was as well drained as it is today the room would flood becoming soft muck into which the bones or bodies of the bats could sink. At present at points of occasional drip from the ceiling small pot holes reveal jack-straw-like piles of bones at the base of the mud. Samples of the mud 30×30 cm were selected at random about the room with the following results:

Sample	*H. diadema*	*E. spelaea*	Other sp.	Miscellaneous
1	65	9	14	Penny dated 1919
2	30	23	1	
3	19	4	1	
4	20	10	—	
5	16	9	—	
Total	150	55	16	
Average	30	11	3	

Hundreds of bones were found, but only the lower jaws or fragments thereof were grouped in pairs and counted. This suggested the minimum number of animals that might have been involved. For example, in one 30×30 cm sample there were enough mandibles and maxillae or fragments to indicate a minimum of 40 or a maximum of 107 *Hipposideros*. At present only a few bats of either species use the ceilings and walls yet the bone deposit in this one room which is over 60 m long and 30 m wide would indicate that more than 600,000 *Hipposideros* and 220,000 *Eonycteris* have died there.

In other bits of undisturbed soil there were similar deposits.

Sample	*H. diadema*	*E. spelaea*	Other sp.	Miscellaneous
Near Onyx Cascade Cavern B	35	5	5	1 snake
Near Entrance Cavern B	12	11	3	1 dog, 1 squirrel, 1 snake
Cavern A	6	—	—	—

From the entrance to the back of Cavern C was 790 m and the average width was more

Table 2. Numbers of Dead Bats Counted in Dark Cave.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Hipposideros diadema							
Cavern A	1959	—	—	—	56	16	—	—	—	—	3	—	3
	1960	—	—	127	95	2	—	—	—	1	—	—	—
Cavern B	1959	—	—	—	8	—	—	—	—	—	—	—	—
	1960	—	—	—	—	—	—	—	—	—	—	—	—
Cavern C	1959	—	—	—	—	—	—	1	1	—	22	2	1
	1960	1	—	—	5	—	—	—	—	—	—	—	—
Total	1959	—	—	—	64	16	0	1	1	0	25	2	4
	1960	1	0	127	100	2	0	0	0	1	0	0	0
						Eonycteris spelaea							
Total	1959	—	—	—	1	1	1	—	1	2	1	5	3
	1960	—	1	5	9	1	—	—	—	—	10	—	—

than 15 m. Assuming that these figures are average then the remains of an estimated 1,500,000 *Hipposideros* and 700,000 *Eonycteris* once lay in the top few cm of mud.

The opening at the Pit was buried 3 m below the present floor and on the layer of mud forming the floor there was a flowstone deposit more than 8 cm thick. The guano diggers had excavated beneath this floor exposing *Hipposideros* bones imbedded in the under surface of the flow-stone. No estimate has been made of the time involved for the deposit of mud and the flow-stone, but the presence of the bat bones imbedded there suggests the great antiquity of the cave exposure and its fauna. Two explanations for the predominance of *Hipposideros* are suggested: 1. There has been a change in the relative abundance of the two since the immediate environs of the massif have been deforested or planted in rubber. 2. The breeding habits of the *Hipposideros* result in proportionately more dying in the cavern than do those of *Eonycteris*. Table 2 lists the numbers of dead counted for each species and as noted above, the bulk of the *Hipposideros* dying in March, April, and May were young or females. The loss in Cavern C in October 1959 was not duplicated in 1960 and remains unexplained. There was some similarity to this pattern among the *Eonycteris*, but young were found down in February, June, August, November, and December suggesting almost continuous breeding for this species.

In Anak Bukit Takun, a small cavern about 12 km north of Batu Caves, the bat population in March 1961 was mainly of *Hipposideros* and *Rhinolophus*. It was a small population but there was a brood chamber at 120 m where partly grown young were clinging to the roof and to each other. Because of the smaller concentration no dead or dying young

Table 3. Abundance of *Hipposideros diadema* in the Cave.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cavern A	1959	—	A	A	N	F	O	O	O	O	O	O	O
	1960	O	O	A	N	F	O	O	O	O	O	O	O
Cavern B	1959	—	—	—	—	—	—	N	O	N	A	N	N
	1960	F	O	F	N	N	A	A	A	A	N	N	O
Onyx Man	1959	—	—	—	—	—	—	N	N	N	A	N	F
Cavern C	1960	O	O	F	N	F	A	A	A	A	N	N	F
At Back	1959	—	—	—	—	—	—	N	—	A	A	N	F
Cavern C	1960	O	O	F	F	F	A	A	A	A	N	N	F

O- none seen; F- few; N- common; A- abundant

Table 4. Abundance of *Eonycteris spelea* in Dark Cave.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cavern A	1959	—	—	—	—	—	N	N	N	N	N	N	N
	1960	N	N	N	N	N	N	N	N	N	N	N	N
Cavern B	1959	—	—	—	—	—	A	A	A	A	F	F	F
Entrance	1960	F	F	F	F	F	F	F	F	F	F	F	F
Cavern B	1959	—	—	—	—	—	N	N	N	N	A	N	N
Entrance	1960	N	N	A	N	N	N	N	N	N	N	N	N
Cavern B	1959	—	—	—	—	—	N	N	N	N	A	N	N
	1960	N	N	A	N	N	N	N	N	N	N	N	N
Onyx Man	1959	—	—	—	—	—	N	N	N	N	N	N	N
Cavern C	1960	N	N	N	A	A	N	N	N	N	N	N	N
Karnak Hall	1959	—	—	—	—	—	N	N	N	N	A	A	A
Cavern C	1960	A	A	A	A	A	A	A	A	A	A	A	A

F- few; N- common; A- abundant

or adults were found on the floor. Outside of the cave, the terrain was similar to that around Batu Cave, tin mine-stripped lands, second growth forest, and primary forest in the background.

H. galiterus and *H. bicolor* were occasionally seen at the back of the Helectite Channel in Cavern D singly or in pairs. It made up a fairly large percentage of the bats at Anak Bukit Takun Cavern.

VESPERTILIONIDAE. *Myotis mystacinus*, Mouse-eared Bat, trogloxene, permanent resident, was regularly counted in two small holes where they roosted daily beneath the Black Cascade in Cavern C. The numbers in the holes, five in one and one or two in the other, and their actions suggested that the same individuals returned daily over long periods. The lip of each hole was worn smooth by many years of use by this species. The average monthly counts suggested that fewer *Myotis* were in the cave during May to August.

EMBALLONURIDAE. *Taphozous melanopogon fretensis* (Thos.), Tomb Bat, trogloxene, was not noted in the Dark Cave, but it was seen in small numbers several times at the entrance of the dark caves in shallow caverns at other points in the massif.

PTEROPIDAE. *Eonycteris spelaea* (Cobs.), Dogfaced Bat, Tables 2, 4, trogloxene, permanent resident, fruitivorous, is at present the most abundant bat in the Caverns. It roosted each day en masse on ceilings of Caverns A, B, and C, and in patches on the ceiling of the Great Room, but its greatest concentrations were in Cavern A and in the Karnak Hall of C. Since this species has large eyes which glow brightly with a reddish cast in a strong beam it was more readily noted on the ceilings than the *Hipposideros* but unlike *Hipposideros* it rarely used the walls. Both species tended to cling to habitual roosts and the oil and dirt of their feet have gradually stained the rocks to a chocolate brown. Streaks of stain on the walls revealed *Hipposideros* roosts while areas of stain on the ceiling indicated those of *Eonycteris*.

The number of dead or dying individuals on the cavern floor was such that only normal losses from old age or accidents were indicated. There was no period of loss as that noted for *Hipposideros*.

SORICIDAE. *Crocidura malayana* Robinson & Kloss, Whitetoothed Shrew, probably a troglobite as well as a troglophile.

Just at sundown, or a little after, the shrews began actively prowling the cavern floor and crevices where they fed upon dead bats or roaches and other arthropods. This species also occurs outside of the cave, and diurnal rhythm is maintained.

MURIDAE. *Rattus rattus jalorensis* (Bonhote), probably an accidental trogloxene. Only one individual was seen, prowling over a wall at the back of Cavern E.

REPTILIA

COLUBRIDAE. *Elaphe taeniura* (Fischer), Striped Racer, troglobite, also an epigean population, has two color phases; those that live in the disturbed forest and brushland are a typical striped gray and cream racer while those within the cave are creamy white with the stripes reduced to the tail. One fully colored individual was noted in the cavern, in Karnak Hall. Captives removed from the caves did not darken even after more than a year and several moults. Only nine individuals were seen in 400 hours of observation, but they may be more abundant than this figure indicates since they habitually remained in crevices of walls and ceiling. The diet was mainly of bats which were caught as they clung to the roof or walls. Coiled in a crevice the snake waited until a bat alighted within range. Then bracing itself with part of the body within the crevice the snake lunged out and captured its victim. It crushed it in a quick coil and swallowed it before withdrawing into the crevice. No young were seen.

Dryophiops rubescens (Gray), Keel-bellied Whip Snake, accidental trogloxene. The chimney at Cavern C was perpendicular and acted as a trap for many species which either fell or crawled into the cavern. One individual of this snake was seen on the mud beneath the chimney.

Ahaetulla formosa (Bois), Elegant Bronze-backed Snake, accidental trogloxene, one was seen beneath Chimney C where it was stalking the frogs living there.

GEKKONIDAE. *Gecko marmorata* (Fitzgerald), Marbled Gecko, accidental trogloxene, was found on two occasions on the rocks beneath Chimney C.

SCINCIDAE. *Lygosoma scotophilum* Boulenger, Skink, accidental trogloxene, a single individual was found on the rocks beneath Chimney C.

AMPHIBIA

Bufo asper, Gravenh., Table 5, habitual trogloxene. Most were found in Cavern A for this had easy access, was threshold and provided abundant food. Only an occasional in-

Table 5. Average numbers of *Bufo asper* seen in Dark Cave.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Small	1959	—	—	—	—	0	0.3	2.0	1.6	1.2	0.2	3.5	1.0
	1960	1.0	2.3	2.0	0.7	0	5.0	3.0	4.0	4.0	4.0	2.0	0
Medium	1959	—	—	—	—	3.0	2.3	3.7	2.3	3.0	2.7	3.0	1.7
	1960	2.5	1.0	3.0	7.0	5.0	3.0	4.0	3.0	0	6.0	5.0	—
Large	1959	—	—	—	—	12.0	20.0	16.5	9.3	11.0	8.0	11.2	13.4
	1960	13.5	10.0	8.4	10.0	12.5	9.0	11.0	3.0	19.0	11.0	16.0	—
Total	1959	—	—	—	—	15.0	22.6	22.2	13.3	15.2	11.2	17.0	16.0
	1960	17.0	13.3	13.2	17.0	17.5	17.0	18.0	10.0	23.0	21.0	23.0	—

dividual was found beyond Cavern A, and often these were thin or starving; however, they did penetrate to the end Cavern C and marked individuals moved between A and B. None was seen in the Cavern D or E complexes. No eggs or tadpoles were found in any of the pools indicating that the females did not lay here. There was a steady appearance of young and half-grown toads throughout the year, but the total numbers of adults remained fairly constant. At many points within the caverns moisture continued to be present after the general area was dry. When old, starving or diseased the toads sought these cooling drips and there died. Accumulations of bones at such points attested the long use of these "graveyards."

Table 6. Average numbers of *Bufo melanostictus* recorded in Cavern A.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Small	1959	—	—	—	—	—	—	—	—	0	0.3	0.3	0.2
	1960	0	0	.2	0	0	0	0	0	1.0	0	0	—
Medium	1959	—	—	—	—	—	—	—	—	0	0	0.6	0.2
	1960	0.7	0	0	0	0.5	1.0	0	0	0	0	0	—
Large	1959	—	—	—	—	—	—	—	—	2.0	3.6	3.0	3.2
	1960	2.7	3.5	2.7	6.0	6.0	2.0	3.0	1.0	6.0	9.0	3.0	—
Total	1959	—	—	—	—	—	—	—	—	2.0	4.0	3.7	3.6
	1960	3.5	3.5	3.0	6.0	6.5	3.0	3.0	1.0	7.0	9.0	3.0	—

Bufo melanostictus Schneider, Table 6, habitual trogloxene, was present in Cavern A, but in smaller numbers than *asper*. It was not found deeper in the cave, but was present in A throughout the year and slightly more numerous during rainy seasons.

Callula pulchra Gray, accidental trogloxene, entered Cavern A only occasionally. Most often seen in Pit where they were trapped by the steep walls.

Table 7. Numbers of *Rana calconota* seen beneath C Chimney.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1956	—	—	—	—	—	5	1	2	3	2	4	5
1960	2	1	2	1	2	3	5	2	6	3	7	4

Rana calconota Schlegel, Grass Frog, Table 7, accidental trogloxene. Beneath Chimney C was a pile of original soil and debris not removed by the guano diggers and clinging to small ledges on it were these frogs. They were trapped here by the light of the chimney and were not found in other part of the cave.

INVERTEBRATE FAUNA

Only those species or groups that were conspicuous or regularly collected are discussed here. Additional groups represented are listed as an appendix.

Turbellaria

Dugesia sp., Table 8, troglobite, may have been a true cave form since it was found in any permanent water throughout the cave. It was most regularly found in Pool B (Cavern B), and in the waters of the Penny Room and Karnak Hall. Its eggs remained dormant in hollows in Cavern A, hatching in intermittent pools as soon as they were formed.

Annelida

MAGASCOLECIDAE. Earthworms abounded in the soil, especially where it was wet from continuous drip. *Pheretima indica* (Horst) was found in Caverns A, B, and C and was

Table 8. Relative population densities of some invertebrates in Batu Cave.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dugesia sp.	1959	—	—	—	—	—	—	A	N	N	A	N	A
Pool B	1960	N	F	A	A	N	N	N	N	N	N	N	N
Opeas spp.	1959	—	—	—	—	A	N	N	N	F	N	N	F
Cavern A	1960	F	F	F	F	A	F	F	F	F	N	N	N
Parabathynella	1959	—	—	—	—	—	—	—	—	—	A	N	A
malaya Pool B	1960	N	F	N	A	N	N	F	N	F	N	N	N
Ostracoda	1959	—	—	—	—	—	—	A	N	N	A	N	A
Pool B	1960	N	F	A	A	N	N	N	N	N	F	N	F
Ostracoda	1959	—	—	—	—	—	—	—	A	A	A	F	N
Pool A	1960	N	F	O	O	O	A	O	O	F	N	N	F
Armadillo intermix-	1959	—	—	—	—	—	—	—	—	—	—	A	N
tus Cavern B	1960	A	N	F	N	N	F	F	F	A	F	N	N
Glyphiulus sp.	1959	—	—	—	—	—	—	—	—	—	—	N	A
Cavern C	1960	N	A	N	N	N	A	F	N	N	F	F	N
Doratodesmus sp.	1959	—	—	—	—	—	—	—	—	—	—	N	A
Cavern C	1960	N	A	N	F	N	A	A	N	N	N	N	N
Damarchus caver-	1959	—	—	—	—	—	—	—	—	—	—	N	A
nicolus Cavern C	1960	N	A	N	N	A	A	N	N	N	F	F	N
Ornithodorus batu-	1959	—	A	F	F	F	F	F	F	F	F	F	F
ensis Cavern A	1960	O	F	A	AA	A	F	F	F	F	O	F	F
Diestrammena	1959	—	—	—	—	—	—	—	—	—	—	A	N
gravely Cavern B	1960	F	O	F	F	F	N	F	F	F	F	F	N
Diestrammena	1959	—	—	—	—	—	—	—	—	—	—	A	A
gravely Cavern C	1960	A	A	N	A	A	A	A	A	A	N	N	N
Gryllotalpa fulvipes	1959	—	—	—	—	—	—	—	—	—	—	N	N
Cavern A	1960	N	A	N	N	N	A	F	N	N	N	N	A
Myrmecopoilus													
dubius Caverns	1959	—	—	—	—	—	—	—	—	—	—	—	—
A and C	1960	N	N	N	A	AA	F	A	N	A	A	A	A
Pycnoscelus striatus	1959	—	—	—	—	A	N	F	F	F	N	N	F
Cavern A	1960	F	F	N	N	A	A	A	A	AA	AAA	AAA	AA
Dermaptera	1959	—	—	—	—	—	—	A	N	N	A	F	F
Cavern A	1960	F	N	N	A	A	F	N	A	N	A	F	N
Coeloeczetes caver-	1959	—	—	—	—	—	—	—	—	—	F	F	N
nicola Cavern A	1960	N	A	A	A	A	A	A	A	—	F	A	N
Staphylinidae	1959	—	—	—	—	—	—	—	A	N	O	O	A
Cavern C	1960	A	N	A	A	AA	F	F	F	F	O	O	F
Tinea palaehrysis	1959	—	—	—	—	—	F	F	F	F	F	F	N
Cavern A	1960	N	A	N	A	A	A	N	F	F	F	F	N
Sargus metallinus													
mactans, Adult	1959	—	—	—	—	—	—	—	—	—	—	—	—
Cavern A	1960	N	N	N	F	F	F	F	F	F	F	F	F
S. metallinus													
mactans, Larvae	1959	—	—	—	A	—	—	—	—	—	—	—	A
Cavern A	1960	F	O	A	A	F	F	F	F	F	F	A	F
Pheidole javana	1959	—	—	—	—	—	—	N	A	A	A	A	A
Cavern A	1960	A	N	N	A	N	N	A	F	N	A	A	N
Pheidole javana	1959	—	—	—	—	—	—	—	—	—	—	A	A
Cavern C	1960	A	N	N	A	A	N	F	N	F	N	N	N

O- absent; F- few; N- common; A- numerous

especially abundant in the Karnak Room where a cubic inch of the wet soil saturated with guano of *Eonycteris* contained hundreds of the worms.

Mollusca

MELANIIDAE. *Paludomus buccula* Reeve, *P. buccula* Reeve var. *minuta* Ghosh, STENOGYRIDAE. *Opeas doveri* Ghosh, *O. dimorpha* Ghosh. Snail populations varied with the changes in the cave moisture and it is suggested that the populations are now much more limited than before the removal of guano drained most of the pools and streams. Deposits of shells throughout the cavern indicate extensive populations in the past.

Permanent water flow over stone formations supported thousands of the aquatic *Paludomus* while *Opeas* crawled over wet stone surfaces, beneath bits of wood or stones and burrowed into the soil when the surface became too dry for them. Both genera occurred throughout the cave where moisture permitted. *Paludomus* appeared to be more sensitive to light than *Opeas* for a beam thrown onto a mass of them would cause a wave of contraction, While *Opeas* ignored the light and responded to touch.

ACHATINIDAE. *Achatina fulica* Ferrussac, Giant African Snail, accidental trogloxene. Intact or crushed shells of this introduced species were found beneath Chimney C. They were fed upon by Whistling Thrushes and shrews.

Crustacea

BATHYNELLIDAE. *Parabathynella malaya* Sars, Table 8, aquatic troglobite. This primitive crustacean was a resident of the permanent pools (B and Geometric) and was not collected from intermittent pools. In Pool B its usual population density was about one per square inch of bottom.

This is a very hardy species which in the laboratory lived and reproduced in jars of water and debris for 24 months. Indirect light did not disturb them and some individuals appeared to develop patches of brown pigment in the integument following weeks of exposure to daylight.

Ostracoda

CYPRIDIDAE. The assemblage of aquatic troglobites in Pool B usually included *Parabathynella malaya*, annelids, *Planaria*, chironomid larvae, and an unidentified species of ostracod. The ostracods were permanent residents in Pool B and appeared in Pool A, Geometric Pool, and others when inundated long enough for the eggs to hatch. The ostracods fed on organic debris such as dead roaches or bats that fell into the water and would assemble in a seething mass. Like *Parabathynella* it lived well in glass containers having survived and bred for 24 months. There appeared to be no competition between ostracods and *Parabathynella* for food, but the former was always in great numerical superiority. They not only swam in the water, but crawled over or burrowed into the flocculent detritus of the pool bottom.

Isopoda

ARMADILLIDIDAE. *Armadillo intermixtus* Lund., ONISCIDAE, *Philoscia dobakholi* Chopra.

Chilton (1929) discussed the two species listed as having been collected in numbers by Dover, but his description of their habits as related by Dover does not fit the isopods that were found throughout the cave during this study. Those of the walls were probably *Armadillo intermixtus*. They were common in Cavern B, less so in C and A and almost non-existent in other caverns, although some (possibly this species) were seen in the deeper totally dark caverns F and H.

Tiny white isopods were common in A beneath sticks and stones and almost always in association with ants and collembola. Their actions suggested that they were ant guests.

Diplopoda

CAMBALIDAE. *Glyphiulus* sp., Table 8, troglobite. Throughout the caverns, but especially in Cavern C, gray millipeds were in abundance. They were usually concentrated along the walls or in deep pits, beneath the Black Cascade or in the throat of Dinosaur Jaws. This and the following species were almost always together, however *Glyphiulus* was often distributed in drier areas than the spiny milliped. All ages were found together. Many of the adult millipeds were hosts to one or more, rarely as many as five, large mites (unidentified) which rode on the back near the head.

Doratodesmus sp. (?), Table 8, troglobite. This white spiny milliped may be a true cavernicolous species. It moves very slowly and deliberately and is usually found in the deepest damp parts of the caverns where it resembles bits of cigarette ash on the floor. There may be a slight population increase during the rainy seasons. Individuals of all ages and sizes were usually found together.

Chilopoda

SCUTIGERIDAE. *Scutigera decipiens* (Verh.), Tables 9, 10, troglobite. Throughout Caverns A, B, and C cave centipedes inhabited the walls and floor. They were sensitive to light and ran rapidly from a beam. They attacked almost any of the lesser creatures, but were most often found feeding upon cave crickets. They were also noted eating trap door spiders and roaches. Although counted regularly during the observations, their numbers were never great and in general they were about 50% more numerous during months when the cavern was dry and external rainfall was less than 7.5 cm. However, those of the Penny Room reversed this pattern and were about 1/4 fewer in dry months. There appeared to be no distinct breeding periods, for young and immature individuals were found during all months. They were often seen copulating, the male passing a spermatheca to the female. No egg pouches were found.

Table 9. Average numbers of cave centipedes *Scutigera decipiens* (Verh.) counted in Caverns B and C.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Small	1959	—	—	—	—	—	—	—	—	1	2	1	3
	1960	7	4	1	2	5	2	1	2	4	0	3	5
Medium	1959	—	—	—	—	—	—	—	—	0	5	1	2
	1960	4	8	3	2	1	3	1	3	4	4	4	8
Large	1959	—	—	—	—	—	—	—	—	10	6	6	7
	1960	10	19	9	12	12	12	10	11	8	9	20	17
Total	1959	—	—	—	—	—	—	—	—	11	13	8	10
	1960	21	31	13	14	18	17	12	16	16	13	27	30

Table 10. Average numbers of cave centipedes on the wall of the Penney Room.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Small	1959	—	—	—	—	—	—	—	—	1.0	2.0	0.0	0.4
	1960	1.5	0.0	0.0	1.0	2.5	0.0	1.0	0.0	0.0	0.0	0.0	4.0
Medium	1959	—	—	—	—	—	—	—	—	0.0	5.0	1.0	0.2
	1960	0.5	0.3	1.5	1.0	0.5	3.0	0.0	0.0	1.0	0.0	2.0	3.0
Large	1959	—	—	—	—	—	—	—	—	10.0	6.0	5.0	5.0
	1960	5.0	5.0	5.0	6.5	6.0	7.0	2.0	4.0	6.0	3.0	7.0	8.0
Total	1959	—	—	—	—	—	—	—	—	11.0	13.0	6.0	5.6
	1960	7.0	5.3	6.5	8.5	9.0	10.0	3.0	4.0	7.0	3.0	9.0	15.0

Scorpionida

CHACTIDAE. *Chaerilus* prob. *celebensis* Pocock, troglobite, a gray scorpion which remained in crevices where it responded to light and withdrew immediately when disturbed. Individuals seen in Cavern C and the Penny Room appeared to remain in the same crack for months at a time. A niche in the Penny Room was occupied continuously from November 1959 until February 1961. A female was noted there with at least six white young in May 1960 and she may have been the continuous resident. If small cave crickets were offered to her she readily took them and retreated into the crevice.

Arachnida

TARANTULIDAE. *Sarax brachydactylus* Sim., troglobite. Whipless scorpions of all ages were found on the walls and in crevices of Caverns B and C, but especially in C. They were most often seen from December through March but their numbers seemed unrelated to cave moisture.

LIPHISTIIDAE. *Liphistius batuensis* Abraham, Table 11, troglobite. Abraham described this living fossil from Batu Cave specimens in 1923 and it was collected by Dover in 1926 and Bristowe in 1930. In February 1961 Bristowe visited the cave with H. E. M. and found the numbers of this trapdoor spider much fewer than 30 years before. During each observation from December 1959 to December 1960 the occupied nets were counted in several selected sites with results as given in Table 11.

In March 1961 a brief exploration of the 180 m cavern in Anak Bukit Takun revealed that this species was in abundance. Hundreds of snares of all sized and aged spiders were on the walls and stalactites as high as the lights could reveal them. This cavern had a low insect fauna compared to Batu Cave, but it was sufficient to support the *Liphistius* population of a magnitude probably resembling that which Bristowe had originally seen in Batu Cave.

The adult spider builds a large case of net from 40 to 50 mm long with a door about 22 mm across. It is loosely constructed, decorated with debris from the surrounding area, and the inside is smoothly lined with white silk. The rear is not completely closed, offering a back door escape. The hinged flap of the door is held partly open by the spider crouching behind it. Radiating from the entrance in a semicircle to a distance of 12.5 or 15 cm are six to ten strands or radii of silk. If a small insect touches one of these the spider throws open the door, dashes out, captures its prey and returns. The spider will respond to the pressure of an insect even in briliant light and dash out when a light-attracted dermestid or flystrikes a strand.

Table 11. Average numbers of *Liphistius batuensis* snares counted in Caverns B and C, at Dinosaur Jaws, and on the Penney Room Wall.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Caverns B and C	1959	—	—	—	—	—	—	—	—	—	—	—	15.0
5 mm door	1960	43.0	58.0	29.2	20.0	15.0	—	32.0	—	33.0	26.0	—	—
10 mm door	1959	—	—	—	—	—	—	—	—	—	—	—	9.0
	1960	27.0	26.0	25.0	19.0	9.0	—	28.0	—	16.0	23.0	—	—
20 mm door	1959	—	—	—	—	—	—	—	—	—	—	—	52.0
	1960	61.0	93.0	91.0	104.0	102.0	—	107.0	—	106.0	80.0	—	—
Total	1959	—	—	—	—	—	—	—	—	—	—	—	76.0
	1960	131.0	177.0	145.0	143.0	126.0	—	184.0	—	155.0	129.0	—	—
Dinosaur Jaws	1959	—	—	—	—	—	—	—	—	—	—	—	3.0
5 mm door	1960	2.0	2.0	2.0	2.5	3.0	3.0	5.0	2.0	2.0	0.0	7.0	5.0
10 mm door	1959	—	—	—	—	—	—	—	—	—	—	—	3.0
	1960	3.0	3.0	2.0	2.0	0.0	2.0	2.0	3.0	0.0	1.0	3.0	1.0
20 mm door	1959	—	—	—	—	—	—	—	—	—	—	—	6.0
	1960	6.0	9.0	9.0	10.5	11.0	8.0	10.0	6.0	13.0	9.0	10.0	11.0
Total	1959	—	—	—	—	—	—	—	—	—	—	—	12.0
	1960	11.0	14.0	13.0	15.0	14.0	13.0	17.0	11.0	15.0	10.0	20.0	17.0
Penney Room	1959	—	—	—	—	—	—	—	—	—	—	1.0	4.0
5 mm door	1960	9.0	5.0	3.5	2.0	1.5	3.0	8.0	6.0	1.0	2.0	7.0	8.0
10 mm door	1959	—	—	—	—	—	—	—	—	—	—	2.0	2.0
	1960	4.0	2.0	3.0	2.0	0.0	7.0	10.0	8.0	3.0	4.0	9.0	9.0
20 mm door	1959	—	—	—	—	—	—	—	—	—	—	5.0	5.0
	1960	5.0	6.0	7.0	10.5	12.0	7.0	18.0	3.0	18.0	12.0	7.0	14.0
Total	1959	—	—	—	—	—	—	17.0	—	8.0	9.0	8.0	11.0
	1960	18.0	13.0	13.5	14.5	13.5	17.0	36.0	17.0	22.0	18.0	23.0	31.0

The eggs are laid within the case at the top and imbedded in loose white webbing. Twenty or more eggshells were counted in one deserted case, but the numbers may be higher.

The nets were tallied by size, those of newly hatched young, about 5 mm across the trap door, those about half grown, 10 mm wide, and the adult cases 20 mm wide. When the young left they tended to build within a few inches of the parental case so that they were in little groups about the large cases. However, either there was wide dispersal or a heavy mortality for there were usually only three or four about any given parent.

The spiderlings caught their prey in the same way as adults. The length of time that the spiderlings remained in their small huts was uncertain. Marked cases were occupied for months with no appreciable growth of the occupants. It appeared that after a period of occupancy the spider did not enlarge its case but deserted, probably molted, and built the 10 mm size. In several instances these medium-sized spiders found deserted adult cases and built the 10 mm size in their entrances. Again there is no certainty as to length of occupancy in the 10 mm size before they were deserted and a 20 mm house built. Dozens of the nets were measured and there was little graduation between sizes suggesting abrupt changes to larger construction.

Although occasionally found on the floor, *Liphistius* apparently preferred to put its snares on a vertical surface. On the stone they did not use a perfectly smooth nor yet a very rough surface. The young, especially, would build along some shallow crack or surface mar. On vertical mud banks of the floor each case was placed above a deep hole into which the spider could retreat. The back door was retained in these cases as well. Camouflage with dirt made such snares nearly invisible.

Even though a fairly large spider as an adult, no age was free of predation and previously occupied cases were often found empty and sometimes torn open. Nets on soil surfaces were occasionally attacked by some predator which chewed or burrowed its way through the webbing leaving a round hole that penetrated to the spiders' shaft beneath. A cave centipede was once seen eating an adult *Liphistius*.

PSECHRIDAE. *Psechrus curvipalpus* Fage, troglophile, spun its irregular cobweb-like snares in Cavern A and from Chimney C back to the Penny Room. The white sticky strands formed an untidy mesh which was soon covered with dust particles and fungus. The spider remained behind the net and fed through it when some creature was snared. Globular egg cases were most often seen in January and February and contained 50 to 100 eggs. These spiders did not appear to be very successful in their acclimatization to cave life, for they apparently lived but a short time and were very susceptible to a fungus which attacked them leaving them suspended in the net a fragile mass of white spores.

CTENIZIDAE. *Damarchus cavernicolus* Abraham, Table 8, troglobite, was present all year, rarely found in Cavern A, occasionally in B, but very common from the Penny Room to the end of Cavern C. Well spiders preferred soil dry enough and deep enough that they could dig their deep pits. They were colonial with groups of 20 to 50 wells of various sizes depending upon the age of the spider. They waited at the well entrances which were lined with silk but with no door and dashed out to catch young cave crickets, flies, or other small creatures. They were not responsive to lights shone upon them but fled down the holes if the soil was jarred as by a step.

Acarina

ARGASIDAE. *Ornithodorus batuensis* Hirst, Table 8, probably troglobite, was an intermittent parasite of the bats, biting them and then digesting the blood while hiding in crevices of the cavern ceilings where their eggs were also laid. They were almost limited to Cavern A, for few were collected deeper in the cave, yet the masses of *Eonycteris* and *Hipposideros* increased progressively into Karnak Hall. *Ornithodorus* was always present on the floor and walls of Cavern A but March, April, and May were peak months when the floor, rocks, walls and undoubtedly the ceiling were crawling with them, all ages, engorged and unengorged. This population peak was directly correlated with the breeding of *Hipposideros diadema*. The ticks probably increased in numbers on the ceiling at this time, and the intense activity of the bats resulted in numerous ticks being knocked down. This was partly substantiated by the fact that they would fall upon observers if the bats were disturbed by lights. The bite is highly irritating with severe swelling and with ulceration at the site of the bite which required ten days to two weeks to heal.

CUNAXIDAE. *Cunaxa setirostris* Herman was taken in Cavern B light traps where they probably fell into the alcohol as they stalked the tiny flies swarming about the lights. Individuals were caught in March and May and 10 were taken in April suggesting some periodicty of activity.

Numerous mites remain unidentified. One large brown coprophagous form with white nymphs was especially abundant in Cavern C, at the Onyx Man and in Karnak Hall, during rainy periods when the fresh droppings from *Eonycteris* remained moist on the mud surface and each dropping was covered by a mass of the mites. The same or another

species responded similarly in Cavern A when Earwig Peak became wet from drip and the guano from an *Eonycteris* concentration above it remained moist.

HEXAPODA

Collembola

The majority of the collembola remain unidentified. Except when the cave was dry in June-July 1960 they were present in numbers. At least one species was found beneath objects in association with ants. Light traps were often attractive to them and they hopped into jars placed at floor level in nearly all of the caverns. They were abundant not only in Cavern A but also in the completely dark Karnak Hall. In April 1960 a heavy rain created a spring which flooded part of the area near Onyx Man and the surface of the resulting pond was covered with thousands of collembola that had floated up from the soil.

Orthoptera

GRYLLACRIDAE. *Diestrammena gravely* Chopard, Table 8, troglobite. This cave cricket with extremely long appendages was the basic animal of the food chains deeper in the caverns. A few were in the threshold zones of Cavern A and they increased in B, but in C from the Onyx Man on back they were very abundant. Other caverns had few or none. Apparently this is a fungus or organic debris feeder, but they were never noted actually feeding since they stopped and remained quiet when touched by a beam of light. The walls of the Black Cascade and Penny Room supported the largest number and here they fell prey to centipedes, scorpions, whipless scorpions and *Liphistius*. Eggs were laid continuously, for nymphs of all ages were always present. There appeared to be no cycles of abundance.

GRYLLOTALPIDAE. *Gryllotalpa fulvipes* Saussure, Table 8, troglophile, was most abundant in Cavern A where it burrowed beneath rocks and surface debris. It occurred the full length of the Caverns and was often heard calling to the end of Cavern C. In soil that was periodically flooded it moved up and down with the moisture. Young migrated over the soil surface, especially where it was flocculent, and were attracted to light traps.

GRYLLIDAE. *Myrmecophilus dubius* Saussure, Table 8, an ant guest that was commonly found in association with the small scavenger ant *Pheidole javana* throughout Caverns A, B, and C. All ages of nymphs as well as wingless adults were in the formicaria. In Cavern A they remained beneath objects, but in the total darkness of Cavern C they walked on the surface along with the ant columns. They could run swiftly. An injured or dead one was quickly dismembered and carried off by their hosts. Four to ten could usually be found with any group of *Pheidole*.

BLATTIDAE. *Pycnoscelus striatus* Kirby, Table 8, troglophile, reached greatest abundance in Cavern A and was distributed all the way to the end of Cavern C in a sparse population. Those in Cavern A feeding upon the guano and organic debris reached such numbers when the soil was damp that they were crawling over each other in several layers. During wet periods they retreated to the walls and when the cave was dry they burrowed into the soil and beneath objects. Peak abundance for the entire two year study was reached

in October–November 1960 when moisture conditions were optimum. The egg capsules were deposited in the soil or beneath stones and nymphs of all ages were always present. All ages were fed upon by Whistling Thrushes, shrews, toads, and invertebrate predators.

Dermaptera

FORFICULIDAE. *Chelisoches morio* Fabr. and *C. brevipennis* Bor., troglophiles, were most abundant under and upon stones and debris in Cavern A and in Karnak Hall of Cavern C. All ages from small nymphs to adults were present. In March 1960 Earwig Peak became soaked from drip, and mites (unidentified) increased to tremendous numbers, clustering densely over the earwigs. The mites disappeared when the rock and guano dried out. The earwig population appeared to increase when moisture drove them from the soil and debris.

Psocoptera

Throughout the cave but especially in Cavern A troglophile psocids were taken in the light traps. In Cavern A feeding upon mold of decaying wood was a feather winged species, *Parasoa haploneura* Thornton. Nymphs, adults and sub-adults or semi-winged individuals were first discovered in March 1960 when they were abundant. There were fewer in April and May, few in June, and they were no longer seen between July and December. They were in close association with ants, collembola, myrmecophiles, hemipterans, and tiny isopods.

Hemiptera

REDUVIIDAE. *Bagauda lucifigus* McAtee & Malloch, Table 12, troglophile, was common from the cave entrance to the end of Cavern C, but was usually found within a meter or so of the entrance to A and in B Chimney where they may have come from the outside. First instar nymphs were found occasionally in A as well as in C and it believed that they hatched within the cavern. The numbers on the walls of Cavern A suggested that they were seasonal in appearance reaching greatest numbers from June through September. They were often seen feeding upon case-bearer moth larvae by piercing the cases.

Reduvius gua Dover, troglophile, a species which has changed in abundance since Dover studied it in 1926. He described adults and nymphs and stated "this species is quite common in bat guano especially in the first 400 feet of the cave. The nymphs are commoner than the adult and closely resemble spiders when running about in the guano." In the present series of observations none was seen in Cavern A and only one individual was discovered on the walls of Cavern B.

MIRIDAE. A tiny red bug, *Fulvinus brevicornis* Reuter, was found beneath damp boards in a woodpile in Cavern A in March 1960 and was present continuously for the remain-

Table 12. Average numbers of the long-legged assassin bug *Bagauda lucifugus*, seen in Cavern A.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1959	—	—	—	—	—	—	—	8.5	5.0	1.0	1.2	4.5
1960	11.0	3.3	7.2	6.0	6.0	26.0	21.0	8.0	41.0	6.0	9.0	4.0

ing observations until the woodpile was burned in 1962. Except in May, June, and July when it was more abundant, the population was fairly uniform.

Neuroptera

MYRMELEONIDAE. *Neglurus vitripennis* Navas, a large antlion described by Navas in 1912 from a specimen collected here. In 1959 two were found in July, one in August, two in November, one in December, and in 1960 one was found in January and three in February. It was thought that they were accidental trogloxenes until an adult only partially emerged was found being attacked by ants in Cavern A and occasional larvae were collected running over the soil surface.

Lepidoptera

TINEIDAE. *Tinea palaechrysis* Meyrick, Table 8, lived in abundance from Cavern A to the end of Cavern C wherever the soil was not too moist and where organic debris was available. Case-bearers were also found in similar situations in the small cavern of Anak Bukit Takun. In Batu Cave it was always present in all stages, and reached peak abundance in April–June following the cessation of heavy rains and after the soil had been pulverized by roaches. Eggs were laid in the soil surface debris and the number of larvae always greatly exceeded the number of adults present suggesting heavy predation by such predators as *Bagauda*, loss from parasitic wasps, or that the moths flew from the cavern. The larvae showed preference for broken bits of chitin in the materials that they used to cover their cases. When full grown they pupated within the cases. The adults were not active fliers, and usually clung to walls or to objects on the soil. They were not heavily attracted to lights.

Coleoptera

STAPHYLINIDAE. Unidentified, Table 8, staphylinids played an important part in the early breakdown of droppings from *Hipposideros*. The scattered semi-solid droppings consisted of broken chitin and organic wastes and one or two of the tiny beetles were usually found feeding under each pellet. Light trap collections indicated greatest numbers when the bats were using the cave heavily.

DERMESTIDAE. *Aethriostoma undulata* Motschulsky, Table 13, troglophile, a dark brown species slightly more abundant in Cavern C than at other locations with a ratio of Cavern A–3.0, B–4.8, C–5.5 in the light traps. Its numbers increased in drier parts of Cavern C where larvae fed on dry guano. The adults were readily attacked by *Liphistius*. In the small cavern of Anak Bukit Takun this was the most abundant beetle taken in light traps.

HYDROPHILIDAE. *Cercyon gebieni* Knisch and *Dactylosternum abdominale* (Fab.) were taken from Cavern A where their predaceous larvae were feeding on roach nymphs and other small arthropods. The adults were found on dead bats and in fresh guano.

LAMPYRIDAE. *Lychnocrepis antricola* Blair, troglobite, was rarely seen. Three were noted in Cavern C on 18 January, and 2 and 22 February 1960. On the evening of 23 February 1961, three were seen in Cavern A, 2 in B and 12 in C, five of them at the back past

Table 13. Average numbers of some species collected in light traps in Batu Cave.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Aver.
Aethriostoma undulata	0.2	4.1	4.3	3.3	16.4	1.5	1.8	3.3	4.4	4.4	7.2	9.7	5.0
Euglenes troglodytes	19.9	76.4	123.3	208.7	639.0	—	14.5	10.3	40.3	63.8	37.8	71.5	108.8
E. malayanus	0.1	2.7	31.6	15.4	7.0	—	0.1	0.6	2.7	2.0	0.1	0.2	5.2
E. batuensis	0.0	0.6	0.7	0.5	1.0	—	0.0	1.0	2.2	0.0	0.2	1.0	.6
Aderus mcclurei	0.1	5.2	6.6	4.2	22.9	—	0.3	2.7	4.0	0.2	0.5	12.0	4.9
Epitranus stantoni	27.0	189.0	96.0	114.0	62.0	—	5.0	21.0	20.0	8.0	7.0	206.0	62.9
Apanteles carpatus	4.0	22.0	9.0	3.0	12.0	—	0.0	0.5	4.5	0.0	1.0	12.5	5.7

Karnak Hall. One beetle was captured by a *Psechrus curvipalpus*. No larvae were noted suggesting that the adults may have entered through the chimneys.

ELATERIDAE. *Cardiophorus carduelis* Candeze, troglobite, was most abundant in the dry last 150 m of Cavern C. Its mahogany red pronotum and yellow and black banded elytra made it the least cave-like of the insects found there. They appeared in the light traps uniformly throughout the year.

Melanoxanthus near *dohrni* Schwarz, found mainly in Cavern B where it was attracted to light traps and was distributed through the year but never abundant.

TENEBRIONIDAE. *Coeloecetes cavernicola* Blair, Table 8, troglophile, was never as numerous as the hydrophilids but was gregarious and preferred dry rocks or walls of Cavern A. They were present in numbers most of the year, but were fewer in October–December 1959 when the cavern was wettest.

ADERIDAE. *Aderus mcclurei* Werner, *Euglenes troglodytes* (Champion), *E. batuensis* Werner, *E. cephalicus* Werner, ahd *E. malayanus* Werner, Table 13, were very abundant. *E. troglodytes* was the most numerous species and most common in Cavern C. It was reported from this cave in 1895, *E. batuensis* and *E. cephalicus* were much fewer and found in B or C. *Aderus mcclurei* was relatively common and found through most of the main channels. All species were present all months of the year; *troglodytes* reached peak abundance in March–May 1960; *malayanus* in March, April 1960; *batuensis* in September 1959, and *mcclurei* in December 1959 and May 1960.

SCARABAEIDAE. *Trox costatus* Wiedemann, troglophile, burrowed into the guano of Cavern A and was rarely seen on the surface. Larvae and pupae were also subterranean, but heavy moisture brought the larvae up to the surface beneath stones or wood.

Diptera

Flies of numerous species made up the bulk of the insect populations throughout the caverns (Table 14). They were attracted to the lights and sometimes swarmed about the observers so that it was difficult to breathe. Some of these flights included chironomids which reached heavy densities in October–December 1959. Flights were less in 1960 but reached a peak in April following spring rains. Many of the muscoids were consistently abundant. Greatest concentrations were found in C in the vicinity of the Penny Room and the Black Cascade. Flights in Caverns A and B always less.

TIPULIDAE. *Helius cavernicolus* Alex., Table 15, troglobite, was occasionally seen in Batu Cave and at Anak Bukit Takun. Peak abundance was in November–December 1959. No larvae were seen.

Table 14. Relative abundance of flies attracted to lights in various sections of the cave.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cavern A	1959	—	—	—	—	—	A	F	—	F	—	—	—
	1960	F	F	F	F	F	F	F	F	F	F	F	F
Cavern B	1959	—	—	—	—	—	A	—	—	—	—	—	—
	1960	F	F	F	F	F	F	F	F	F	F	F	F
Penney Room	1959	—	—	—	—	—	A	N	A	A	AA	A	A
	1960	F	A	F	F	F	F	F	F	F	N	N	N
At Back	1959	—	—	—	—	—	A	N	N	AA	AA	A	A
	1960	F	A	N	A	A	F	F	F	F	N	N	N
Black Cascade	1959	—	—	—	—	—	—	—	—	—	—	—	—
	1960	—	—	A	A	F	F	F	F	F	N	N	N

F—few; N—common; A—abundant

SCIARIDAE. Numerous sciarids were collected in light traps throughout Caverns A, B, and C. They were also found feeding on dead bats. Dover found *Bradysia leucocerca* (Kieffer) in the caverns in 1928 but gives no indication of abundance. No seasonal abundance was noted.

PSYCHODIDAE. Psychodids were abundant on wet walls and in the pools of Cavern A and B and they appeared sparingly in the light traps. Twenty-two species were identified, 10 of them new to science (Table 16).

Sycorax malayensis Quate was collected most commonly in light traps at the Penny Room where they reached peak abundance in May, August, and December. *Trichomyia batu* Quate was occasionally taken and was nearly restricted to Cavern A. *T. malaya* Quate was also an uncommon species which was found in Cavern B where 15 of the 20 specimens collected were taken. Only *Phlebotomus asperules* Quate & Fairchild were collected, all in Cavern C in the Penny Room; 23 specimens of *Telmatoscopus mcclurei* Quate were collected, 13 of them in the Penny Room. *T. albipunctatus* (Williston) bred in large numbers in the pools of Cavern A and in those of B and C when filled during May, August, December, and January.

Of the several species of *Psychoda*, *P. lutea* Quate and *P. malayica* Quate were the most abundant in the light trap collections with population densities as follows: *P. lutea* (Cavern A–30, B–10, C–60); *P. malayica* (A–53, B–10, C–37). *P. savaiiensis* Edwards was collected mainly in Caverns A and B; *P. makati* del Rosario was taken throughout the caverns.

CERATOPOGONIDAE. *Atrichopogon jacobsoni* (de Meijere), Table 17, is probably synonymous with *A. cavernarum* Edwards which both Ridley (1898) and Dover (1929) noted as being abundant 240–600 m in the caverns. In this study the species was found mainly in Cavern C with a population ratio: A–9.7, B–4.5, C–85.8. It was most abundant when the Cavern was wet.

Forcipomyia spp., Table 17, less common than the foregoing species this population was

Table 15. Average numbers of the tipulid *Helius cavernicolus* Alex. adults counted in the caverns.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black Cascade	1959	—	—	—	—	—	—	—	—	—	—	13	18
	1960	9	5	0	0	0	0	0	0	1	0	1	2
Total Cave	1959	—	—	—	—	—	—	—	—	3	4	24	25
	1960	14	7	4	1	1	2	3	2	3	1	2	2

Table 16. Abundance of Psychodidae as indicated by the total flies collected in light traps.

		Jan	Feb	Mat	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sycorax malayensis	1959	—	—	—	—	—	—	2	18	5	1	6	34
Quate	1960	1	5	5	4	17	—	0	1	0	0	0	3
Trichomyia batu	1959	—	—	—	—	—	—	0	0	2	0	0	2
Quate	1960	0	0	2	0	5	—	2	0	0	3	0	0
Trichomyia malaya	1959	—	—	—	—	—	—	0	1	8	0	0	1
Quate	1960	0	6	2	2	0	—	0	0	0	0	0	0
Phlebotomus asperules	1959	—	—	—	—	—	—	0	3	2	0	0	5
Quate & Fchld	1960	0	0	0	0	1	—	0	0	0	0	0	0
P. anodontis	1959	—	—	—	—	—	—	0	9	15	0	0	8
Quate & Fchld	1960	0	3	5	3	4	—	0	0	0	0	0	0
Telmatoscopus mcclurei	1959	—	—	—	—	—	—	0	0	1	0	0	5
Quate	1960	0	4	2	1	10	—	0	0	0	0	0	0
T. albipunctatus	1959	—	—	—	—	88	—	0	79	8	0	3	36
(Williston)	1960	67	5	1	2	3	—	0	0	4	0	0	3
P. lutea Quate	1959	—	—	—	—	—	—	0	109	197	2	0	291
	1960	0	56	18	41	171	—	0	0	0	1	16	0
P. malayica Quate	1959	—	—	—	—	17	—	2	109	189	10	23	169
	1960	6	72	20	10	138	—	0	0	0	3	35	27
P. savaiiensis	1959	—	—	—	—	—	—	0	0	0	0	0	0
Edwards	1960	1	17	3	4	0	—	0	0	0	0	0	0
P. makati del	1959	—	—	—	—	—	—	9	20	0	0	0	0
Rosario	1960	0	0	0	0	0	—	0	0	0	0	0	0

Table 17. Total numbers of *Diptera* taken in light traps in Caverns A, B, and C.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Atrichopogon	1959	—	—	—	—	60	30	11	32	52	1	21	169
jacobsoni	1960	2	66	9	20	111	P	P	P	P	P	P	P
Forcipomyia sp.	1959	—	—	—	—	—	0	0	6	14	0	0	78
	1960	0	6	24	2	0	0	0	0	0	0	0	0
Paratendipes	1959	—	—	—	—	—	0	0	3	6	438	162	2660
inarmatus	1960	P	P	P	0	0	0	0	0	0	0	0	0
Pentaneura batuensis	1959	—	—	—	—	—	0	14	75	28	112	4	158
	1960	1	11	9	9	146	P	1	P	P	P	5	P
Eusmittia cavernae	1959	—	—	—	—	—	P	62	131	123	P	P	168
	1960	P	29	56	19	85	9	0	16	0	1	16	4
Podonomus sp	1959	—	—	—	—	—	P	250	2465	2518	459	99	1367
	1960	76	12538	2214	2724	4286	118	25	6	0	30	787	9517
Diploneura peregrina	1959	—	—	—	—	—	0	0	2	0	0	0	60
	1960	0	5	28	78	243	17	P	P	P	20	30	37
Tricimba batucola	1959	—	—	—	—	—	0	0	3	25	P	80	221
	1960	90	50	54	105	375	218	169	16	20	73	186	738
Chyromya prob.	1959	—	—	—	—	—	20	P	9	P	21	124	379
dubia	1960	42	12	11	164	700	255	269	133	71	155	481	393
Phyllomyza cavernae	1959	—	—	—	—	—	1	11	12	39	6	16	138
	1960	26	336	2247	948	291	34	625	74	354	200	634	492
Leptocera brevicostata	1959	—	—	—	—	—	0	0	30	3	0	0	101
var. *rufifrons*	1960	4	8	0	4	105	8	1	0	1	0	99	95

P– present but numbers not counted

distributed in the Caverns: A–1.6, B–18.1, C–80.3. It appeared in the collections sporadically.

Table 18. Distribution of *Uranotaenia* sp. larvae in the caverns.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pool B	1959	—	—	—	—	—	—	P	0	P	0	0	0
	1960	0	0	0	0	0	0	0	0	0	0	0	0
Geometric Pools	1959	—	—	—	—	—	—	—	—	9	0	10	25
	1960	26	80	25	0	0	—No	Water	—	0	0	3	0
	1961	0	25	60	—	—	—	—	—	—	—	—	—

0- Absent; P- Present but numbers not counted

CULICIDAE. *Aedes albopictus* (Skuse), trogloxene, flew into Chimneys A and B, into the entrance to Cavern A, and occasionally into the Great Room. No larvae were found in any of the waters of the cave.

Uranotaenia sp. (Table 18) was found breeding in semidarkness in Pool B in 1959 and in the Geometric Pools. The population was a winter one and the larvae were very slow to develop. In both 1960 and 1961 only one generation of larvae developed in the Geometric Pools followed by several months of absence.

CHIRONOMIDAE. Following periods of extended rains when the caverns became very wet chironomids rapidly developed in the pools and became the most abundant of insects in the caverns, especially in the Penny Room and beneath the Black Cascade. Here moisture, guano, and the absence of light provided optimum breeding conditions. Table 17 lists the abundance of some of the common species.

Pentaneura batuensis Freeman, collected in numbers in light traps, was nearly restricted to Cavern C with a population ratio of: A-0, B-5.8, C-94.2. It was most abundant in the Penny Room and at the Black Cascade and increased following periods of heavy rain.

Eusmittia cavernae Freeman, was more widely distributed through the caverns than the previous species with a population ratio of: A-11.2, B-34.8, C-54.0. The conditions in the Penny Room were most favorable to it.

Paratendipes inarmatus Freeman, was also widely distributed through the caverns with a population ratio of: A-4.4, B-9.0, C-86.6. Those from the Penny Room made up the bulk of collections and greatest numbers emerged during the wet months of 1959.

Podonomus sp. the most numerous fly in the caverns during wet periods. More than 40,000 were collected in the light traps with a cavern ratio of: A-.7, B-5.5, C-93.8. The Penny Room and the Black Cascade had the highest populations.

STRATIOMYIDAE. *Sargus metallinus* var. *mactans* Walker, Table 8, habitual trogloxene, common in Cavern A and rarely seen farther back. The adulted entered Cavern A and deposited thousands of eggs in the guano which hatched when the guano was water soaked. The larvae pupated in the drying guano and left the cave soon after emergence.

PHORIDAE. *Diploneura peregrina* Wiedemann, Table 17, habitual trogloxene, a widespread species found throughout the Caverns where its larvae fed upon freshly dead bats. Its population ratio was: A-24.5, B-27.5, C-48.0, and it was most numerous during the months of March, April, and May when there were many dead bats.

CHLOROPIDAE. *Tricimba batucola* Sabrosky, Table 17, was common throughout the caverns with a population ratio of A-.5, B-34.0, C-65.5. It was present every month of the year.

CHYROMYIDAE. *Chyromya* prob. *dubia* Lamb, Table 17, Dover collected this at the back of Cavern C, but in our studies more than 3000 were taken with a Cavern ratio of A-

44.6, B-29.3, C-26.1. It was most numerous during November and December and May.

MILICHIIDAE. *Phyllomyza cavernae* de Meijere, Table 17, was present throughout the year. More than 6000 were taken with a Cavern population ratio of A-6.5, B-63.2, C-30.3.

SPHAEROCERIDAE. *Leptocera brevicostata* var. *rufifrons* Duda, Table 17, was not abundant but was most common in December and May. Nearly 600 were collected with a Cavern population ratio of A-3.7, B=43.7, C-52.6.

NYCTERIBIIDAE. *Eucampsipoda sundaicum* Theodor. STREBLIDAE. *Nycteribosca* prob. *gigantea* Speiser. The winged *E. sundaicum* and wingless *Nycteribosca* were found in Cavern A. Their abundance fluctuated with that of *Hipposideros*, for more were present in May and June of each year. They occasionally attacked the observers, were taken in light traps in Cavern A, or were seen running over the surfaces of stones and debris. Even though *Hipposideros* and *Eonycteris* were abundant in Caverns B and C, these were rarely found there at floor level.

Hymenoptera

BRACONIDAE. *Apanteles carpatus* (Say), Table 13. In Cavern A this species increased to a peak during the dry season of February 1960 and disappeared in March. It was in association with tenebrionids, *Ornithodorus*, earwigs, and mites. The cavern ratio of light-trapped specimens was A-57.7, B-7.6, C-34.6.

CHALCIDIDAE. *Epitranus stantoni* (Ashmead), Table 13, an orange and black chalcid that was regularly taken in light traps with a cavern ratio of A-2.3, B-6.5, C-91.2

Epitranus lacteipennis Cameron, closely similar in appearance to the foregoing species was found only in Cavern A until a series of 10 were collected by light trap beneath the Black Cascade in June 1960. These and other parasitic Hymenoptera in the caverns have apparently made no color or structural modifications for cavern life.

MUTILLIDAE. *Trogaspidio* sp., troglobite, was found only in Karnak Hall. It was solitary and rarely was more than one or two seen during an observation. It was observed walking among the openings of the well spiders, *Damarchus cavernicolus*, but was not noted attacking or being attacked by them.

FORMICIDAE. *Pheidole javana* Mayr, Table 8, occurred throughout the length of the caverns. Outside of the caverns it normally built tunnels over the forest floor and it continued to cover all its runways on the floor and walls of the caverns. In A it was commonly found beneath wood or stones where the colonies contained eggs, larvae, pupae, and winged adults. They were always in association with collembola, isopods, and *Myrmecophila*. *Pheidole* was a scavenger, but was also found attacking moribund or weak insects such as newly emerging myrmelionids or flies.

In addition to *Pheidole* a colony of hunting ants was first found in Cavern B, but moved its nest site into C where it was last found in a mud bank beneath the Black Cascade.

Additional Species Collected

Additional groups or species collected during this study were as follows: ANNELIDA. OCTOCHAETIDAE *Dichogaster*. sp., *D. bolavi* (Michaelsen). ARACHNIDA. IDEORONICIDAE. *Cryptocheiridium lucifugum* Birer, *Dhanus sumatranus* Red., *D. doveri* Bristowe. OCHYROCERA-

TIDAE. *Psiluderces crinitus* Fage. SCYTODIDAE. *Scytodes magnus* Bristowe. PHOLCIDAE. *Spermophora miser* Bristowe. ULOBORIDAE. *Uloborus spelaeus* Bristowe. THERIDIDAE. *Theridion rufipes* Luc. HETEROPODIDAE. *Heteropoda robusta* Fage. ACARINA. TROMBICULIDAE. *Trombicula batui* Phillip & Traub, *T. insolli* Phillip & Traub. CHEYLETIDAE. *Paracheyletia* sp. GALUMNIDAE. *Galumna* sp., *Vaghia* sp. ORIBATULIDAE. *Scheloribates* sp., *S. exuvium.* BELBIDAE. *Belba* sp. COLLEMBOLA. BRACHYSTOMELLIDAE. *Brachystomella contorta* Denis. NEOGASTRURIDAE. *Willemia nadchatrami* Yoshii. PSOCOPTERA. LIPOSCELIDAE. *Liposcelis* spp. LEPIDOPSOCIDAE. *Parasoa haploneura* Thornton. PSYLLIPSOCIDAE. *Psyllipsocus batuensis* Thornton. PERIPSOCIDAE. *Ectopsocus maindroni* Badonnel. EPHEMEROPTERA. EPHEMERIDAE. *Cleon* sp. HEMIPTERA. REDUVIIDAE. *Myiophanes fluitaria* McAtee & Malloch. CYDNIDAE. Unidentified. LEPIDOPTERA. LYONETIDAE. *Opogona cerodelta* Meyrick. SATURNIDAE. *Attacus atlas* L. COLEOPTERA. CARABIDAE. Unidentified. PSELAPHIDAE. Unidentified. SCYDMAENIDAE. Unidentified. SILPHIDAE. Unidentified. NITIDULIDAE. Unidentified. LANGURIIDAE. *Thallisellodes limbooliati* Chujo. ERCTYLIDAE. *Platycladoxena* near *angulosa* Arrow. ENDOMYCHIDAE. Unidentified. DERMESTIDAE. *Trinodes* sp. MELYRIDAE. Unidentified. ELATERIDAE. *Platynuchus* sp. ORTHOPERIDAE. Unidentified. SILVANIDAE. Unidentified. SCOLYTIDAE. Unidentified. CURCULIONIDAE. Unidentified. DIPTERA. SCIARIDAE. *Plastosciara* near *brevicalcarata* Hardy, *Soudekia* sp., *Phorodonta malayana* (Edwards), *Bradysia leucocerca* (Kieffer), *B. flagellicornis* Tuomikoski, *B. platytergum* Tuomikoski, *Bradysia* spp. PSYCHODIDAE. *Phlebotomus stantion* Newstead, *P. argentipes* Annandale & Brunetti, *P. anodontis* Quate & Fairchild, *Telmatoscopus kulas* Quate, *Brunettia* sp., *Psychoda aponesos* Quate, *P. pellucida* Quate, *P. alternata* Say, *P. vagabunda* Quate, *P. acanthostyla* Tokunaga, *P. harrisi* Satchell, *P. malleola* Tokunaga. CERATOPOGONIDAE. *Culicoides huffi* Causey, *C. peregrinus* Kieffer, *C.* prob. *arakawai* (Arakawa), *Stilobezzia* sp. CULICIDAE. *Culex tritaeniorhynchus summorosus* Dyer. CECIDOMYIDAE. Unidentified. MYCETOPHILIDAE. *Chetoneura cavernae* Colless. DROSOPHILIDAE. *Drosophila melanogaster* Meigen, *D. ananassae* Doleschall. DOLICHOPODIDAE. *Condystylus* sp. CHYROMYIDAE. *Gymnochiromyia* sp. MILICHIIDAE. *Leptometopa mcclurei* Sabrosky, *Milichia* sp., *Desmometopa* spp. SARCOPHAGIDAE. Unidentified. MUSCIDAE. *Fannia leucosticta* (Meigen), *Ophyra chalcogaster* (Wiedemann). SIPHONAPTERA. ISCHNOPSYLLIDAE. *Thaumapsylla breviceps orientalis* Smit. HYMENOPTERA. ICHNEUMONIDAE. *Hypsicerca fullawayi* Beardsley, *H. cavicola* Cushman. BRACONIDAE. *Aulosaphes* sp., *Apanteles* spp. FORMICIDAE. *Bathroponera rufipes* (Jerdon), *B. tridentata* (Sm.), *Leptogenys diminuta* (Fr. Sm.), *Paratrechina longicornis* (Latreille), *Pristomyrmex* sp., *Monomorium pharaonis* (L.), *Tapinoma melanocephalum* (Fabr.,), *Ponera* sp. *Camponotus* sp.

SUMMARY

Observations and collections of the fauna of the Dark Cave of Batu Caves at Kuala Lumpur, Malaysia, were made between May 1959 and January 1961. The 0.8 km long caverns had an extensive invertebrate population, many species of which remain unidentified. Twenty-three species of vertebrates were observed, the most abundant of which were *Eonycteris spelea* and *Hipposideros diadema.* The collections included 151 identified species of 94 families of invertebrates. Coprophagous mites of several species and Diptera were the most abundant arthropods. Populations and species representation varied from the entrance to the rear of the caverns. Most species developed maximum populations where light and moisture conditions were optimum.

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